

A new Rotylenchulinae: *Senegalonema sorghi* n. gen., n. sp. (Nematoda: Tylenchida)

Gaetano GERMANI *, Michel LUC ** and James G. BALDWIN ***

* Laboratoire de Nématologie, ORSTOM, B.P. 1386, Dakar, Sénégal;

** Muséum national d'Histoire naturelle, Laboratoire des Vers, 61, rue de Buffon, Paris
and *** Department of Nematology, University of California, Riverside, Ca 92521, USA.

SUMMARY

Description is given of *Senegalonema sorghi* n. gen., n. sp., parasitic on sorghum, at Patar, Senegal. This new genus, close to *Rotylenchulus* Linford & Oliveira, 1940, differs from it by several characters: more anterior position of the dorsal oesophageal gland orifice; genital branches outstretched in immature female; stylet and oesophagus only slightly regressed in males which exhibit terminal caudal alae; moreover the structure of the lip region, as seen by SEM, appears very specific. *Senegalonema* n. gen. is considered as constituting, with *Rotylenchulus*, the subfamily Rotylenchulinae, within the Hoplolaimidae. Relationships between those genera of this family where females are inflated, with the family Heteroderidae (incl. Meloidogyninae) are discussed.

RÉSUMÉ

Un nouveau Rotylenchulinae: Senegalonema sorghi n. gen., n. sp. (Nematoda: Tylenchida)

Senegalonema sorghi n. gen., n. sp., parasite du sorgho à Patar, Sénégal, est décrit et figuré. Proche de *Rotylenchulus* Linford & Oliveira, 1940, le nouveau genre en diffère par la position plus antérieure de l'ouverture de la glande oesophagienne dorsale; des ébauches génitales droites chez la femelle immature; une faible régression seulement du stylet et de l'oesophage et une bourse terminale chez le mâle. La structure de la région labiale, observée au microscope électronique à balayage, apparaît très particulière. Les auteurs considèrent les Rotylenchulinae comme appartenant aux Hoplolaimidae et discutent les relations entre genres de cette famille où les femelles sont renflées et ceux appartenant aux Heteroderidae (incl. Meloidogyninae).

During a survey of various food crops in Senegal, the senior author observed a nematode parasitizing roots of sorghum, which, at first glance, was thought to be a new species of *Rotylenchulus* Linford & Oliveria, 1940. Closer examination indicated that the species observed pertains to a new genus, morphologically similar to *Rotylenchulus*. These taxa are described below as *Senegalonema sorghi* n. gen., n. sp.

1974 and *M. chitwoodi* (Golden & Jensen, 1974). Stone, 1977 were examined with SEM for comparison. Fixed specimens were infiltrated with glycerin and mounted as reported by Sher and Bell (1975). Specimens were sputter-coated with 20 μ m gold-palladium and examined with a Jeol 35C SEM at 5KV.

Senegalonema n. gen.

Material and methods

Examination has been made on specimens killed by gentle heat, fixed with FA 4 : 10 and then processed to glycerin by Seinhorst's (1959) rapid method.

Young females, males and juveniles of *S. sorghi* n. gen., n. sp. were prepared for observations of the lip region with the scanning electron microscope (SEM). In addition, immature females of *Rotylenchulus reniformis* Linford & Oliveria, 1940 and *Nacobbus dorsalis* Thorne & Allen, 1944 as well as juveniles of *Meloinema kerongense* Choi & Geraert,

DIAGNOSIS

Tylenchida. Hoplolaimidae. *Mature female* fixed in roots; body entirely annulated, swollen posteriorly; vulva postequatorial; two genital branches, convoluted; tail short; phasmids large. *Immature female* free in soil; lip region not set-off; cephalic framework conspicuous; dorsal oesophageal gland orifice less than one half stylet length posterior to base of stylet. Oesophagus long, with glands filling pseudocoelom, overlapping intestine laterally, or ventrally, more often laterally. Genital tract immature, composed of two outstretched branches. *Male* free

** Nematologist of ORSTOM.

in soil; stylet shorter than in female; oesophagus less developed than in female, but not degenerated. Caudal alae shallow, terminal. *With SEM*, in both male and immature female, labial area characterized by labial disc fused with four dorso-ventrally elongated triangular submedial lips; apex of submedial lips and trapezoidal lateral lips extend posterior to region of basal plate; labial area without transverse annules. Amphids elongate. Eggs embedded in gelatinous matrix.

TYPE AND ONLY SPECIES

Senegalonema sorghi n. gen., n. sp.

Relationships of the genus are discussed below.

***Senegalonema sorghi* n. gen., n. sp.**

(Fig. 1-3)

MEASUREMENTS

Adult females (n = 7). L = 0.21-0.78 mm; a = 2.6-4.7; V = 61.5-76.9; stylet = 17-23 μ m.

Immature females (n = 45). L = 0.49 mm (0.39-0.55); a = 24.4 (18.5-29); b' = 2.3 (1.9-3.3); c = 16.7 (14-19.5); V = 73.9 (70.3-76.5); stylet = 25.5 μ m (22-28).

Males (n = 19). L = 0.38 mm (0.35-0.42); a = 18.4 (15.8-18.9); b' = 4.5 (3.7-6.0); c = 17.1 (15.4-20.7); c' = 1.6 (1.3-1.9); T = 59.6 (48.5-74.6); stylet = 19.5 μ m (18-21.5); spicules = 27 μ m (23-32.5); gubernaculum = 11.5 μ m (9-13.5).

Holotype (immature female). L = 0.53 mm; a = 24.1; b' = 2.9; c = 16.4; c' = 2.2; V = 8074.27²; stylet = 25 μ m; cone = 15 μ m.

DESCRIPTION

Adult female

Anterior part of the body irregular, vermiform; posterior part swollen, variously shaped including kidney-shaped, or saccate, most often with a constriction at vulva level which is more pronounced ventrally. Cuticle with irregularly rounded annules in anterior part; posterior part entirely annulated, annules flat, separations weak. Cuticle thin (1.5-2 μ m) anteriorly, progressively thickened posteriorly (to 10-13 μ m). Lateral field not seen. Lip area irregularly rounded, often with a circular depression, but no annulation. Cephalic sclerotization weak. Cephalids not seen. Stylet weak; basal knobs rounded, closely appressed to shaft. Dorsal oesophageal gland opening at 5-8 μ m from stylet base. Oesophagus procorpus long, cylindrical; median bulb strong, with well developed valve; isthmus short, encircled by nerve ring; oesophageal glands apparently lying free in

the pseudocoelom, short but well expanded laterally. Oesophago-intestinal junction obscure, devoid of conspicuous valve. Excretory pore at mid level of oesophageal glands. Hemizonid and hemizonion not seen. Vulva postequatorial; vulva lips not protruding. Two genital branches, long convoluted, filling posterior part of the body. Anus situated in depression. Tail conical, short (15-22 μ m), annulated at its base. Phasmids prominent, large (5 μ m diam), associated with one or more specialized cells.

Immature female

When heat-relaxed, body ventrally curved, assuming bracket to U-shape. Body cylindrical, with slight tapering at anterior end as well as tapering beginning a short distance from posterior end. Cuticle thin; transverse annulations shallow (annules about 1.8 μ m, at mid-body), more pronounced posteriorly including tail. Lateral fields about 6 μ m wide (*i.e.*, 1/3 of body diameter, at mid-body), with four lateral lines; outer lines slightly wavy, inner lines straight; areolation of outer bands faint, only present posteriorly including tail; lateral field nearly extends to tail extremity. No deirids. Lip area rounded, flat anteriorly, not annulated, continuous with the rest of the body. SEM: labial disc fused with four submedial lips; submedial lips triangular and very elongate with apex of triangle extending posteriorly to level of basal plate; lateral lips trapezoidal, also extend to level of basal plate; lip area without transverse annulation. Amphid openings slit-like. Cephalic sclerotization of medium development. Anterior cephalids at level of 1st or 2nd body annule; posterior cephalids at level of 6th or 7th body annule. Stylet strong, basal knobs rounded, closely appressed to the shaft. Dorsal oesophageal gland opening at 5-7 μ m from the base of stylet. Oesophagus procorpus swollen at anterior end and more or less regularly tapering to median bulb. Median bulb oval in profile, of medium development, not sharply set-off from procorpus, or from isthmus. Isthmus thick, short, encircled by nerve ring. Oesophageal glands considerably developed, filling almost all the pseudocoelom, apparently free within it; dorsal gland smaller than subventral ones, with posterior part hyaline and with prominent nucleus; subventral glands with fine, dense granulation, provided with smaller more obscure nuclei. Oesophago-intestinal junction inconspicuous, rather anteriorly situated, without conspicuous valve; overlapping of oesophageal glands laterally and ventrally, mainly laterally. Intestine without fasciculi; no post-anal sac. Rectum straight, short (at most one anal diameter long). Excretory pore 93-113 μ m from anterior end. Hemizonid width of two annules, one or two annules anterior to excretory

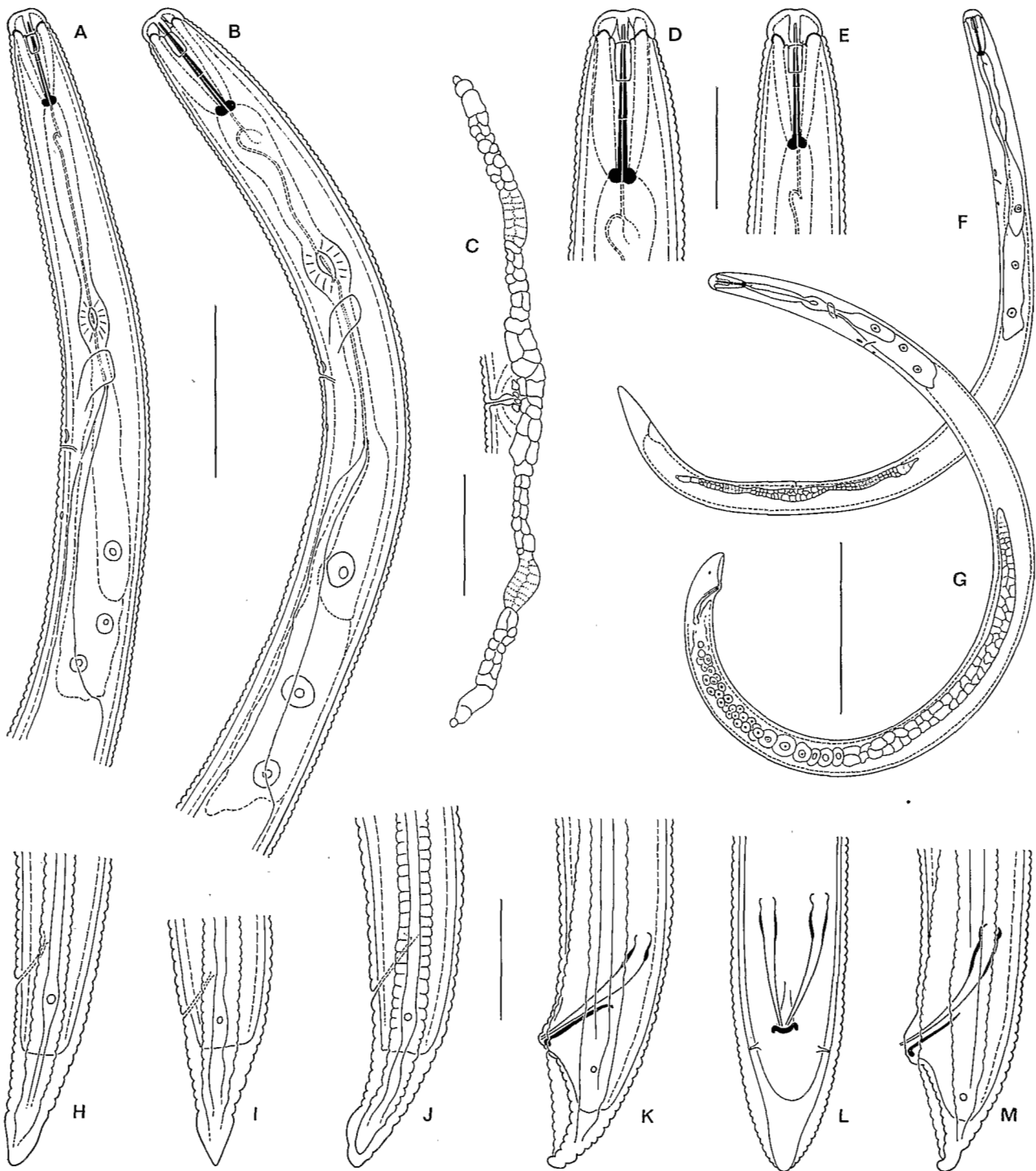


Fig. 1. *Senegalonema sorghi* n. gen., n. sp. *Young female*. B : Oesophageal part ; C : Genital tracts ; D : Anterior part ; F : Animal *in toto* ; H, I, J : Tails. *Males*. A : Oesophageal part ; E : Anterior part ; G : Animal *in toto* ; K, L, M : Tails and spicule apparatus. (Each bar represents : F, G : 100 μ m ; A, B : 50 μ m, C, D, E, H-M : 20 μ m).

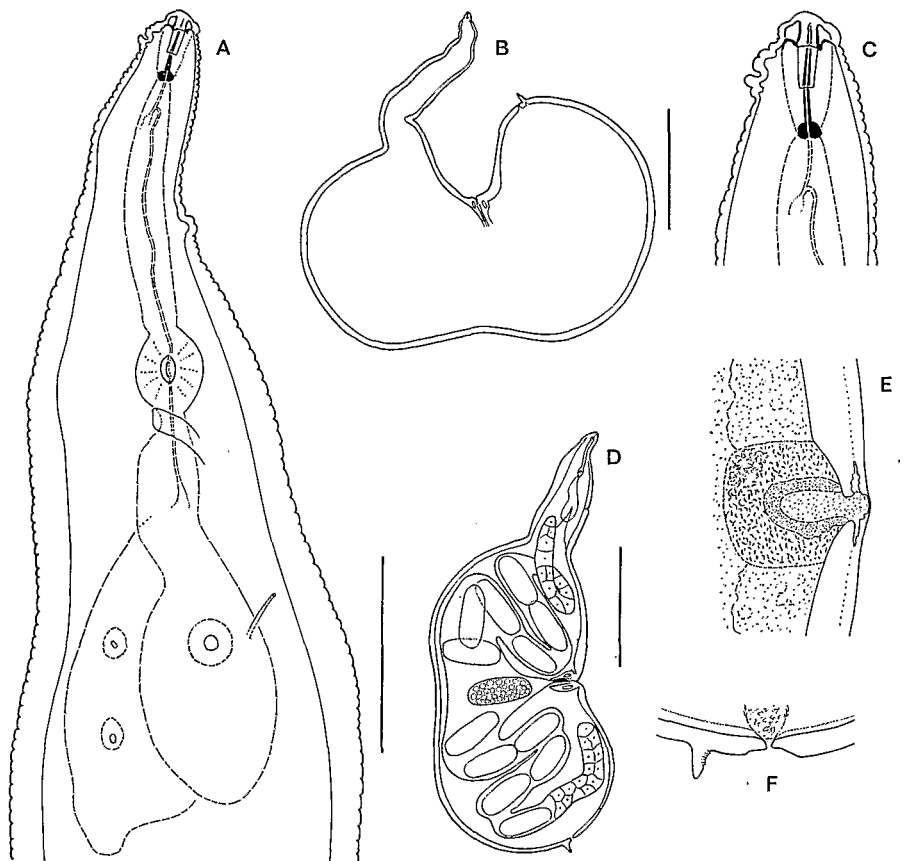


Fig. 2. *Senegalonema sorghi* n. gen., n. sp. Adult female. A : Oesophageal part ; B, D : Animal *in toto* ; C : Anterior part ; E : Detail of phasmid ; F : Tail and anus. (Each bar represents : B, D : 250 μm ; A : 50 μm ; C, E, F : 20 μm).

pore ; hemizonion width of one annule, seven to nine annules posterior to excretory pore. Vulva not protruding, postequatorial ; immature genital tracts composed of two outstretched branches, similar in structure and length (anterior branch = 41-80 μm ; posterior branch = 32-82 μm). Tail conical, 24-32 μm long ; extremity generally rounded, more rarely pointed ; with 9-15 annules (ventrally) which are more prominent and wider than on body ; extremity (8-10 μm) without annules ; cuticle of tail very thick at extremity, forming a hyaline portion 15-21 μm long or 51-81% of tail length ; outer lines of lateral field reaching nearly to tail extremity ; inner lines ending slightly anteriorly ; outer bands of lateral field areolated on tail as well as a short distance anterior to anus. Phasmid rounded, 1.5 μm diameter, very refringent, positioned in center of central band of lateral field, situated 1-4 μm posterior to anus.

Male

General appearance and anatomy similar to immature female, except for genital system and some secondary sexual characters. Cuticular annules about 1.5 μm , at mid-body. Lateral field similar to immature female, 6 μm (5-8.5) wide or 28% (22-37) of body diameter at mid-body. No deirids. Lip area with cephalic sclerotization similar to that of immature female ; height of lip area 3-5.5 μm , diameter at base = 8.5-10 μm ; SEM face pattern as in immature female. Stylet shorter and weaker than in immature female with basal knobs more closely appressed to shaft ; knob width = 1.5-2 μm ; knob height = 3-3.5 μm ; cone length = 10.5 μm (9.5-12). Dorsal oesophageal gland orifice 6 μm (3-8) from stylet base. Oesophagus similar to that of immature female, but less developed, particularly the median bulb ; but oesophagus not

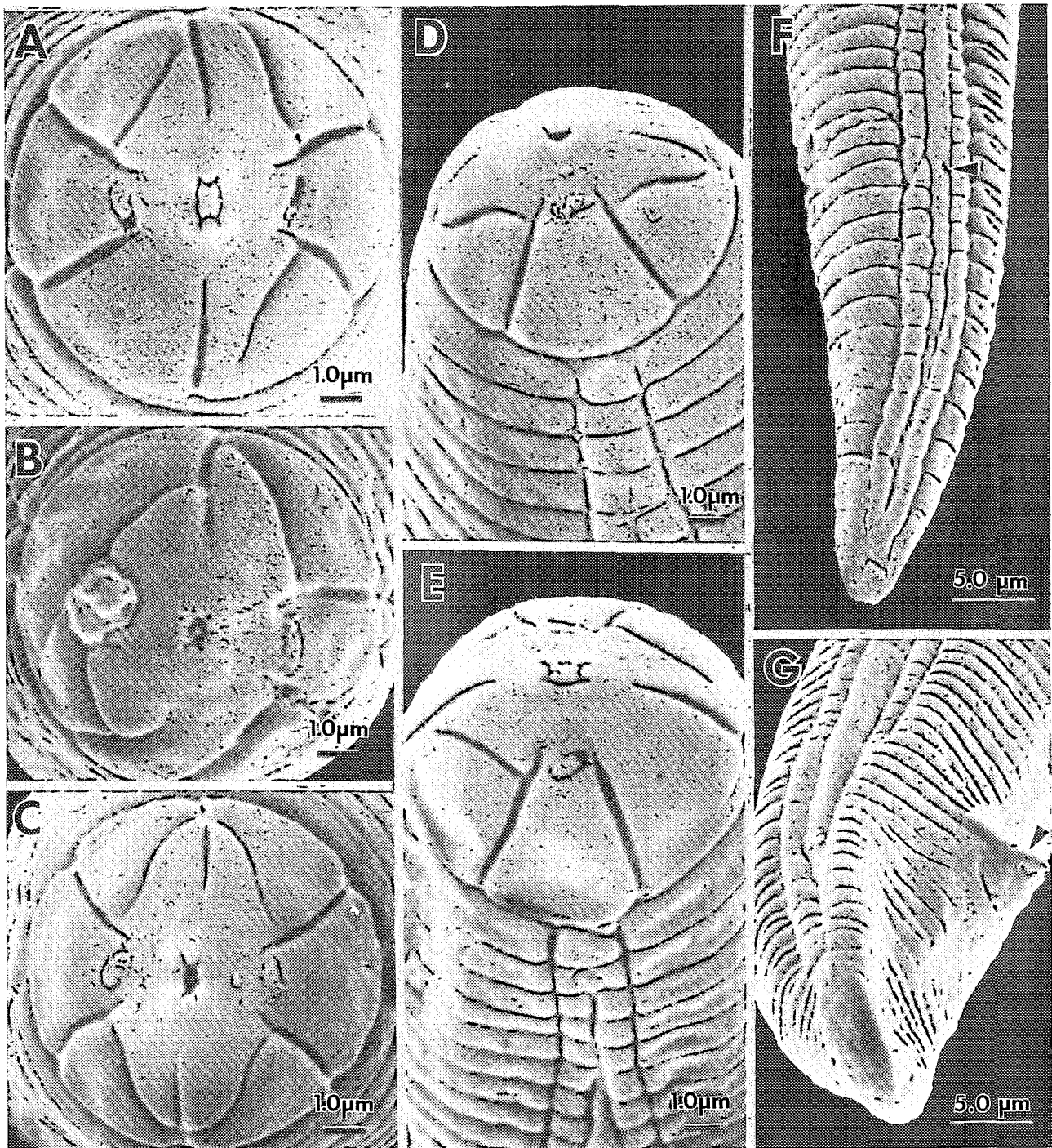


Fig. 3. *Senegalonema sorghi* n. gen., n. sp. SEM pictures. A : *En face* view of immature female. B : *En face* view of male. C : *En face* view of second stage juvenile. D : Lateral view of anterior region of second stage juvenile. E : Lateral view of immature female. F : Lateral view of tail region of immature female. (Arrow-head indicates position of phasmid). G : Latero-ventral view of tail region of male. (Arrowhead indicates position of spicule).

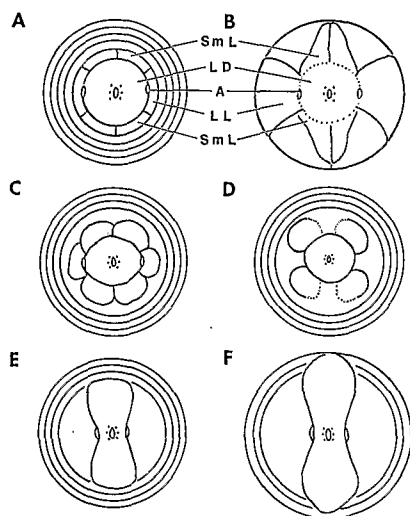


Fig. 4. Drawing illustrating *en face* pattern of *Senegalonema sorghi* n. gen. n. sp. in relation to certain other Tylenchida. A : Basic pattern for Tylenchida. A : amphid ; LD : labial disc ; LL : lateral lip sector ; SmL : submedial lip sector. B : Immature female of *Senegalonema sorghi* n. gen. n. sp. C : Immature female of *Rotylenchulus reniformis*. D : Immature female of *Nacobbus dorsalis*. E : Second stage juvenile of *Meloinema kerongense*. F : Second stage juvenile of *Meloinema chitwoodi*.

degenerated and apparently functional. Excretory pore 100 μm (94-109) from anterior end ; hemizonid extending width of one or two annules, 2-5 annules anterior to excretory pore ; hemizonion punctiform, 7-12 annules posterior to excretory pore. Genital tract unique ; spicules slightly curved, cephalated, pointed at distal end ; gubernaculum straight, with titillae, not protruding ; cloaca marked by prominent cone. Tail conical, pointed, terminus variously shaped, annulation nearly reaching tail extremity ; hyaline tail terminus 9.5 μm (6-13.5) long or 42% (27-51) of tail length. Caudal alae narrow, shallow, terminal. Phasmids on tail, 7.5 μm (4.5-12.5) posterior to cloaca.

TYPE HOST AND LOCALITY

Roots and soil of *Sorghum* sp., near Patar, Sénégal.

TYPE MATERIAL

Holotype : immature female, slide No. 21520, deposited at the Laboratoire des Vers, Muséum national d'Histoire naturelle, 61 rue de Buffon, Paris, France.

Paratypes : Two imm. ♀♀ and two ♂♂ deposited in each of the following nematological collections : Univ. California, Riverside, U.S.A. ; Univ. California, Davis, U.S.A. ; US National Collection, Beltsville, Md., U.S.A. ; Rothamsted Experimental Station, Harpenden, U.K. ; Landbouwhogeschool, Wageningen, Netherlands ; ORSTOM, Dakar, Sénégal. Remaining type material in Paris Muséum's Collection.

RELATIONSHIPS

Senegalonema n. gen. appears morphologically similar to *Rotylenchulus* with respect to several characters. Mature females are embedded in roots and swollen posteriorly, immature females are vermiform, free in soil and with well-developed genital primordium ; oesophageal glands are well-developed and overlap the intestine laterally and slightly ventrally ; eggs are embedded in a gelatinous matrix.

Senegalonema n. gen. differs, however, from *Rotylenchulus* by a series of important characters ; i) in both immature females and males the lip area is distinctive, as shown by SEM (Figs. 3 A-E ; 4 B) ; the dorsal oesophageal gland orifice is located less than one half stylet length posterior to base of stylet *vs.* more than one half of this length, and often one stylet length in *Rotylenchulus* ; ii) in immature females the genital branches are outstretched *vs.* having a double flexure in *Rotylenchulus* ; iii) in males the stylet and oesophagus are reduced, but not degenerate ; caudal alae are terminal *vs.* adanal ; the gubernaculum is provided with titillae.

The position of both genera with respect to family and subfamily present some difficulties to be assessed. A good historical account of *Rotylenchulus* up to 1967, has been given by Dasgupta, Raski and Sher (1968). The opinion of these authors is to follow Husain and Khan (1967) who created within the Hoplolaimidae Wieser, 1953 the subfamily Rotylenchulinae elevated to the rank of family by Husain (1976). Andrassy (1976) also placed *Rotylenchulus* in Hoplolaimidae, but in the subfamily Radopholinae Allen & Sher, 1967, with *Apratylenchoides* Sher, 1973, *Hirschmanniella* Luc & Goodey, 1963, *Pratylenchoides* Winslow, 1958, *Radopholus* Thorne, 1949 and *Rotylenchoides* Whitehead, 1958 ; all these genera, except the last one, are most generally considered as pertaining to the family Pratylenchidae Thorne, 1949. On an other hand, Golden and Jensen (1974) consider Rotylenchulinae as a subfamily of Nacobbiidae Chitwood, 1950 in Heteroderoidea.

We do not accept these decisions concerning families and consider that *Rotylenchulus* and *Senegalonema* n. gen. share sufficient characteristics with

« classical » Hoplolaimidae (*i.e.* not as defined by Andrásy, 1976) to be included in that family. The discovery of *Senegalonema* n. gen. reinforces this opinion by its lesser regression of the male stylet and oesophagus, the shorter tail, the terminal caudal alae and the outstretched genital female immature branches. On the other hand, however, the structure of the labial area in *Senegalonema* n. gen., as shown by SEM, appears unique, as far as it is known, among tylenchids.

Both genera considered here suggest a morphological link between Hoplolaimidae and Meloidogyninae Skarbilovich, 1959. Another step to Meloidogyninae (Heteroderidae) is suggested by the genera *Nacobbus* Thorne & Allen, 1944 and *Meloinema* Choi & Geraert, 1974 (= *Nacobboder* Golden & Jensen, 1974). The two species of *Nacobbus* exhibit (in spite of the particular shape of the mature female, the presence of only one female genital branch and the dorsal overlapping of the oesophageal glands) a series of characters shared with *Rotylenchulus* and/or *Senegalonema* n. gen. : lip area continuous, stylet strong, cephalic sclerotization well developed, bursa terminal; *Nacobbus aberrans* (Thorne, 1935) Thorne & Allen, 1944 has the same pattern as *N. dorsalis* which are quite distinguish from *Rotylenchulus*. Mature females exhibit a tail. *Meloinema* also exhibits characters which frequently occur in Meloidogyninae : males and juveniles with labial area offset, excretory pore positioned anteriorly in females (as in *Meloidogyne* Goeldi, 1887), male twisted posteriorly and devoid of bursa, more posterior position of the vulva, although the female genital tract has two branches (but in *Meloidodera* Chitwood, Hannon & Esser, 1955, considered as pertaining to Heteroderidae, the vulva is submedian). This situation is reflected by the placement of *Meloinema*, in Heteroderidae-Meloidogyninae by Choi & Geraert (1974) whereas Golden and Jensen (1974) considered it (under the name *Nacobboder*) as pertaining to the subfamily Nacobboderinae Golden & Jensen, 1974.

The lip region of *Senegalonema* n. gen. appears to be highly derived from the basic hexaradiate lip pattern which occurs throughout many Tylenchida (Baldwin, Luc & Bell, 1983). It can be interpreted as the result of fusion of four submedial lips with the labial disc (without fusion of adjacent submedial lips) and elongation of the submedial lips to the base of the lip region. The lateral lips also extend posteriorly to the base of the lip region, and transverse lip annules are absent. In *Rotylenchulus reniformis* lateral lips may extend somewhat posteriorly, but submedial lips are not fused with the labial disc. Although Dasgupta, Raski and Sher (1968) indicate that the lip region is variable among species of *Rotylenchulus* specimens of a large number

of species have not been available for elucidation of the lip region with SEM. In *Meloinema kerongense* and *M. chitwoodi* submedial lips fuse with the labial disc and are elongate similar to *Senegalonema*; however, adjacent lips become fused in *Meloinema* and the remainder of the lip region is not characterized by longitudinal markings.

Relationship between *Rotylenchulus*, *Senegalonema* n. gen., *Nacobbus* and *Meloinema* (and perhaps the genus *Acontylus* Meagher, 1967 which shares a tendency to the regression of males and swelling of the mature females) have to be further explored. Specifically, polarity (primitive *vs.* derived) of character states must be identified for *Verulus volvingentis* Esser, 1981. This only species of the genus, placed by the author in the Heteroderidae, subfam. Verutinae Esser, 1981, shows in females some similarities to Rotylenchulinae : anterior part of body elongate, posterior part saccate, vulva submedian, remnants of tail in some specimens, anus situated in a depression. But the absence of a free immature female stage and the morpho-anatomy of males, which is close to that of *Alalodera* Wouts & Sher, 1971 (Heteroderidae), prohibit classification of the genus *Verulus* in the Rotylenchulinae and justify its placement within the Heteroderidae.

At the moment, we propose, based on a broad spectrum of similarities, *Rotylenchulus* and *Senegalonema* n. gen. as pertaining to the family Hoplolaimidae and grouped together within the subfamily Rotylenchulinae.

Within the cited genera, polarity (primitive *vs.* derived) of character states can not be identified for use in phylogenetic analysis including the higher taxa to which they pertain. Nevertheless, the overall resemblances between supposed "evolved" Hoplolaimidae (Rotylenchulinae) with supposed "primitive" Meloidogyninae (*Meloidodera*) and other Heteroderidae (*Verulus*) reinforce the hypothesis of a close common origin of the two families.

ACKNOWLEDGEMENTS

Thanks are due to A.H. Bell for making SEM photographs.

REFERENCES

- ANDRÁSSY, I. (1976). *Evolution as a basis for the systematization of nematodes*. London, Pitman Publishing : 288 p.
- BALDWIN, J.G., LUC, M. & BELL, A.H. (1983). Contribution to the study of the genus *Pratylenchoides* Winslow (Nematoda : Tylenchida). *Revue Nématol.*, 6 : 111-125.

- CHOI, Y.E. & GERAERT, E. (1974). Description of *Meloinema kerongense* n.g. n. sp. (Nematoda : Meloidogynidae) from Korea. *Nematologica*, 19 (1973) : 334-341.
- DASGUPTA, D.R., RASKI, D.J. & SHER, S.A. (1968). A revision of the genus *Rotylenchulus* Linford and Oliveira, 1940 (Nematoda : Tylenchidae). *Proc. helminth. Soc. Wash.*, 35 : 169-192.
- GOLDEN, A.M. & JENSEN, H.J. (1974). *Nacobbodera chitwoodi* n. gen., n. sp. (Nacobbidae, Nematoda) on Douglas Fir in Oregon. *J. Nematol.*, 6 : 30-37.
- HUSAIN, S.I. (1976). Phylogeny and inter-relationships of the superfamily Heteroderoidea (Skarbilovich, 1947) Golden, 1971. *Geobios*, 3 : 9-12.
- HUSAIN, S.I. & KHAN, A.M. (1967). A new subfamily, a new subgenus and six new species of nematodes from India belonging in the superfamily Tylenchoidea. *Proc. helminth. Soc. Wash.*, 34 : 175-186.
- SEINHORST, J.W. (1959). A rapid method for the transfer of nematodes from fixative to anhydrous glycerin. *Nematologica*, 4 : 67-69.
- SHER, S.A. & BELL, A.H. (1975). Scanning electron micrographs of the anterior region of some species of Tylenchoidea (Tylenchida : Nematoda). *J. Nematol.*, 7 : 69-83.

Accepté pour publication le 25 mars 1983.