

# A new nematode genus *Rugoster* (Leptolaimina: Chronogastridae), with descriptions of six new species

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**Abstract.** A new genus *Rugoster* is proposed in the family Chronogastridae. It is characterized by having longitudinal cuticular grooves on the body cuticle and a tail having a stem-like mucro bearing two lateral, strongly hooked spines and two finer terminal hooked spines. *R. magnifica* (Andrássy, 1956) comb. n. is proposed as type species of *Rugoster*, and *Chronogaster magnifica* Andrásy, 1956 and *Chronogaster tessellata* Mounport, 2005 are transferred to it. The new genus is diagnosed, some notes on its morphology added and its relationships discussed. Six new species of *Rugoster* are described and illustrated. These are: *R. colbrani* from Queensland, Australia, *R. recisa*, *R. virgata* and *R. neomagnifica* from West Africa, and *R. orientalis* and *R. regalia* from India. *R. magnifica* is briefly redescribed from West Africa with photomicrographs to illustrate its important morphological characters. Chronogastridae has been redefined and assigned to Superfamily Plectoidea, Suborder Leptolaimina, Order Araeolaimida. A key to the species of *Rugoster* gen. n. is given.

**Keywords.** Descriptions, India, new taxa, Queensland, *Rugoster* gen. n., *R. colbrani*, *R. neomagnifica*, *R. orientalis*, *R. recisa*, *R. regalia*, *R. virgata*, taxonomy, West Africa.

## INTRODUCTION

At the present time, the free-living nematode genus *Chronogaster* Cobb, 1913 of the Family Chronogastridae Gagarin, 1975, comprises 46 valid nominal species (Andrássy, 2005) which show considerable differences in morphological characters, for example, in body, cephalic setae and tail lengths, cuticular structures, shape and position of amphidial fovea and its aperture and the structure, shape and size of the tail mucro. Heyns and Coomans (1983) assigned the genus *Chronogaster* to the Family Leptolaimidae Örley, 1880. Andrásy (2005) redefined the Family Chronogastridae and assigned it to the Superfamily Plectoidea, Suborder Leptolaimina, Order Araeolaimida. About the main family characters of the Chronogastridae, Andrásy (2005) stated, "Within the superfamily Plectoidea, this family differs from Plectidae Örley, 1880 by the longitudinal and serrate valvular apparatus in the oesophagus bulb (vs. a complicated valve with transverse elements too), the unpaired gonads (vs. always paired), and by the absence of caudal glands and spinneret (vs. both present). He remarked, "The family includes continental nematodes, which can be grouped under

two genera, the old and widely distributed *Chronogaster* Cobb, 1913 and the quite recently established *Keralanema* Siddiqi, 2003. The latter has an only species, *K. spinicorpus* (Maggenti, Raski, Koshy & Sosamma, 1983) Siddiqi, 2003, discovered in India."

Among the members of the Family Chronogastridae, we have noticed a correlation between the occurrence of longitudinal cuticular grooves on the body cuticle and four hook-like spines on terminal mucro of the tail. This correlation is clearly seen in *Chronogaster magnifica* Andrásy, 1956 and *C. tessellata* Mounport, 2005. There is no named species in the genus *Chronogaster* that has rod-like mucro bearing hook-like spines but which lacks longitudinal cuticular grooves. We have studied these two species as well as several others similar to them and have come to the conclusion that they form a coherent generic group herein named and defined as *Rugoster* gen. n.

The present paper provides the descriptions of *Rugoster* gen. n. and its six new species. The new species are described and illustrated. The two known species of *Chronogaster* having longitudinal cuticular grooves and a rod-like mucro bearing four hooked spines have been

transferred to the genus *Rugoster* as *Rugoster magnifica* (Andrássy, 1956) comb. n. and *R. tessellata* (Mounport, 2005) comb. n. The morphological characters and systematic position of the new genus *Rugoster* and the systematics and composition of Chronogastridae have been discussed.

## MATERIAL AND METHODS

The nematodes were killed by applying heat and fixed in 3-4% formalin solution. They were processed to glycerine using warm lactophenol and mounted in dehydrated glycerine on glass slides with glass rods and wax support. Measurements and drawings were made using an Olympus BH2 research microscope fitted with a drawing tube.

Photomicrographs were taken at the USDA Nematology Laboratory, Beltsville, MD, with a Q-Imaging Retiga EXi Color Digital Camera (Q-Imaging, Austin, TX) attached to a Leica Wild MPS48 Leitz DMRB compound microscope (Leica Microsystems, Wetzlar, Germany), and measurements were made with an ocular micrometer on the same microscope.

The type specimens of these new species have been deposited in the following collections:

1. The British Nematode Collection at The Food and Environment Research Agency, Sand Hutton, York, YO41 1LZ, England (herein referred to as the British Nematode Collection). 2. The USDA Nematode Collection at Beltsville, Maryland, USA. 3. Indian Nematode Collection at Indian Agricultural Research Institute, New Delhi 110012, India, and 4. Dr. M. R. Siddiqi's Nematode Collection at the Nematode Taxonomy Laboratory, 24 Brantwood Road, Luton, LU1 1JJ, England.

## Comments on some morphological structures of the Chronogastridae

### 1. The oesophagus

The oesophagus in the species of the genera of Chronogastridae and Plectidae shows three peculiarities discussed below.

**(i). Feeding pump chamber.** Anteriorly the muscular cylindrical oesophagus has a broad region with thickened more conspicuous radial canals and muscular walls making it a distinct structure different from the rest of the corpus. We call this region 'feeding pump chamber' because it likely expands and contracts to create a suction pressure for the semi-liquid food to be sucked in. This chamber has three radial canals, one ventral and two subdorsals, that are well separated and anteriorly form three arches and then run posteriorly along the outer margins of the chamber, gradually narrowing and coming closer to join the oesophageal lumen and mark the end of the chamber. The thick inner cuticular walls and conspicuous lumen of the canals especially in the anteriormost region and the musculature show that the chamber is highly elastic. This coupled with non-muscular anteriormost region of the corpus between the chamber and the stoma points to the functions of the median oesophageal

bulbs, which act as feeding pumps somewhat similar to that in *Myctolaimus*, *Tylopharynx* as well as aphelenchs and most tylenchs. The cylindrical stoma is adapted as a passage for the food when the feeding pump chamber is in action. This type of feeding explains the absence of teeth or other buccal armature in Chronogastridae and related families.

A similar chamber is found in various other genera of the Suborder Leptolaimina particularly those belonging to the families Chronogastridae and Plectidae, which have a masticatory organ in the basal oesophageal bulb called the gizzard. Both the chamber and the gizzard are the most important diagnostic characters of these families comprising the Superfamily Plectoidea.

**(ii). Gizzard.** The basal region of the oesophagus in Chronogastridae is swollen to form an oval bulb containing a masticatory oval structure in its anterior half. It has longitudinal rows of 6-10 minute denticles arranged on dorsal and two subventral plates. According to Heyns and Coomans (1980), there are nine rows of denticles that reduce to three towards the base. This region has thick cuticular walls and is expandable as seen in some specimens of *Rugoster* spp. in which its lumen is enlarged. This together with a rasp-like inner surface provides a macerating organ for crushing the food before it is passed on to the intestine. We propose to name it 'gizzard' because it has a similar function to that found in a bird's stomach. For birds, a gizzard is defined as: a thick-walled structure in which hard food is broken with grit and small stones. A gizzard is also found in other invertebrates such as annelids and insects. In members of the Chronogastridae this organ has longitudinal rows of small denticles for crushing the food, and in the Plectidae it has several cuticularized hard ridges of the inner cuticle which likely perform the same function. Thus the basal bulb in these families is very different from the valvate basal bulb found in Rhabditida and Cephalobida and does not show any homology to it.

**(iii). Stem-like extension of the basal oesophageal bulb and cardia.** In the members of the Family Chronogastridae the basal oesophageal bulb has a stem-like short-to-long extension to which the cardia is attached. In the Plectidae the extension is also found but is not so pronounced. Heyns and Coomans (1980) have given details of the stem-like extension of the basal oesophageal bulb and cardia.

### 2. Male tuboid ventromedian supplements

Several authors have described tuboid, spicule-like ventromedian supplements in *Chronogaster* species (see Heyns & Coomans, 1980): Exactly 100 years ago 9 tuboids were reported by Cobb (1913) in *C. longicollis*. Loof and Jairajpuri (1965) described and illustrated five pre-anal ventromedian tubular supplements in *Chronogaster andrassyi* (wrongly spelt *andrassyi*). Khera (1972) reported 14 tuboids in *C. bigubernacula* and 9 in *C. indica* by Bajaj and Bhatti (1979). Similar tubular supplements were described for *Chronogaster spinicorpus* by Maggenti *et al.* (1983). Siddiqi (2009) described these tuboid organs and

their hypodermal glands, and stated, "The secretion of these glands perhaps helps in the attraction of the males or helping the male to locate the vulva during copulation, but more importantly, in providing firm adhesion by their secretions to the female during copulation (compare the caudal gland and spinneret as holdfast mechanism)." Similar tuboid supplements are of common occurrence in Plectidae and have also been reported for *Leptolaimus pumilus* by Gagarin (2009) who stated, "Four similar midventral tubular plus 22-24 twin glandular supplement (present). Each tubule is connected with a single gland-like cell." Besides the Plectoidea, such tuboid ventromedian supplements are of common occurrence in the Leptolaimoidea, and represent a strong higher rank taxonomic character.

## SYSTEMATICS

Holovachov and De Ley (2006) included the Superfamilies Leptolaimoidea and Plectoidea in the Order Plectida Malakhov, 1982, whereas for the former Superfamily Leptolaimoidea, the Suborder Leptolaimina already existed and it should have been elevated to ordinal rank as Leptolaimida. Andrassy (2005) divided the Order Araeolaimida De Coninck & Schuurmans Stekhoven, 1933 into two Suborders: Araeolaimina De Coninck & Schuurmans Stekhoven, 1933 with members having no oesophageal basal bulb, and Leptolaimina Lorenzen, 1979 characterized by the presence of a basal oesophageal bulb. The Superfamily Plectoidea Örley, 1880 containing the Family Chronogastridae was considered under Leptolaimina along with three other Superfamilies: Leptolaimoidea Örley, 1880, Haliplectoidea Chitwood, 1951 and Metateratocephaloidea Eroshenko, 1973. We accept this system of classification of these groups. Thus Chronogastridae belongs in the Superfamily Plectoidea, Suborder Leptolaimina, and Order Araeolaimida.

The Order Araeolaimida is characterized by the annulated cuticle lacking punctations, four cephalic setae usually present, labial sensilla not in the form of setae, amphids postlabial unispiral, sometimes cyathiform, buccal cavity mostly narrow cylindroid lacking armature except for occasional denticles, tubular muscular oesophagus usually with feeding pump chamber anteriorly and posteriorly a basal bulb with macerating gizzard which might not have been developed in certain genera, excretory-secretory system present with excretory pore usually near nerve ring leading into a long excretory duct to renette cell which is usually located a little anterior to oesophageal base, ovaries paired, antidromously reflexed (posterior ovary may be lost secondarily), males with paired spicules with protractor muscles attached to the head of the spicule and the body wall, not forming a capsule enclosing each spicule (as in Triplonchida and Tripylida, see Siddiqi (1983)), tuboid ventromedian supplements usually present, each provided with a unicellular gland, and tails mostly with three caudal glands and a terminal spinneret. Araeolaimida are found in aquatic habitats, mostly marine or freshwater and/moist soil, feeding on microorganisms and algae.

## Family Chronogastridae Gagarin, 1975

**Diagnosis.** Superfamily Plectoidea, Suborder Leptolaimina. Cuticle annulated, sometimes with longitudinal grooves and occasionally with plates, but devoid of ornamentations and lateral fields. Cephalic setae four, over 2  $\mu\text{m}$  long. Labial sensilla indistinct, papilla- or pit-like. Amphids cyathiform, near cephalic region, rarely unispiral or inverted U-shaped. Stoma elongate-tubular, less than two head-widths long, lacking teeth or denticles. Oesophageal bulb with a prominent gizzard having inner rasp-like denticles, and posteriorly with a stem-like extension merging with the cardia. Intestine attached to the posterior half of the cardia. Excretory-secretory system with a renette cell located near oesophageal bulb present, with long duct and pore located behind nerve ring. Monodelphic, prodelphic. Ovary single, antidromously reflexed. A rudimentary postvulval uterine sac present, rarely absent. Tail elongate-conoid to filiform, similar between sexes. Male rare, with two testes, simple spicules and tuboid ventromedian supplements which may rarely be absent. Free-living, freshwater and soil inhabiting forms, rarely marine.

**Type subfamily:** Chronogastrinae Gagarin, 1975.

**Type genus:** *Chronogaster* Cobb, 1913.

**Other genus:** *Rugoster* gen. n.

**Other subfamily:** Keralanematinae subfam. n.

**Type and only genus:** *Keralanema* Siddiqi, 2003.

**Remarks:** Holovachov and De Ley (2006) synonymised the genus *Keralanema* Siddiqi, 2003 with *Chronogaster*, but Andrassy (2005) upheld it and gave a key (page 151) to differentiate the two genera. *Keralanema* stands out in the entire Suborder Leptolaimina by the characteristic cuticle having strong annules divided into plate-like structures each of which bears lateral hook-like spines. On this character and the inverted U-shaped amphidial fovea, we propose a new subfamily, Keralanematinae, to accommodate *Keralanema* Siddiqi, 2003, as its type genus.

### Differential key to subfamilies and genera of Chronogastridae

1. Cuticular annules divided into plate-like structures bearing lateral spines; amphidial fovea inverted U-shaped ..... Keralanematinae subfam. n.  
(with type and only genus *Keralanema* Siddiqi, 2003)
- Cuticular annules not bearing plate-like structures or spines, amphidial apertures transverse slit- or pore-like ..... Chronogastrinae Gagarin, 1975
2. Body with longitudinal cuticular grooves, tail mucro rod-like bearing two subterminal and two terminal hook-like spines ..... *Rugoster* gen. n.
- Body lacking longitudinal cuticular grooves, tail mucro not so ..... *Chronogaster* Cobb, 1913

## DESCRIPTIONS

### *Rugoster* gen. n.

**Diagnosis.** Chronogastrinae, Chronogastridae. With the characters of Chronogastridae as given above. Cuticle strongly annulated, with longitudinal folds, grooves and/or ridges from head to near tail tip dividing the surface into minute blocks. Cephalic setae four, over 3  $\mu\text{m}$  long. Labial sensilla not raised above body surface. Amphidial fovea cyathiform, usually with oval slit-like aperture, 1-3 annules behind cephalic region. Stoma elongate-tubular, short, less than two head-widths in length. Oesophagus typical of the family, anteriorly with feeding expansion chamber with prominent loop-like radial canals and posteriorly with a bulb having gizzard with several longitudinal rows of denticles 6-9 in each row, and posteriorly with stem-like extension merging with cardia. Excretory pore distinct, a little behind nerve ring; excretory duct leads inward then backward to the renette cell that lies close to the basal oesophageal bulb. Cardia cylindroid, conoid-rounded posteriorly, about as long as oesophageal bulb extension; intestine attached to the cardia.

Gonad single, prodelphic; a short postvulval uterine sac present. Vulva a transverse slit or an irregular pore. Ovary with less than 15 oocytes, antidromously reflexed. Uterus sac-like. Spermatheca not formed. Rectum 1-2 anal body-widths long. Tail elongate-conoid to filiform, similar between sexes. Caudal glands and terminal spinneret absent. Male not known.

**Etymology:** The generic name is derived from rugose, rugae, having wrinkles, folds and rugged surface, referring to the surface of cuticle, and suffix, with the last four letters, of *Chronogaster* to which it is closely related. The genus is feminine in gender.

**Type species:** *Rugoster magnifica* (Andrássy, 1956) gen. n., comb. n.

Syn. *Chronogaster magnifica* Andr ssy, 1956.

#### Other species:

*Rugoster colbrani* gen. n., sp. n.

*Rugoster neomagnifica* gen. n., sp. n.

*Rugoster orientalis* gen. n., sp. n.

*Rugoster recisa* gen. n., sp. n.

*Rugoster regalia* gen. n., sp. n.

*Rugoster tessellata* (Mounport, 2005) gen. n., comb. n.

Syn. *Chronogaster tessellata* Mounport, 2005

*Rugoster virgata* gen. n., sp. n.

**Remarks.** Gerlach (1956) described a new marine nematode species *Chronogaster alata* having longitudinal cuticular ridges but which lacks denticulate gizzard in oesophageal bulb and 4 hook-like spines on tail terminus. Hence it is not considered to belong in the new genus *Rugoster*.

*Adelonema camerunense* Holovachov & Sturhan, 2003

also has a strongly annulated cuticle bearing longitudinal ridges, and four cephalic setae, tubular stoma, monodelphic gonad with postvulval uterine sac and elongate conoid tail with a simple terminal mucro. It lacks a feeding pump chamber, gizzard of the oesophagus and hook-like spines on the mucro, so does not belong in the Chronogastridae.

The six new species of *Rugoster* gen. n. are described below.

### 1. *Rugoster recisa* gen. n., sp. n.

(Fig. 1, A-I; 1a, A-G)

#### Measurements

**Holotype female:** L=0.62 mm; a=30.8; b=3.6; c=8.3; c'=5.7; V=57.7; longitudinal cuticular grooves=26; Roes=65; Rex=43; Rtail=55.

**Paratype females (n=25):** L=0.52-0.65 (0.6) mm; a=22-30 (26); b=3.5-4.3 (3.7); c=6.5-8.5 (7.6); c'=5.5-6.5 (6.0); V=56-59 (57); longitudinal cuticular grooves=26-30 (28); Roes=55-75 (64); Rex=38-44 (42); Rtail=48-59 (55).

**Female:** Body rather robust, cylindroid tapering anteriorly from feeding pump chamber to small low, rounded head and more so behind anal region, slightly arcuate ventrally when relaxed (Fig. 1, A). Maximum body width 21-25 (22.5)  $\mu\text{m}$  (Maximum body width not measured at swollen regions at mature oocytes and eggs, this is true for all other species). Cuticle moderately thick, strongly annulated; annules measuring 2.4-3.0  $\mu\text{m}$ , 1.8-2.5  $\mu\text{m}$  and 1.8-2.0  $\mu\text{m}$  wide at mid-oesophagus, mid-body and rectum region, respectively. There are 26-30 longitudinal cuticular grooves along the entire body length except the extremities, giving the surface a tessellated appearance, which together with transverse cuticular grooves divide the cuticle surface into minute blocks which are squarish or rectangular (Fig. 1, E; 1a, E). Body pores, setae, lateral fields, or crystalloids not seen. Cephalic region smooth, unstriated, continuous with body contour, about two adjacent body annules high, anteriorly round to truncate with central oral depression seen slightly shifted from centre in lateral specimens, and with straight to concave outer margins. Labial sensilla indistinct, papilla- or pore-like. Cephalic setae four, originating near base of cephalic region, pointing forward and not clearly projecting outside cephalic contour, 2.5-3.5  $\mu\text{m}$  long. Amphidial apertures about 2-2.5  $\mu\text{m}$  long slit-like between first and second body annule behind cephalic region.

Stoma almost cylindroid except for short conoid cheilostom and telostom, 11-14  $\mu\text{m}$  or about two head-widths long and 2.3-3.0  $\mu\text{m}$  wide; its wall not sclerotized except for pro-mesostom which is slightly more thickened; metastom about as long as pro-mesostom (Fig. 1, B, C). Oesophagus cylindroid, muscular except for about two-and-a-half stoma lengths behind stoma until radial canals become widened and conspicuous for a short region which is distinct, very muscular and highly expandable. Anteriorly the radial canals are loop-like and widened and posteriorly they taper and merged with the axial lining of oesophageal lumen. This region is here called the feeding pump chamber (Fig. 1, B).

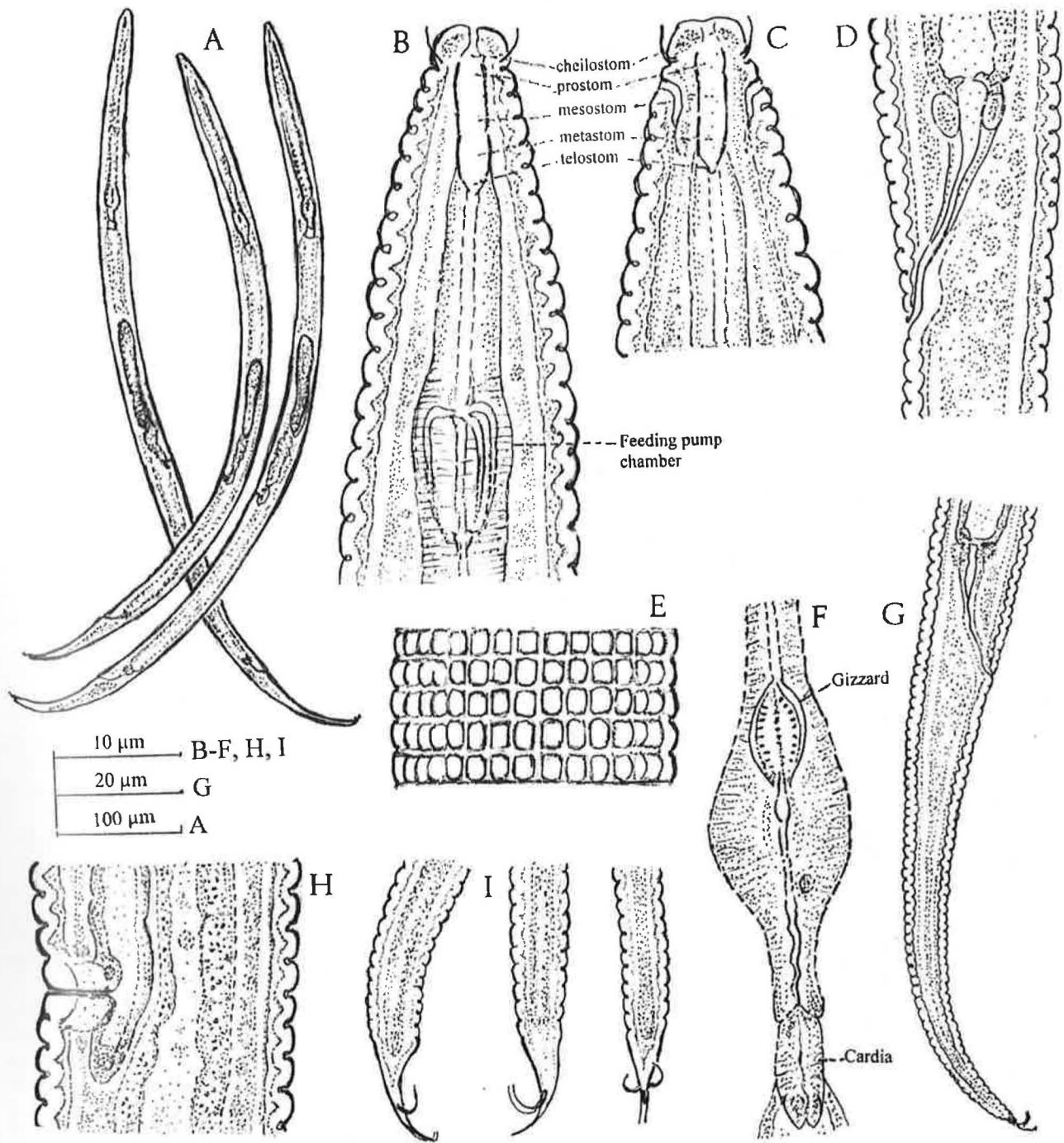
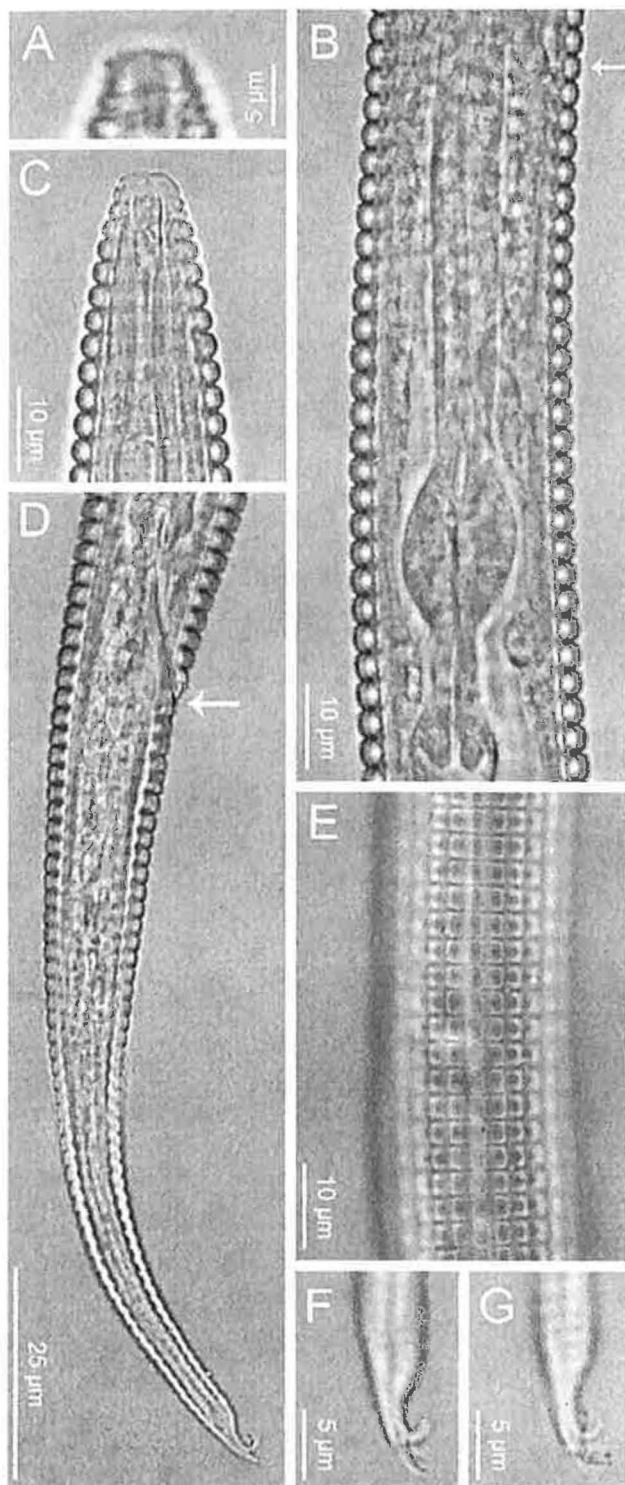


Fig. 1. A-I. *Rugoster recisa* gen. n., sp. n. Females. A. Three mature adults. B, C. Anterior ends of body. D. Anal region. E. Cuticle surface pattern at mid-body. F. Basal oesophageal bulb showing dilated masticatory gizzard and cardia projecting into intestine. G. Tail. H. Vulva region. I. Tail ends showing mucro with hook-like spines.



**Fig. 1a.** A-G. *Rugoster recisa* gen. n., sp. n. Females. A. Head showing setae. B. Oesophageal region, arrow pointing to excretory pore. C. Head. D. Tail with arrow pointing to anal area. E. Cuticle surface pattern at mid-body. F, G. Tail terminus showing mucro and its hook-like spines.

It is situated at 10-12 (11) annules behind cephalic region, 16-19  $\mu\text{m}$  and 27-32 (29)  $\mu\text{m}$  from stoma and head end, respectively. It extends over 4-5 body annules and measures 9-16  $\mu\text{m}$  long, 6-8  $\mu\text{m}$  wide, and is continued with the long slender muscular oesophageal tube that ends in a large basal bulb. Basal oesophageal bulb oval, 14-17 (15.5)  $\mu\text{m}$  long and 8-11 (9.5)  $\mu\text{m}$  wide. It has in its anterior half and slightly protruding into the narrower slender part of oesophagus an oval, 7-9  $\mu\text{m}$  long, 3-5  $\mu\text{m}$  wide at middle, a rasp-like masticatory organ with longitudinal rows of 7-9 denticles in each row (there may be 9 rows on the dorsal and two ventrolateral sectors). Herein it is called the gizzard (Fig. 1, F). A short 6-8 (7)  $\mu\text{m}$  long cylindroid extension of the basal bulb present, joining with the cylindrical 5.5-9  $\mu\text{m}$  long cardia with conoid posterior end projecting into intestinal lumen; intestine attached to middle of cardia (Fig. 1, F; 1a, B). Total oesophageal length 150-173 (164)  $\mu\text{m}$ . Oesophageal glands and their ducts and outlets could not be seen with certainty. Possibly the gland nuclei are within the bulb or its posterior extension and the gland orifices, at least those of ventrolateral glands, lie within the bulb behind the gizzard. Some authors have depicted the dorsal gland opening at mid-way between stoma and radial canals, but it is uncertain. Nerve ring a broad band encircling oesophagus at 78-93 (83)  $\mu\text{m}$  from anterior end of body. Excretory pore on 38-44<sup>th</sup> (42<sup>nd</sup>) annule from cephalic region, 102-114 (108)  $\mu\text{m}$  from head end, leading to a distinct long excretory duct that leads inward then backward to the renette cell that lies just anterior to basal oesophageal bulb (Fig. 1a, B).

Gonad monodelphic, prodelphic, with a short (6-7  $\mu\text{m}$ ) narrow postvulval uterine sac about one-third of body width long. Vulva pore-like with irregular margins, in a ventral depression in body wall, located at 300-375 (355)  $\mu\text{m}$  from head and 233-277 (259)  $\mu\text{m}$  from tail end. Vagina about one-third as long as body width, walls thick but not sclerotized (Fig. 1, H). Uterine egg 80 $\times$ 20  $\mu\text{m}$ .

Intestine made up of large cells which number 3-4 in a circumference containing few small-sized granules, with distinct lumen throughout. Rectum oblique to body axis, 18-24 (20)  $\mu\text{m}$  or 1.7-2.0 anal body diameters long, dilated in proximal half. Anus a large oval pore facing backward and outward, occupying about two-fifths of corresponding body diameter, located at 160-197 (176)  $\mu\text{m}$  behind the vulva.

Tail robust, regularly tapering, slightly arcuate ventrally in its distal two-thirds, 71-86 (78)  $\mu\text{m}$  or 5.5-6.5 (6) anal body-widths long; tail annules distinct, 48-59 (55), being slightly less than those in oesophageal region; anal body width 12-15  $\mu\text{m}$  (Fig. 1, G; 1a, D). Tail mucro strongly developed, stem-like, 6.5-8.5 (7)  $\mu\text{m}$  long, with a pair of lateral hooked spines directed posteriorly at about its two-thirds length, and a pair of more slender, close to each other terminal spines with tip slightly curved hook-like (Fig. 1, I; 1a, F, G). Thus there are four spines on a rod-like mucro and this provides a good character for the generic differentiation.

Several similar general comments and details about

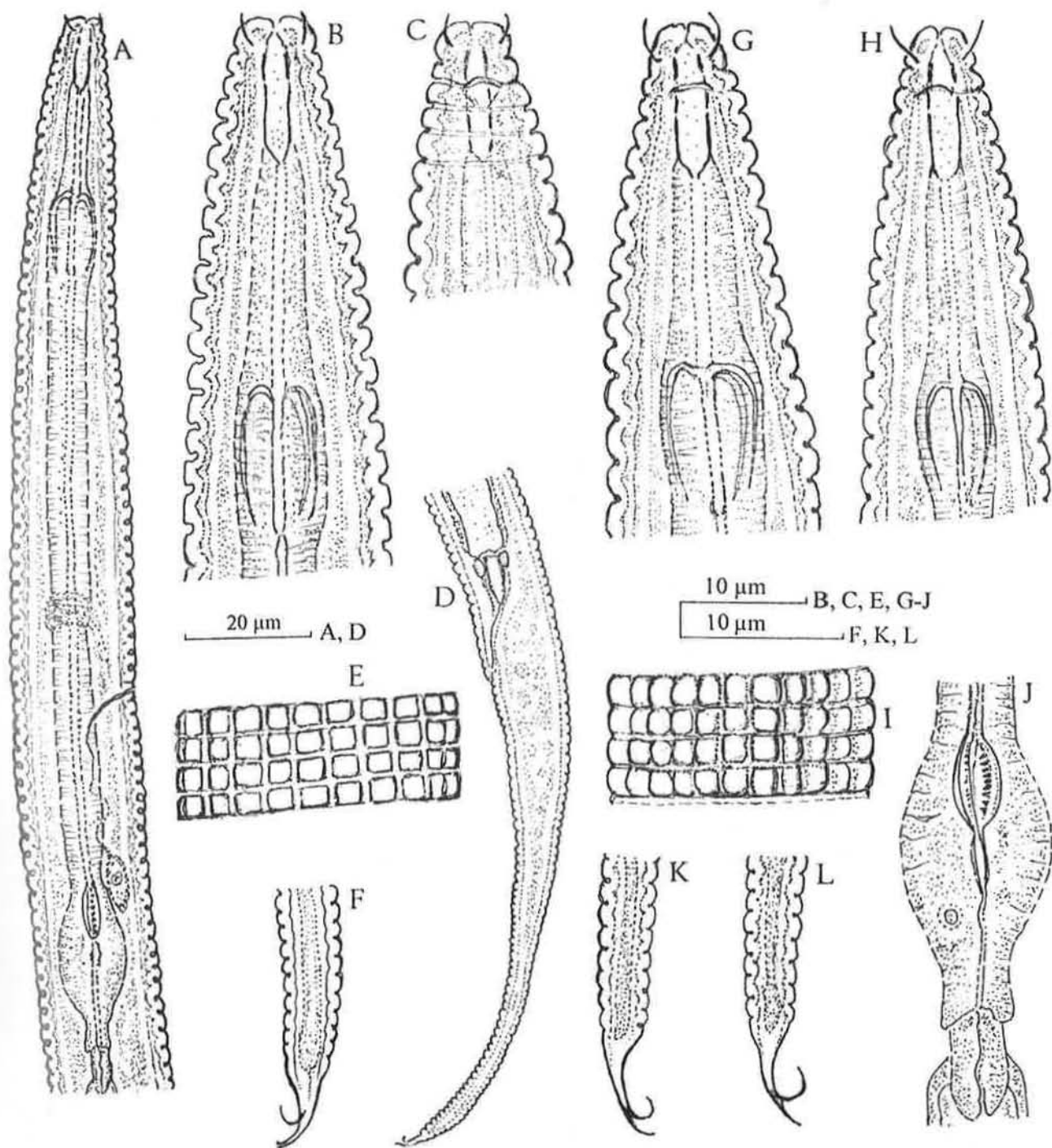


Fig. 2. A-F. *Rugoster orientalis* gen. n., sp. n. G-L. *Rugoster virgata* gen. n., sp. n. Females. A. Oesophageal region. B, G, H. Anterior ends of body showing head, amphidial aperture, stoma and feeding pump chamber with distinct radial canals. C. Anterior end showing amphidial fovea. D. Tail. E, I. Cuticular surface patterns at mid-body. J. Basal oesophageal bulb showing masticatory gizzard and cardia projecting into intestine. F, K, L. Tail ends showing mucro with hook-like spines.

various morphological characters common between other species, for example, about the feeding pump chamber, the gizzard, cardia, oesophageal glands and mucro, will henceforth not be repeated in descriptions of other species unless warranting further information and explanation.

**Male:** Not found.

**Juveniles:** Similar to adult female in general morphology except for smaller size and lacking reproductive organs. Because we have found only a few juveniles and not in all species, we did not compare them and their descriptions will be omitted from this report.

**Type habitat and locality:** Soil around roots of grasses and weeds in experimental plots of the International Institute of Agriculture (IITA), Ibadan, Nigeria.

**Type specimens:** Collected by Dr Fields E. Caveness in 1984 and sent as fixed whole extracts of samples to the first author. Holotype female and 10 paratype females deposited in the UK Nematode Collection, Sand Hutton, England, 5 paratype females are in each of these nematode collections: the USDA Nematode Collection, Beltsville, MD, USA; IARI Collection at New Delhi, India and M. R. Siddiqi's Collection at Luton, England.

**Etymology:** The species name is derived from Latin *recedere* meaning to recede, and refers to its comparatively short body, cephalic setae and tail.

**Differential diagnosis and relationship:** *Rugoster recisa* gen. n., sp. n. has short body ( $L=0.52-0.65$  (0.6) mm), cephalic setae 2.5-3.5  $\mu\text{m}$  long, vulva located at 56-59 (57) per cent of body length, tail 71-86 (78)  $\mu\text{m}$  long and large terminal mucro (6.5-8.5 (7)  $\mu\text{m}$  long). In having over 25 longitudinal cuticular grooves it comes close to *R. tessellata* (Mounport, 2005) comb. n. from which it can be differentiated by its smaller body size (vs. 0.714 (0.629-0.771) mm), lesser number of longitudinal cuticular grooves (vs. 40) and shorter tail (vs. 91 (78-104)  $\mu\text{m}$  long tail in *R. tessellata*).

## 2. *Rugoster orientalis* gen. n., sp. n.

(Fig. 2, A-F)

### Measurements

**Holotype female:**  $L=0.635$  mm;  $a=28.2$ ;  $b=3.94$ ;  $c=7.55$ ;  $c'=6$ ;  $V=57.3$ ; longitudinal cuticular grooves=20; Roes=67; Rex=40; Rtail=65.

**Paratype female (n=4):**  $L=0.60-0.64$  (0.623) mm;  $a=27.8-31.7$  (29.6);  $b=3.63-3.87$  (3.73);  $c=7.2-7.8$  (7.4);  $c'=6-7$  (6.4);  $V=56.5-58.5$  (57.5); longitudinal cuticular grooves =18-20; Roes=65-71 (68.3); Rex=39-44; Rtail=56-68 (64).

**Female:** Body cylindrical, slightly arcuate ventrally, attenuated in tail distal half; maximum body width 20-23  $\mu\text{m}$ . Cuticle about 3  $\mu\text{m}$  thick, with prominent annules and transverse and longitudinal cuticular grooves; latter 18-20 in number, reducing towards extremities (Fig. 2, E). Annules measuring 2.5-2.7  $\mu\text{m}$ , 2.0-2.3  $\mu\text{m}$  and 1.7-1.9  $\mu\text{m}$  wide at opposite mid-oesophagus, mid-body and rectum region,

respectively. Cephalic region hemispheroidal with straight to convex outer margins and a terminal oral depression. Cephalic setae 3-3.5  $\mu\text{m}$  long, projecting forward. Amphidial apertures transversely oval, 3  $\mu\text{m}$  long, located between first and second body annule behind cephalic region (Fig. 2, C).

Stoma 10.5-11.5 (11)  $\mu\text{m}$  long, 2-3  $\mu\text{m}$  wide; its promesorhabdions slightly sclerotized (Fig. 2, B). Oesophagus 163-170 (167)  $\mu\text{m}$  long. Feeding pump chamber 7.5-12 $\times$ 5-7  $\mu\text{m}$ , located at 28-29  $\mu\text{m}$  from anterior end or 11-12 annules behind cephalic region. Oesophageal bulb oval, 16-17 $\times$ 10-11  $\mu\text{m}$ ; its extension 6-9  $\mu\text{m}$  long. Gizzard elongate-oval, 9-10  $\mu\text{m}$  long, anterior to centre of oesophageal bulb and slightly extending into corpus, with 8-9 denticles in a row. Cardia 7-9  $\mu\text{m}$  long. Excretory pore 107-110  $\mu\text{m}$  and nerve ring 93-98  $\mu\text{m}$  from anterior end of body; renette near distal end of basal oesophageal bulb (Fig. 2, A).

Gonad monodelphic, prodelfic, with a reflexed ovary comprising of 7-9 oocytes. Uterus thin-walled. Postvulval uterine sac 7-8  $\mu\text{m}$  long. Vulva located at 335-370 (358)  $\mu\text{m}$  and 258-275 (267)  $\mu\text{m}$  from head end and tail end, respectively.

Rectum with wide lumen proximally, 18-20  $\mu\text{m}$  long; anal body width 12-14  $\mu\text{m}$ . Anus located at 175-190 (181)  $\mu\text{m}$  behind vulva. Tail regularly tapering, ventrally arcuate, with a slight depression dorsally behind its middle, 82-85 (83)  $\mu\text{m}$  or 5.6-7.7 times anal body width long (Fig. 2, D). Tail mucro well developed with 4 hooked spines, anterior pair arising near its middle and pointing backwards, 6-7  $\mu\text{m}$  long (Fig. 2, D, F).

**Male:** Not found.

**Type habitat and locality:** Soil around roots of rice (*Oryza sativa* L.) near Agartala in Tripura State, northeastern India.

**Type specimens:** Collected in 1993. Holotype female and a paratype female deposited in the UK Nematode Collection, Sand Hutton, England; one paratype female is deposited in each of these collections: the USDA Nematode Collection, Beltsville, MD, USA, IARI Collection at New Delhi, and M. R. Siddiqi's Collection at Luton, England.

**Etymology:** The species name is derived from Latin *oriens* meaning rising (of the sun) and eastern or pertaining to east.

**Differential diagnosis and relationship:** *Rugoster orientalis* gen. n., sp. n. has a small body 0.60-0.64 mm, 18-20 longitudinal cuticular grooves, 3-3.5  $\mu\text{m}$  long cephalic setae, 10.5-11.5  $\mu\text{m}$  long stoma, Roes=65-71, Rtail=56-68, vulva located at 56.5-58.5 (57.5) per cent of body length and tail 82-85 (83)  $\mu\text{m}$  long. In having a small body size and 18-20 longitudinal cuticular grooves it comes close to *R. virgata* gen. n., sp. n. but differs in having smaller cephalic setae (vs. 3.5-4.5  $\mu\text{m}$ ), smaller and narrower stoma (vs. 11.5-12.5 (12)  $\mu\text{m}$  long, 3-3.5  $\mu\text{m}$  wide), a more posterior vulva (vs.  $V=51-55$  (53)) and a smaller tail (vs. 98-130 (116)  $\mu\text{m}$  or 8-11 anal body-widths long in *R. virgata*). It differs from *R. magnifica* (Andrássy, 1956) gen. n. comb. n. in having a smaller body,



cephalic setae and tail, a shorter distance between feeding pump chamber and anterior end of body, and smaller numbers of oesophageal and tail annules.

### 3. *Rugoster virgata* gen. n., sp. n.

(Fig. 2, G-L; 2a, A-G)

#### Measurements

**Holotype female:** L=0.71 mm; a=31.5; b=3.98; c=6.96; c'=7.8; V=55; longitudinal cuticular grooves=18; Roes=66; Rex=43; Rtail=65.

**Paratype females (n=7):** L=0.67-0.76 (0.72) mm; a=30-34 (32); b=3.8-4.3 (3.96); c=5.9-7.0 (6.2); c'=8-11 (9.4); V=51-55 (53); longitudinal cuticular grooves=18-22 (20); Roes=63-77 (68); Rex=39-45 (42); Rtail=66-82 (77).

**Female:** Body slender (a=30-34), slightly arcuate ventrally; maximum width 22-24  $\mu$ m. Cuticle 3  $\mu$ m thick, with prominent annules separated by transverse grooves; longitudinal cuticular grooves 18-22 in number reducing towards extremities (Fig. 2, I; 2a, E). Annules measuring 2.6-3.0  $\mu$ m, 2.3-2.7  $\mu$ m and 2.0-2.4  $\mu$ m wide at mid-oesophagus, mid-body and rectum, respectively. Cephalic region rather elevated, trapezoid with straight to concave sides, anteriorly rounded to flattened (Fig. 2, g, H; 2a, C), 3.5-4.0  $\mu$ m high and 6-7.2  $\mu$ m wide at base. Cephalic setae thin, 3.5-4.5  $\mu$ m long, projecting outward and forward. Amphidial apertures 3-3.5  $\mu$ m long oval transverse slits, located on anterior margin of second annule from cephalic region (Fig. 2, G, H).

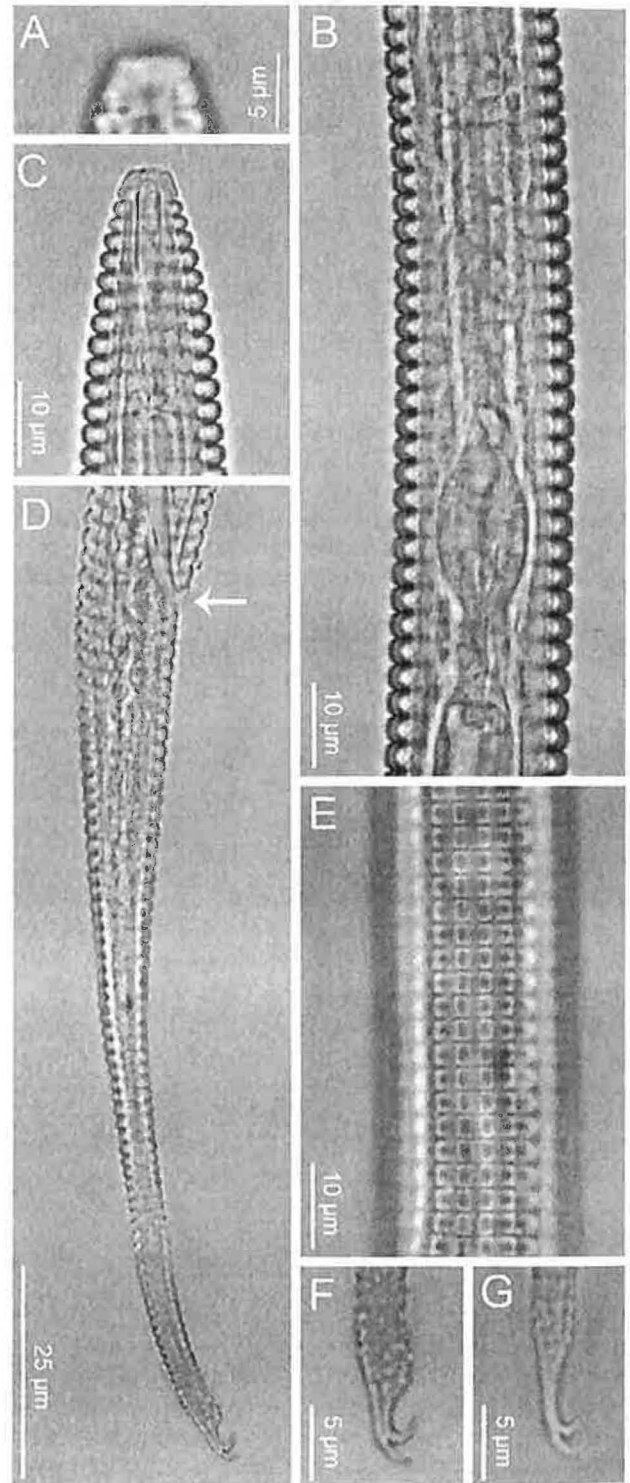
Stoma 11.5-12.5 (12)  $\mu$ m long, 3-3.5  $\mu$ m wide; its promesothorax slightly sclerotized. Oesophagus 165-193 (177)  $\mu$ m long. Its feeding pump chamber about 10-13 $\times$ 6-8  $\mu$ m, located at 28-32 (30)  $\mu$ m from anterior end or 10-12 annules behind cephalic region (Fig. 2, G, H). Oesophageal bulb oval, 17-18 $\times$ 10-12  $\mu$ m; its extension 7-8  $\mu$ m long, about 5  $\mu$ m wide. Gizzard 6-7  $\mu$ m long, with 7-9 denticles in each row, located in anterior half of bulb (Fig. 2, J). Cardia 6-7  $\mu$ m long, 4-6  $\mu$ m wide. Excretory pore 106-113 (108)  $\mu$ m from head end, 14-18  $\mu$ m behind anterior margin of nerve ring. Distance from oesophagus to vulva 185-220 (203)  $\mu$ m.

Gonad monodelphic, prodelphic, with a short postvulval sac just under one-third of body width long. Ovary reflexed antidromously, with 7-9 oocytes, on right side of intestine; its terminal portion extending on dorsal side of uterus. Vulva located at 385-410 (394)  $\mu$ m and 285-365 (333)  $\mu$ m from head end and tail end, respectively. Uterine egg 80 $\times$ 20  $\mu$ m.

Rectum 20-23  $\mu$ m or 1.2-1.6 times anal body width long. Anus located at 185-228 (198)  $\mu$ m behind vulva. Tail regularly tapering, slightly arcuate ventrally, 98-130 (116)  $\mu$ m or 8-11 (9.4) anal body-widths long. Tail mucro strongly developed, 7-8.5  $\mu$ m long, with two hook-like spines at about two-thirds of its length and a pair of fine hooked terminal spines (Fig. 2, K, L; 2a, F, G).

**Male:** Not found.

**Type habitat and locality:** Soil around roots of rice (*Oryza sativa* L.) in Togo, West Africa. Also collected from rice soil in Guinea and bush soil in Nigeria.



**Fig. 2a.** A-G. *Rugoster virgata* gen. n., sp. n. Females. A. Head showing setae. B. Oesophageal region. C. Head end. D. Tail with arrow showing anal area. E. Cuticle surface pattern at mid-body. F-G. Tail terminus showing hook-like spines.

**Type specimens:** Holotype female and four paratype females deposited in the UK Nematode Collection, Sand Hutton, England; one paratype female is deposited in each of these collections: the USDA Nematode Collection, Beltsville, MD, USA, IARI Collection at New Delhi, India and M. R. Siddiqi's Collection at Luton, England.

**Etymology:** The species name *virgata* is a declension from the Latin word *virgatus* meaning thin long rods, referring to the longitudinal ridges of body cuticle, well separated from each other.

**Differential diagnosis and relationship:** *Rugoster virgata* gen. n., sp. n. has body 0.67-0.76 (0.72) mm long, trapezoid head, 4-5  $\mu\text{m}$  or about two adjacent body annules high, cephalic setae 3.5-4.5  $\mu\text{m}$  long, 18-22 (20) longitudinal cuticular grooves, oesophagus 165-193 (177)  $\mu\text{m}$  long, vulva at 51-55 (53) per cent of body, Roes=63-77 (68); Rtail=65-82 (77), and tail 98-130 (116)  $\mu\text{m}$  long. In having 18-22 longitudinal cuticular grooves, it comes close to *R. magnifica* (Andrássy) comb. n. and *R. orientalis* sp. n. It differs from *R. magnifica* in having smaller body under 0.8 mm long (vs. 9 mm or more) and smaller cephalic setae, oesophagus and tail. Its differences from *R. orientalis* are given under the latter's differential diagnosis and relationship.

### 3. *Rugoster colbrani* gen. n., sp. n.

(Fig. 3, A-E; 3a, A-F)

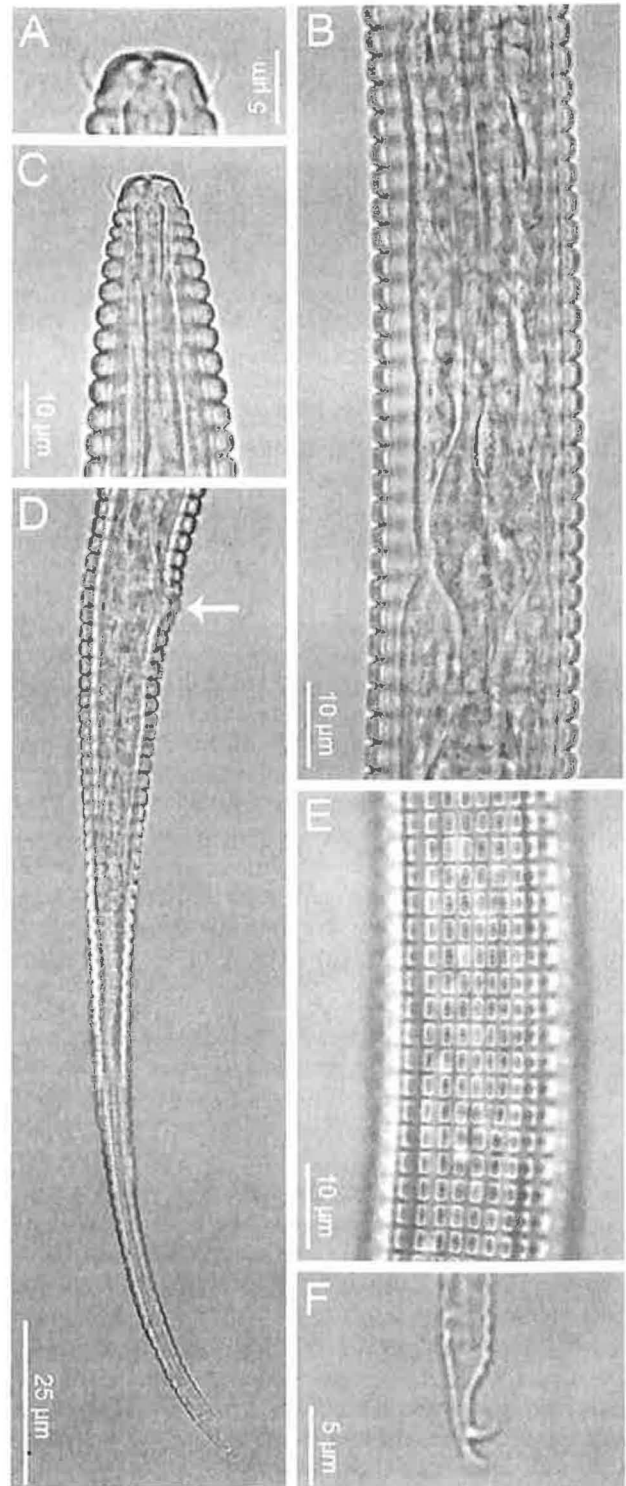
#### Measurements

**Holotype female:** L=0.89 mm; a=42.3; b=4.2; c=6.8; c'=8.9; V=54.4; longitudinal cuticular grooves=24; Roes=65; Rex=42; Rtail=63.

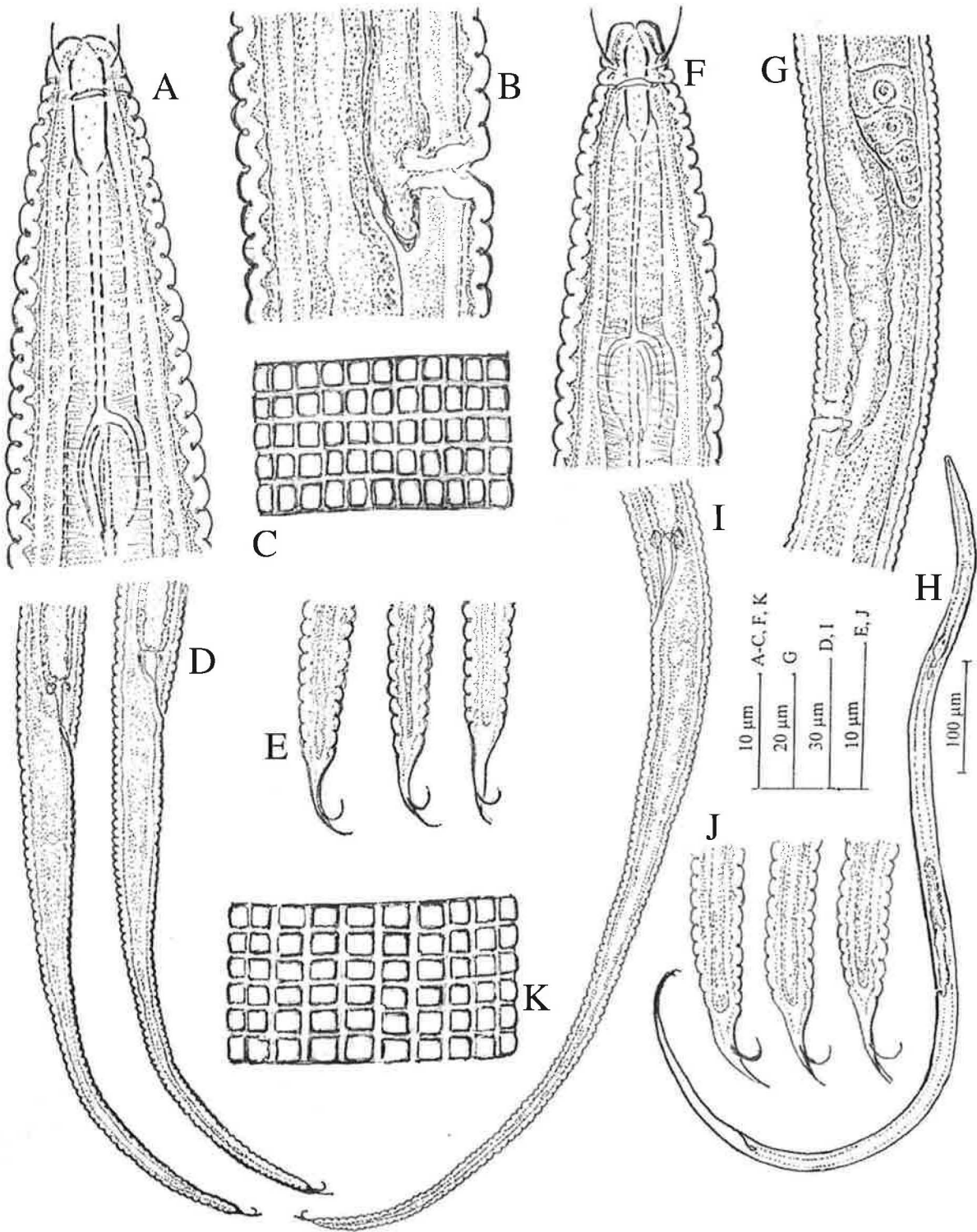
**Paratype females (n=3):** L=0.84-0.90 (0.86) mm; a=37-43 (38.5); b=4.2-4.4 (4.3); c=6.8-7.2 (6.9); c'=8.9-10.0 (9.56); V=53-55 (53.8). longitudinal cuticular grooves=24; Roes=64-65; Rex=40-43; Rtail=62-66.

**Female:** Body slender (a=37-43), slightly arcuate ventrally, more so in tail region upon relaxation, tapering anteriorly from mid-oesophagus to cephalic region which becomes 5-6  $\mu\text{m}$  at its widest near base; posteriorly from a little anterior to rectum to small rounded tip provided with 7-8  $\mu\text{m}$  long mucro bearing 4 hooked spines. Maximum body width 21-23  $\mu\text{m}$ . Cuticle moderately thick, strongly annulated; annules measuring 3.2-3.4  $\mu\text{m}$ , 2.7-3.0  $\mu\text{m}$  and 2.5-2.9  $\mu\text{m}$  wide at opposite mid-oesophagus, mid-body and rectum, respectively. Longitudinal cuticular grooves and transverse grooves divide the cuticle surface into minute blocks which are longer than wide, 24 blocks per annule on most of body (Fig. 3, C; 3a, E). Thus there are 24 longitudinal grooves on most of body. Cephalic region rather hemispheroidal with convex to straight outer margins, about two adjacent body annules high. Cephalic setae pointing outwardly and anteriorly, measuring 4.5-5.0  $\mu\text{m}$  (Fig. 3, A; 3a, A, C). Amphidial apertures rather indistinct 3-3.5  $\mu\text{m}$  long slits, at the anterior margin of second body annule.

Stoma almost cylindroid except for cheilostom which is



**Fig. 3a.** A-F. *Rugoster colbrani* gen. n., sp. n. Females. A. Head showing setae. B. Oesophageal region. C. Head. D. Tail with arrow showing anal area. E. Cuticle surface pattern at mid-body. F. Tail terminus showing hook-like spines.



**Fig. 3.** A-E. *Rugoster colbrani* gen. n., sp. n. F-K. *Rugoster regalia* gen. n., sp. n. Females. A, F. Anterior ends of body showing head, amphidial aperture, stoma and feeding pump chamber with distinct radial canals. B. Vulva region. C, K. Cuticle surface pattern at mid-body. D, I. Tails. E, J. Tail ends showing mucro with hook-like spines. G. Reproductive organs. H. Entire body.

conoid, 11.5-12.5  $\mu\text{m}$  long, 3-3.5  $\mu\text{m}$  wide; its walls not sclerotized except for pro-mesostom which is slightly more thickened. No buccal armature. Feeding pump chamber with prominent radial canals, 12-13  $\mu\text{m}$  long and 8-8.5  $\mu\text{m}$  wide and located at 34-37  $\mu\text{m}$  from anterior end, 11-12 annules behind cephalic region (Fig. 3, A). Oesophagus weakly muscular for about two stoma lengths, then it becomes broader and strongly muscular up to the basal bulb, 193-210 (202)  $\mu\text{m}$  long. Excretory pore 120-130 (126)  $\mu\text{m}$  from anterior end of body, 12-16  $\mu\text{m}$  behind anterior margin of nerve ring. Hemizonid seen as 1.5  $\mu\text{m}$  wide transparent band, one annule anterior to excretory pore.

Gonad monodelphic, prodelphic, with a short narrow postvulval uterine sac. Vulva small circular with irregular margins, 453-495 (477)  $\mu\text{m}$  and 395-415 (406)  $\mu\text{m}$  from head end and tail end, respectively. Vagina thick-walled, about one-third of body width long (3, B).

Rectum 22-24  $\mu\text{m}$  or 1.5-1.8 anal body-widths long, with three glands at its proximal end. Anus flush with body contour, situated at 265-290 (278)  $\mu\text{m}$  behind vulva. Anal body width 13-15  $\mu\text{m}$ . Tail regularly tapering, more so in posterior half (Fig. 3, D; 3a, D), 122-130 (125)  $\mu\text{m}$  or about 9-10 anal body-widths long. Tail annules 62-66 in number, about as many as the oesophageal annules. Tail terminal mucro large, 7.5-8.5  $\mu\text{m}$  in length (Fig. 3, E; 3a, F).

**Male:** Not found.

**Type habitat and locality:** Soil around roots of weeds in Beerwah Forest in an area devoid of trees, about 200 miles from Brisbane, Queensland, Australia.

**Type specimens:** Collected in Australia in 1983. Holotype female and a paratype female deposited in the UK Nematode Collection, Sand Hutton, England, a paratype female is in the USDA Nematode Collection, Beltsville, MD, USA, and in M. R. Siddiqi's Collection at Luton, England.

**Etymology:** The species name is a patronym honouring Dr R. C. Colbran, a well-known Australian nematode taxonomist who helped the senior author in 1983 to collect nematode samples for study from Beerwah Forest in Queensland, which yielded this new species.

**Differential diagnosis and relationship:** *Rugoster colbrani* gen. n., sp. n. is recognized by its body 0.84-0.90 (0.86) mm long,  $a=37-43$ ,  $c=6.8-7.2$  (6.9), longitudinal cuticular grooves 24 in number, dividing the cuticle surface into blocks which are longer than wide, cephalic setae 4.5-5 long, feeding pump chamber of oesophagus 12-13  $\mu\text{m}$  long and 8-8.5  $\mu\text{m}$  wide, located 34-37  $\mu\text{m}$  from anterior end of body, vulva located at 53-55 per cent of body length, vulva-anus distance 265-290 (278)  $\mu\text{m}$ , tail 122-130 (125)  $\mu\text{m}$  and tail mucro 7.5-8.5  $\mu\text{m}$  long, and 62-66 tail annules. It comes close to *R. magnifica* (Andrássy) comb. n. but differs in having slightly smaller body, 24 longitudinal cuticular grooves and a shorter tail (vs. 152-170 (159)  $\mu\text{m}$  long). It differs from *R. neomagnifica* in having slightly longer body, higher 'a' and 'c' ratios, longer cephalic setae (vs. 3.5-4.5 (4)  $\mu\text{m}$ ) and

tail mucro and fewer tail annules (vs. 69-90 (78) tail annules in *R. neomagnifica*).

### 3. *Rugoster regalia* gen. n., sp. n.

(Fig. 3, F-K; 3b, A-G)

#### Measurements

**Holotype female:**  $L=0.95$  mm;  $a=39.5$ ;  $b=4.3$ ;  $c=5.43$ ;  $c'=12.5$ ;  $V=51.9$ ; longitudinal cuticular grooves=18;  $R_{ces}=89$ ;  $R_{ex}=59$ ;  $R_{tail}=106$ .

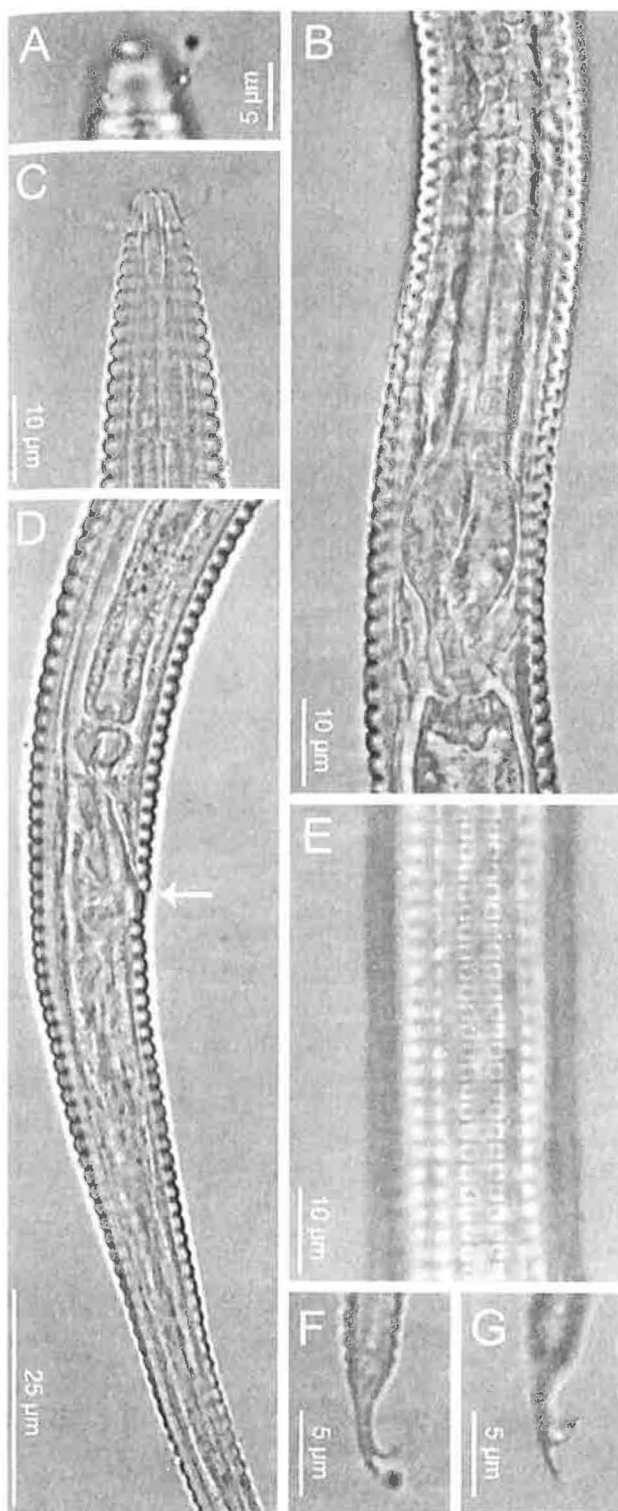
**Paratype female (n=4):**  $L=0.93-0.95$  (0.94) mm;  $a=39-42$  (40.5);  $b=4.0-4.9$  (4.4);  $c=5.1-5.4$  (5.25);  $c'=10.7-13.4$  (12.3);  $V=50.8-54.0$  (51.7); longitudinal cuticular grooves =18-20;  $R_{oes}=85-89$  (87);  $R_{ex}=53-59$  (56);  $R_{tail}=100-106$  (104).

**Female:** Body slender ( $a=39-42$ ), slightly arcuate anteriorly, more curved in posterior half; maximum body width 22-24  $\mu\text{m}$ . Cuticle 3-3.5  $\mu\text{m}$  thick, with prominent annules separated by transverse grooves; longitudinal cuticular grooves 18-20 in number (Fig. 3, K; 3b, E) reducing towards extremities. Annules measuring 2.5-2.8  $\mu\text{m}$ , 2.2-2.4  $\mu\text{m}$  and 1.8-2.0  $\mu\text{m}$  wide at mid-oesophagus, mid-body and rectum, respectively. Cephalic region elevated, trapezoid with straight to concave sides (Fig. 3, F; 3b, A, C), 4.8-5.0  $\mu\text{m}$  or three adjacent body annules high, about three quarters as high as wide and 6-6.5 (6.25)  $\mu\text{m}$  wide at base.

Cephalic setae thin, 5-6 (5.5)  $\mu\text{m}$  long, projecting outward and forward (Fig. 3, F; 3b, A, C). Amphidial apertures 3.5-4.0  $\mu\text{m}$  long, oval slits located behind the first body annule (Fig. 3, F). Stoma 10-11 (10.3)  $\mu\text{m}$  or 1.7-1.8 head-widths long, narrow tubular about 2.5  $\mu\text{m}$  wide; its pro-mesostom slightly sclerotized (Fig. 3, F). Oesophagus 200-220 (208)  $\mu\text{m}$  long. Its feeding pump chamber about 10 $\times$ 6  $\mu\text{m}$ , located at 28-29  $\mu\text{m}$  from anterior end or 11-12 annules behind cephalic region (Fig. 3, F). Oesophageal bulb oval, 20 $\times$ 12  $\mu\text{m}$ ; its extension 8-9  $\mu\text{m}$  long, 5-6  $\mu\text{m}$  wide. Gizzard elongate-oval, 6-7  $\mu\text{m}$  long, with 6-7 denticles in each row, located in anterior half of bulb. Cardia 7-8  $\mu\text{m}$  long, 5-6  $\mu\text{m}$  wide. Excretory pore 118-123  $\mu\text{m}$  and nerve ring 102-108  $\mu\text{m}$  from anterior end of body.

Gonad monodelphic, prodelphic, with a short postvulval uterine sac about one-third of body width long (Fig. 3, G). Ovary reflexed antidromously, with 7-9 oocytes, on right side of intestine. The terminal portion of mature ovary extending on dorsal side of uterus (Fig. 3, G). Vulva located at 473-496 (480)  $\mu\text{m}$  and 452-458 (455)  $\mu\text{m}$  from head end and tail end, respectively.

Rectum 20-23  $\mu\text{m}$  or about 1.5 times anal body width long, proximally with three rectal glands (Fig. 3, I; 3b, D). Anus located at 268-280 (275)  $\mu\text{m}$  behind vulva. Tail regularly tapering in its anterior third then thinning considerably to become 3-4  $\mu\text{m}$  in diameter a little anterior to mucro, slightly arcuate ventrally (Fig. 3, I), 167-183 (174)  $\mu\text{m}$  or about 11-13 anal body-widths long. Tail mucro elongate-slender, 7-8  $\mu\text{m}$  long, with two hook-like spines at slightly anterior to its middle and a pair of hooked terminal



**Fig. 3b.** *Rugoster regalia* gen. n., sp. n. A. Head showing setae. B. Oesophageal region. C. Head. D. Part of tail with arrow showing anal area. E. Cuticle surface pattern at mid-body. F, G. Tail terminus with large mucro and spines.

spines (Fig. 3, J; 3b, F, G).

**Male:** Not found.

**Type habitat and locality:** Soil around roots of rice (*Oryza sativa* L.) in Tirupati, Andhra Pradesh, southwestern India.

**Type specimens:** Holotype female and one paratype female deposited in the UK Nematode Collection, Sand Hutton, England; one paratype female is deposited in each of these collections: the USDA Nematode Collection, Beltsville, MD, USA, IARI Collection at New Delhi, and M. R. Siddiqi's Collection at Luton, England.

**Etymology:** The species name is derived from Latin *regalis* meaning regal, royal, because of its imposing head appearing crown-like.

**Differential diagnosis and relationship:** *Rugoster regalia* gen. n., sp. n. has females with body 0.93-0.95 mm long, 4.8-5.0 µm high trapezoid head, 5-6 µm long cephalic setae, 18-20 longitudinal cuticular grooves, oesophagus and tail measuring 200-220 (208) µm and 167-183 (174) µm long, respectively, and 7-8 µm long tail mucro. It comes close to *R. magnifica* (Andrássy) comb. n. but differs in having a trapezoid 4.8-5.0 µm high head (vs. head hemispheroidal, 3-4 µm high), shorter distance between anterior end of body and feeding pump chamber of oesophagus (34-35 µm long in *R. magnifica*), smaller oesophagus (vs. 245-257 (249) µm long) and longer tail mucro (vs. 5-7 (6) µm).

### 6. *Rugoster neomagnifica* gen. n., sp. n.

(Fig. 4, A-G; 4a, A-G)

#### Measurements

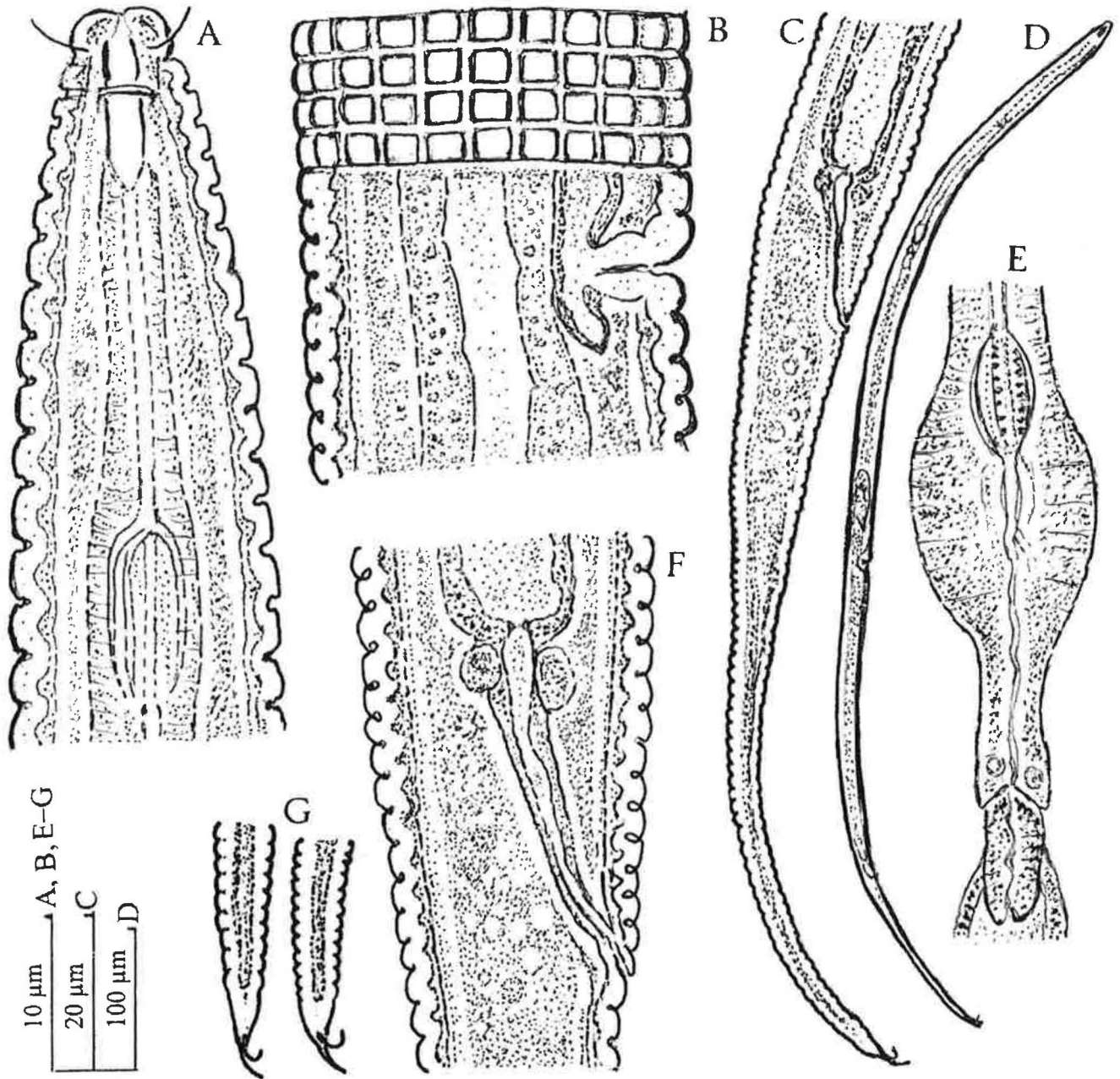
**Holotype female:** L=0.77 mm; a=32; b=4.2; c=6.3; c'=8.5; V=53.9; longitudinal cuticular grooves=26; Roes=71; Rex=44; Rtail=89.

**Paratype females (n=10):** L=0.70-0.84 (0.75) mm; a=29-36 (32); b=4.0-4.4 (4.2); c=5.9-6.7 (6.38); c'=8.5-10.5 (9.4); V=51-55 (53.4); longitudinal cuticular grooves=24-26 (25); Roes=65-74 (68); Rex=41-44 (42.3); Rtail=69-88 (78).

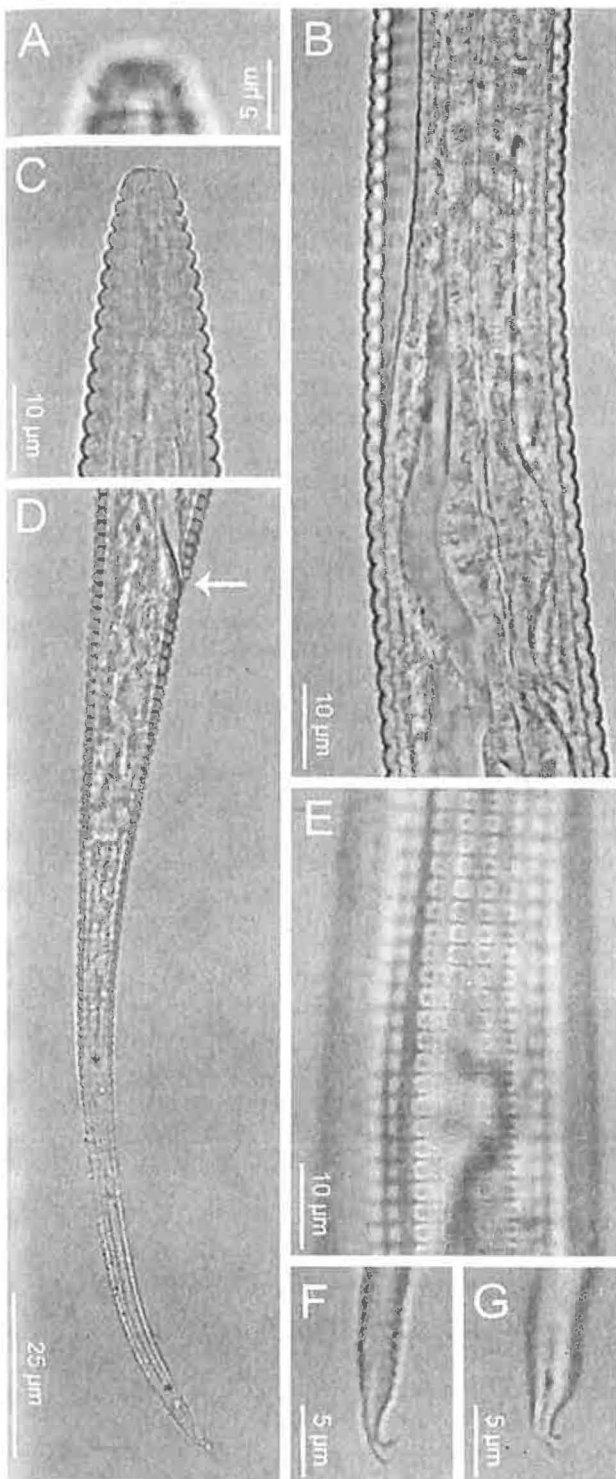
**Female:** Body slender (a=29-36), slightly arcuate ventrally, usually more so in tail region upon relaxation. Maximum body width 22-25 µm. Cuticle strongly annulated; annules measuring 2.8-3.0 µm, 2.5-2.7 µm and 2.0-2.3 µm wide at opposite mid-oesophagus, mid-body and rectum, respectively. Longitudinal cuticular grooves 24-26, giving the surface a tessellated appearance with minute block which are squarish (Fig. 4, B; 4a, E).

Cephalic region hemispheroidal or slightly truncate anteriorly, with straight to convex outer margins and a terminal oral depression. Cephalic setae projecting outward and pointing forward, measuring 3.5-4.5 (4) µm long. Amphidial apertures 2.5-3 µm long transversely oval slits on second annule. Stoma almost cylindroid except for cheilostom which is conoid, 12-12.5 µm long, 3-4 µm wide; its walls thickened but not sclerotized.

Oesophagus 175-190 (183) µm long. Feeding pump chamber with prominent radial canals, about 10-12 µm long



**Fig. 4.** A-G. *Rugoster neomagnifica* gen. n., sp. n. Females. A. Anterior end of body showing head, cephalic setae, amphidial aperture, stoma and feeding pump chamber with distinct radial canals. B. Vulva region showing vagina, postvulval uterine sac and cuticle surface pattern. C. Tail. D. Entire body. E. Basal oesophageal bulb showing masticatory gizzard, bulb extension and cardia projecting into intestine. F. Rectum region. G. Tail ends showing mucro with hook-like spines.



**Fig. 4a.** A-G. *Rugoster neomagnifica* gen. n., sp. n. Females. A. Head showing setae. B. Oesophageal region. C. Head end. D. Tail with arrow showing anal area. E. Cuticular ridges at mid-body. F, G. Tail terminus showing mucro and spines.

and 6.5-8 µm wide, located at 29-32 (30.5) µm from anterior end, 10-12 annules behind cephalic region (Fig. 4, A). Basal bulb oval, 18-21 µm long, 12-13 µm wide; bulb extension 7-8 µm long, gizzard oval, 7-8 µm long, 3-4 µm wide, with 7-8 denticles in each row (Fig. 4, E). Cardia cylindroid, 7-7.5 µm long. Excretory pore 108-112 (110) µm from anterior end of body, 10-15 µm behind anterior margin of nerve ring. Hemizonid not seen. Gonad monodelphic, prodelphic, with a short narrow postvulval uterine sac. Vulva oval, in a depression of body, 390-427 (412) µm and 315-375 (344) µm from head and tail end, respectively. No spermatozoa in genital tract. Uterine egg 85×21µm.

Rectum 19-22 µm or about 1.5 anal body-widths long. Vulva-anus distance 210-240 (225) µm. Anus flush with body contour. Tail elongate, regularly tapering (Fig. 4, C; 4a, D), 110-135 (118) µm or 8.5-10.5 anal body-widths long. Tail mucro 5-6 µm long, with two almost median and two terminal hook-like spines. (Fig. 4, G; 4a, F&G)

**Male:** Not found.

**Type habitat and locality:** Forest soil at Man, Ivory Coast.

**Type specimens:** Holotype female and four paratype females deposited in the UK Nematode Collection, Sand Hutton, England, two paratype females are in each of these collections: The USDA Nematode Collection, Beltsville, MD, USA; IARI Collection at New Delhi, and M. R. Siddiqi's Collection at Luton, England.

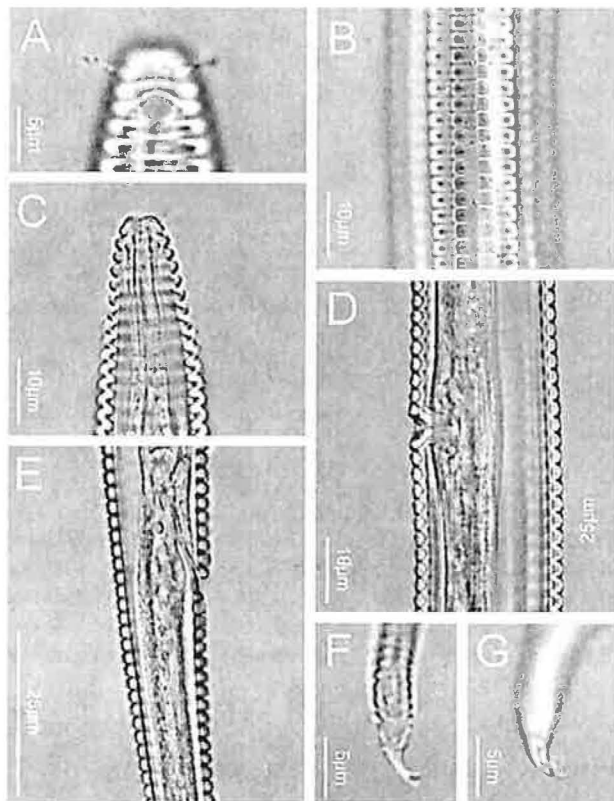
**Etymology:** The species name is Latin meaning 'new magnificent one'.

**Differential diagnosis and relationship:** *Rugoster neomagnifica* gen. n., sp. n. is recognized by its 0.70-0.84 (0.75) mm long body, 24-26 longitudinal cuticular grooves, feeding pump chamber at 29-32 µm from head end, 175-190 (183) µm long oesophagus, vulva at 51-55 (53.4) per cent of body length, vulva-anus distance 210-240 (225) µm, tail 110-135 (118) µm long bearing 69-83 (78) annules and 5-6 µm long terminal mucro. It comes close to *R. magnifica* (Andrássy) comb. n. and *R. colbrani* gen. n., sp. n. From *R. magnifica* it differs in having smaller body size, oesophagus, and tail and more longitudinal cuticular grooves. It can be differentiated from *R. colbrani* in having less coarse body annules, more tail annules, feeding pump chamber located more anteriorly at 29-32 µm from head end (vs. 34-37 µm) and a shorter vulva-anus distance (vs. 265-290 (278) µm).

### 7. *Rugoster magnifica* (Andrássy, 1956) gen. n., comb. n. (Fig. 5)

The type species of the genus *Rugoster* gen. n., *Chronogaster magnifica* (originally named as *magnificus*) was proposed and described by Andrássy in 1956) on the basis of one female and a juvenile from aquatic habitat at Adiopodoume near Abidjan, Ivory Coast. Its morphometrics and some morphological details after Andrássy (1956) are

as follows: ♀ L= 0.987 mm; a=44.4; b=4.4; c=6.1; V=54.3; annules 2.8 µm wide; longitudinal cuticular ridges=20-24; cephalic setae 4.5-4.8 µm long; stoma 11.7 µm in length; amphidial fovea stirrup-shaped, at anterior margin of second body annule.



**Fig. 5.** A-G. *Rugoster magnifica* (Andrássy, 1956) gen. n., comb. n. Females. A. Head showing setae and amphid. B. Cuticular ridges at mid-body. C. Anterior end of body. D. Vulva region. E. Anal region. F, G. Tail terminus showing mucro and spines.

*R. magnifica* has been reported and commented upon by Heyns and Coomans (1980), Raski and Maggenti (1984) and Abebe and Coomans (1996). There is a possibility, however, that these authors had a mixed population of more than one species, as we have encountered them from West Africa.

The species is here redescribed briefly based on specimens collected from aquatic habitats in West Africa including Ivory Coast, the type locality of the species. Morphometric details and measurements of the females, supported by photomicrographs to illustrate their morphological characters have been provided here. The measurements and morphological description of the present specimens fit well with the original description of *Chronogaster magnifica* Andrássy, and will help in establishing the true identity of the type species.

## Measurements

**Females** (n=5): (from Nigeria, Togo and Ivory Coast). L=0.90-0.98 (0.95) mm; a=38-42 (40); b=3.75-4.1 (3.9); c=6.0-6.5 (6.2); c'=10-13 (11.6); V=52-55 (53.5); longitudinal cuticular grooves=18-20; Roes=97-107 (101); Rex=52-57 (56); Rtail= 90-104 (95).

**Female:** Body after fixation more or less straight or slightly curved ventrally. Maximum body width 22-23 (22.5) µm. Cuticle thick, strongly annulated; annules measuring 2.3-2.6, 2.3-2.5, 2.0-2.2 µm wide at opposite mid-oesophagus, mid-body and rectum, respectively. Entire body except for extremities bearing well separated cuticular ridges giving the surface a lamellate appearance with rows of minute blocks which are squarish to somewhat rectangular; 18-20 cuticular ridges on most of body length. Cephalic region smooth, 3-4 µm or about two adjacent body annules high, hemispheroidal to anteriorly tapering, continuous with body contour, anteriorly round to truncate with prominent central oral depression and straight to convex outer margins. The four thin cephalic setae originating near base of cephalic region and pointing outward and forward, measuring 4.5-6 µm long. Amphidial apertures transversely oval slits, more or less stirrup-shaped, 5-6 µm long, located just behind the first body annule (Fig. 5a, A).

Stoma almost cylindroid except for conoid cheilostom and telostom, 12-14 µm long, 3-3.5 µm wide. The feeding pump chamber is located at 33-35 µm or 15 annules behind cephalic region. Oesophagus 245-257 (249) µm long. Oesophageal bulb oval, 20-23 µm long, 12-14 µm wide; its extension 10-14 µm long. Gizzard 7.0-7.5 µm long, 3.5-4.0 µm wide, with 8-9 denticles in each row. Cardia 7-12 µm long. Excretory pore 110-117 µm from anterior end of body. Oesophagus-vulva distance 230-283 (265) µm. Gonad monodelphic, prodelfhic. Postvulval uterine sac 7-8 µm long. Vulva pore like located in a ventral depression of body wall (Fig. 5, D). Vagina about one-fourth as long as body width, walls thick but not sclerotized.

Rectum with wide lumen proximally, 20-22 µm long; three rectal glands at its proximal end well developed. Anal body width 12.5-14 µm. Distance between vulva and anus 260-290 (279) µm. Tail elongate-conoid, regularly tapering, ventrally arcuate, 152-170 (159) µm or 10-13 times anal body width long. Tail mucro 5-7 (6) µm long, with four hooked spines, two at its middle and two at terminus (Fig. 5, F&G).

**Male:** Not found.

**Habitat and locality:** Grass and bush soil, near IITA, Ibadan, Nigeria and rice soil in Togo.

**Specimens:** Two females are deposited in UK Nematode Collection, Sand Hutton, England, one female is in each of these collections: The USDA Nematode Collection, Beltsville, MD, USA; IARI Nematode Collection at New Delhi. Two females and one juvenile are in M. R. Siddiqi's Collection at Luton, England



Key to species of *Rugoster* gen. n.

1. Longitudinal cuticular grooves 18-22 ..... 2  
Longitudinal cuticular grooves over 22 ..... 5
2. Body 0.9 mm or longer; cephalic setae  
4.5-6.0  $\mu$ m long ..... 3  
Body under 0.9 mm long; cephalic setae  
3.0-4.5  $\mu$ m long ..... 4
3. Cephalic region low, half as high as wide;  
feeding pump chamber 33-35  $\mu$ m  
from anterior end ..... *R. magnifica* (Andrássy)  
Cephalic region elevated, three-quarters as high  
as wide; feeding pump chamber 28-29  $\mu$ m  
from anterior end ..... *R. regalia* sp. n.
4. Tail 82-85  $\mu$ m;  $c'=6-7$ ;  $V=$   
56.5-58.5 ..... *R. orientalis* sp. n.  
Tail 98-130  $\mu$ m;  $c'=8-11$ ;  $V=51-55$  ..... *R. virgata* sp. n.
5. Longitudinal cuticular  
grooves 40 ..... *R. tessellata* (Mounport)  
Longitudinal cuticular grooves under 38 ..... 6
6. Body over 0.66 mm; tail over 90  $\mu$ m ..... 7  
Body under 0.66 mm; tail under 86  $\mu$ m ..... *R. recisa* sp. n.
7. Feeding pump chamber 29-32  $\mu$ m from  
anterior end; vulva-anus distance 210-240  
 $\mu$ m long ..... *R. neomagnifica* sp. n.  
Feeding pump chamber 34-37  $\mu$ m from  
anterior end; vulva-anus distance 265-290  
 $\mu$ m long ..... *R. colbrani* sp. n.

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## LITERATURE CITED

- Abebe, E. and A. Coomans 1996.** Aquatic nematodes from Ethiopia VI. The genera *Chronogaster* Cobb, 1913, *Plectus* Bastian, 1865 and *Prismatolaimus* de Man, 1880 with descriptions of *C. ethiopica* n. sp. and *C. getachewi* n. sp. (Chromadorida: Nematoda). *Hydrobiologia* **332**, 41-61.
- Andrássy, I. 1956.** Süßwasser-Nematoden aus Französisch-West-Afrika. *Opuscula Zoologica Budapestinensis* **1**, 3-18.
- Andrássy, I. 1958.** Noch einmal über die Gattung *Chronogaster* Cobb, 1913. *Opuscula Zoologica Budapestinensis* **2**, 7-11.
- Andrássy, I. 2005.** Free-living nematodes of Hungary (*Nematoda errantia*), I. *Pedozoologica Hungarica*, Taxonomic, zoogeographic and faunistic studies on the soil animals, Series no. 3. Budapest, Hungary: Hungarian Natural History Museum and Systematic Zoology Research Group of the Hungarian Academy of Sciences, Budapest, 518 pp.
- Bajaj, H. K. and D. S. Bhatti 1979.** *Chronogaster indica* n. sp. and *C. typica* (Nematoda: Plectidae) from Haryana, India. *Indian Journal of Nematology* **8** (1978), 78-81.
- Cobb, N. A. 1913.** New nematode genera found inhabiting fresh water and non-brackish soils. *Journal of the Washington Academy of Sciences* **3**, 432-444.
- Coomans, A. and D. De Waele 1983.** Species of *Aphanolaimus* (Nematoda, Araeolaimida) from Belgium. *Hydrobiologia* **101**, 165-178.
- Gagarin, V. G. and N. V. Thanh 2009.** Two species of free-living nematodes of the family Leptolaimidae (Nematoda, Plectida) from mangrove of Mekong River Delta, Vietnam. *International Journal of Nematology* **19**, 1-6.
- Gerlach, S. A. 1956.** Brasilianische Meeres-Nematoden. 1. *Boletim do Instituto Oceanográfico São Paulo* **5**, 3-69.
- Heyns, J. and A. Coomans 1980.** Freshwater nematodes from South Africa 5. *Chronogaster* Cobb, 1913. *Nematologica* **26**, 187-208.
- Heyns, J. and A. Coomans 1983.** New and known species of *Chronogaster* Cobb, 1913 (Nematoda: Leptolaimidae). *Nematologica* **29**, 245-265.
- Holovachov, O. 2004.** Morphology, phylogeny and evolution of the superfamily Plectoidea Örley, 1880 (Nematoda: Plectida). *Annales Zoologici* **54**, 631-672.
- Holovachov, O. and D. Sturhan 2003.** *Adenolaimus camerunense* gen. et sp. n. (Araeolaimida: Diplopeltidae) from rain forest in Cameroon. *Russian Journal of Nematology* **11**, 63-66.
- Holovachov, O. and S. Bostrom 2004.** Morphology and systematics of the superfamilies Leptolaimoidea Örley, 1880 and Camacolaimoidea Micoletzky, 1924 (Nematoda: Plectida). *Journal of Nematode Morphology and Systematics* **7**, 1-49.
- Holovachov, O. and P. De Ley 2006.** Order Plectida. In: Freshwater Nematodes: Ecology and Taxonomy, pp. 611-647 (eds Eyuaalem-Abebe, I. Andrássy and W. Traunspurger). Wallingford, UK: CABI Publishing, xix+752 pp.
- Khera, S. 1972.** Nematodes from the banks of still and running waters. 12. Order Araeolaimida. *Proceedings of the Zoological Society, Calcutta* **52**, 49-58.
- Loof, P. A. A. and M. S. Jairajpuri 1965.** Two new species of *Chronogaster* Cobb, 1913 (Nematoda : Plectidae).

*Proceedings of the Helminthological Society of Washington* **32**, 181-186.

- Maggenti, A. R., D. J. Raski, P. K. Koshy and V. K. Sosamma 1983.** A new species of *Chronogaster* Cobb, 1913 (Nematoda : Plectidae) with an amended diagnosis of the genus and discussion of cuticular ornamentation. *Revue de Nématologie* **6**, 257-263.
- Mounport, D. 2005.** *Chronogaster tessellata* n. sp. (Nematoda: Chronogastridae) from Senegal. *Nematology* **7**, 53-57.
- Raski, D. J. and A. R. Maggenti 1984.** Four new species of *Chronogaster* Cobb, 1913 (Nemata: Plectidae) with a

key to species of the genus. *Nematologica* **30**, 117-130.

- Siddiqi, M. R. 1983.** Phylogenetic relationships of the soil nematode orders Dorylaimida, Mononchida, Triplonchida and Alaimida, with a revised classification of the subclass Enoplia. *Pakistan Journal of Nematology* **1**, 79-110.
- Siddiqi, M. R. 2003.** *Keralanema spinicarpus* (Maggenti *et al.*, 1983) gen. n., comb. n. (Nematoda: Chronogastridae). *International Journal of Nematology* **13**, 236.
- Siddiqi, M. R. 2009.** Ten new species of *Aphanolaimus* de Man, 1880 (Nematoda: Areaeolaimida). *International Journal of Nematology* **19**, 63-86.