Fundam. appl. Nematol., 1993, **16** (2), 137-149

Cuticle fine structure of nine species in the genus *Tylenchorhynchus* Cobb, 1913 (Nemata : Belonolaimidae)

Danamou MOUNPORT *, Pierre BAUJARD ** and Bernard MARTINY **

* *Département de Biologie Animale, Faculté des Sciences, Université Cheikh Anta Diop, Dakar, Sénégal,* and ** *Laboratoire de Nématologie, Centre ORSTOM, B.P. 1386, Dakar, Sénégal.*

Accepted for publication 29 May 1992.

Summary – The cuticle fine structure of females of nine species in the genus *Tylenchorhynchus,* belonging to three morphological types according to external cuticular ornamentations outside lateral fields, is described : first type of species without longitudinal ridges and longitudinal incisures *(T. indicus, T. ventralis, T. annulatus* and *T. vulgaris);* second type with longitudinal ridges and incisures *(T. gladiolatus);* third type with longitudinal ridges but without longitudinal incisures (*T. germanii, T. microphasmis, T. sulcatus* and an unidentified species). Six groups are identified in the nine *Tylenchorhynchus* species studied according to cuticle fine structure criteria.

Résumé – ***Ultrastructure de la cuticle chez neuf espèces du genre* Tylenchorhynchus *Cobb, 1913 (Nemata : Belonolaimidae)*** – L'ultrastructure de la cuticule de neuf espèces du genre *Tylenchorhynchus* appartenant à trois types morphologiques – suivant les ornementations externes de la cuticule en dehors des champs latéraux – est décrite. Le premier type comprend des espèces sans crêtes ni incisures longitudinales *(T. indicus, T. annulatus, T. ventralis* et *T. vulgaris).* Le deuxième type, des espèces avec crêtes et incisures longitudinales *(T. gladiolatus).* Le troisième type, des espèces avec crêtes et sans incisures longitudinales (*T. germanii, T. microphasmis, T. sulcatus* et une espèce non déterminée). Six groupes sont identifiés dans l'ensemble des neuf espèces étudiées sur la base de trois critères se rapportant à l'ultrastructure de la cuticule : nombre de couches dans la zone médiane en dehors des champs latéraux, nombre de couches dans la zone basale au niveau des champs latéraux et aspect de la couche basale striée. La structure de la cuticule au niveau des champs latéraux chez *Tylenchorhynchus* sp. rappelle celle observée chez les Hoplolaiminae.

The family Belonolaimidae Whitehead, 1960 was redifined by Fortuner and Luc (1987) and the following nine genera were proposed as synonyms of *Tylenchorhynchus* Cobb, 1913 : *Bitylenchus* Filip'ev, 1934; *Telotylenchus* Siddiqi, 1960; *Quinisulcius* Siddiqi, 1971; *Dolichorhynchus* Mulk & Jairajpuri, 1974; *Trilineellus* Lewis & Golden, 1981; *Divittus* Jairajpuri, 1984; *Morasinema* Javed, 1984; *Tessellus* Jairajpuri & Hunt, 1984; *Neodolichorhynchus* Jairajpuri & Hunt, 1984. Morphobiometric criteria used in the generic diagnosis were too variable and so could not be used in the characterization of the rejected genera. The taxonomic importance of cuticle layering was demonstrated by Shepherd, *et al.* (1972) and Maggenti (1979). Mounport *et al.* (1990, 1991*a, b*) confirmed the constancy of cuticle layering in the genera *Criconemella, Pratylenchus* and *Scutellonema.* The aim of this paper is to appraise the variability of cuticle ultrastructure in the genus *Tylenchorhynchus* as redefined by Fortuner and Luc (1987).

Material and methods

MATERIAL

The nine available species studied here belong to three major types according to morphological features of the cuticle :

Type 1 : longitudinal ridges and incisures absent outside lateral fields.

Tylenchorhynchus annulatus (Cassidy, 1930) Golden, 1971
= *Tylenchorhynchus martini* Fielding, 1956.
Tylenchorhynchus indicus (Siddiqi, 1960) Fortuner & Luc, 1987
= *Telotylenchus indicus* Siddiqi, 1960.
Tylenchorhynchus ventralis (Loof, 1963) Fortuner & Luc, 1987
= *Telotylenchus ventralis* Loof, 1963.
Tylenchorhynchus vulgaris Upadhyay, Swarup & Sethi, 1972
= *Bitylenchus vulgaris* (Upadhyay, Swarup & Sethi, 1972) Siddiqi, 1986.

Type 2 : longitudinal ridges and incisures present outside lateral fields.

Tylenchorhynchus gladiolatus Fortuner & Amougou, 1974
= *Dolichorhynchus (Neodolichorhynchus) gladiolatus* (Fortuner & Amougou, 1973) Mulk & Siddiqi, 1982;
= *Neodolichorhynchus gladiolatus* (Fortuner & Amougou, 1973) Jairajpuri & Hunt, 1984.

Type 3 : longitudinal ridges present and longitudinal incisure absent outside lateral fields.

Tylenchorhynchus germanii (Germani & Luc, 1984) Fortuner & Luc, 1987
= *Dolichorhynchus (Dolichorhynchus) elegans* Germani & Luc, 1984;
= *Tylenchorhynchus elegans* (Germani & Luc, 1984) Fortuner & Luc, 1987.

Tylenchorhynchus microphasmis Loof, 1960
= *Dolichorhynchus (Neodolichorhynchus) microphasmis* (Loof, 1960) Mulk & Siddiqi, 1982
= *Neodolichorhynchus microphasmis* (Loof, 1960) Jairajpuri & Hunt, 1984.

Tylenchorhynchus sulcatus de Guiran, 1967
= *Dolichorhynchus (Neodolichorhynchus) sulcatus* (de Guiran, 1967) Mulk & Siddiqi, 1982;
= *Neodolichorhynchus sulcatus* (de Guiran, 1967) Jairajpuri & Hunt, 1984.

Tylenchorhynchus sp.

Locality and date of collection of species

T. annulatus : Richard-Toll (Senegal) in 1982.
T. germanii : topotypes from Patar (Senegal) in 1984.
T. gladiolatus : Nebe (Senegal) in 1986.
T. indicus : Thienaba (Senegal) in 1988.
T. sulcatus : N'Dindy (Senegal) in 1982.
T. ventralis : Louga (Senegal) in 1982.
T. vulgaris : Agadez region (Niger) in 1987.
Tylenchorhynchus sp. : Aogadut region (Niger) in 1987.

These species are cultured on *Sorghum vulgare* in the laboratory from the sampling date. Specimens of *T. microphasmis* were obtained from Dr. F. C. Zoon (The Netherlands) in FP 4:1 fixative.

Processing techniques for electron microscopy

Females of all nine *Tylenchorhynchus* species were fixed overnight at 4 °C in glutaraldehyde 2.5 % in a 0.1 M sodium cacodylate buffer at pH 7.2; they were then cut into two or three pieces and prepared for embedding in low viscosity epoxy resin (Spurr, 1969) as previously described by Mounport *et al.* (1990). Ultrathin sections were cut with a diamond knife on a Sorvall Porter Blum MT1 ultramicrotome; grids were contrasted (Reynolds, 1963) and observed in a Jeol 100 CXII electron microscope operating at 80 kV. Cross and longitudinal sections of at least ten females of each species were examined.

Definitions

The following definitions will be used for incisures and ridges observed in the different species :

incisures = longitudinal invaginations of the external cortical layer;

ridges = longitudinal band on the cuticle appearing more or less hemispherical in cross-section, demarcated or not by incisures.

Results

Species without longitudinal ridges and incisures outside lateral fields

Cross-sections at mid-body show that the cuticle is thinner in *T. vulgaris* (0.50 µm) than in the other species (0.80 µm). Cuticle ultrastructure of *T. indicus* and *T. ventralis* is similar and observations on the latter species are presented.

The cuticle outside lateral fields (Fig. 1 B, C; Fig. 2 B, C; Fig. 3 B, C) is composed of three major zones :

The cortical zone, consists of *i)* an external trilaminate layer whose thickness is constant (0.03 µm); *ii)* an internal granular layer averaging 0.20 µm in *T. vulgaris* and 0.17 µm to 0.25 µm in thickness in the other species.

The median zone, consists of an electron-lucent or electron-dense layer, which is very thin in *T. vulgaris* (0.05 µm *vs* 0.20 µm in the other species). Infiltrations of granular material from the inner cortical layer are observed in this layer in *T. ventralis* (Fig. 2 B, D) and *T. annulatus* (Fig. 1 C). In *T. ventralis* tangential section of the oesophagus (Fig. 2 E) shows that theses infiltrations of circular section are arranged in four rows under each annulation; at the mid-body these rows are less obvious (Fig. 2 F). Near the vulva the median layer is thicker (1.20 µm), resulting in a cuticular ridge (Fig. 2 D).

The basal zone, consists of a striated layer, ranging from 0.20 µm in thickness in *T. vulgaris* to 0.40 µm in the other species (Fig. 1 C; Fig. 2 C; Fig. 3 C). Striations are perpendicular to the somatic muscles and their periodicity in longitudinal sections is higher than in cross-sections. We observed a particular pattern in *T. indicus, T. ventralis* and *T. vulgaris* where the striated layer is regularly interrupted by parallel bands without striation; these bands correspond to the body annulations (Fig. 2 G; Fig. 3 D). The striated layer in all species is attached to somatic muscles by hemidesmosomes (Fig. 1 C; Fig. 2 B).

The cuticle at the level of the lateral fields is shown in Fig. 1 D; Fig. 2 H; Fig. 3 E, F and Fig. 4. Lateral fields are not prominent (Fig. 2 A, H; Fig. 3 A) except in *T. annulatus* (Fig. 1 A). The cuticle is composed of :

The cortical zone, whose ultrastructure and thickness is identical to that outside the lateral fields, except in *T. annulatus* where the inner cortical layer is thicker and seems to be stratified (Fig. 1 D).

The median zone, which in cross-sections of *T. annulatus* and *T. ventralis* reveals a discontinuity of the median layer, located only between the incisures (Fig. 1 D; Fig. 2 H); the layer is continuous in *T. vulgaris* (Fig. 3 F).

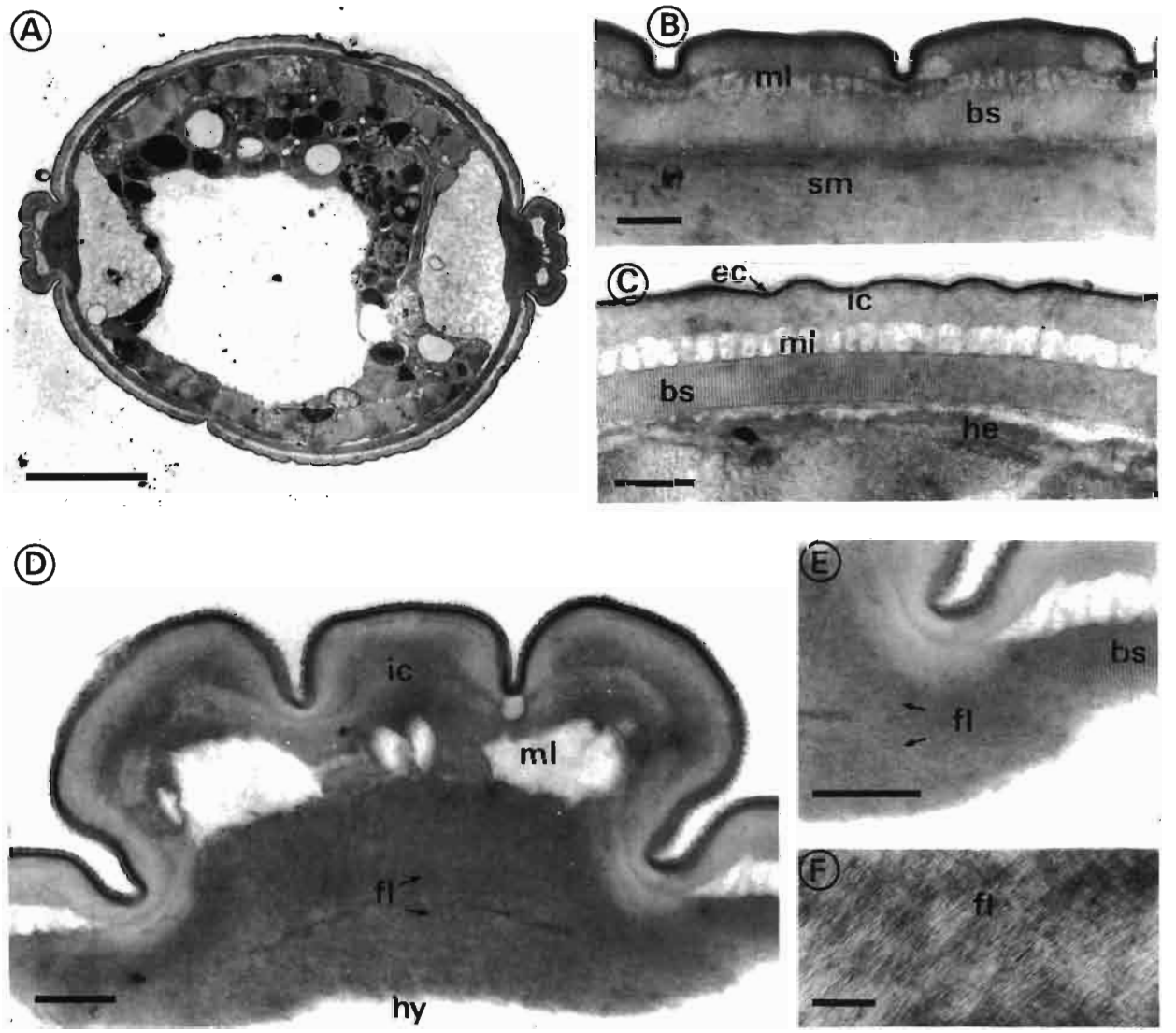

Fig. 1. Cuticle fine structure of *Tylenchorhynchus gladiolatus* females in longitudinal (LS) and cross (CS) sections. A : CS near mid-body; B : LS between two incisures; C : LS at level of an incisure; D : CS between two incisures, E : CS of an external incisure of a lateral field; F : CS of a lateral field; G : Detail of F showing layers of the basal zone. *(Bars : A = 5 µm; B-G = 0.5 µm).*

List of abbreviations used in the Figures. – bfl = basal fibrillar layer; bs = basal striated layer; bv, vb, vbl = basal vacuolar layer; ec = external cortical layer; fl = fibrillar layer; fm = fibrillar median layer; gl = granular layer; he = hemidesmosome; hy = hypodermis; i = longitudinal incisure; ic = internal cortical layer; l = line; li = intestine lumen; lm = limiting membrane; md = median dense layer; ml = median layer; sm = somatic muscles; u = uterine wall.

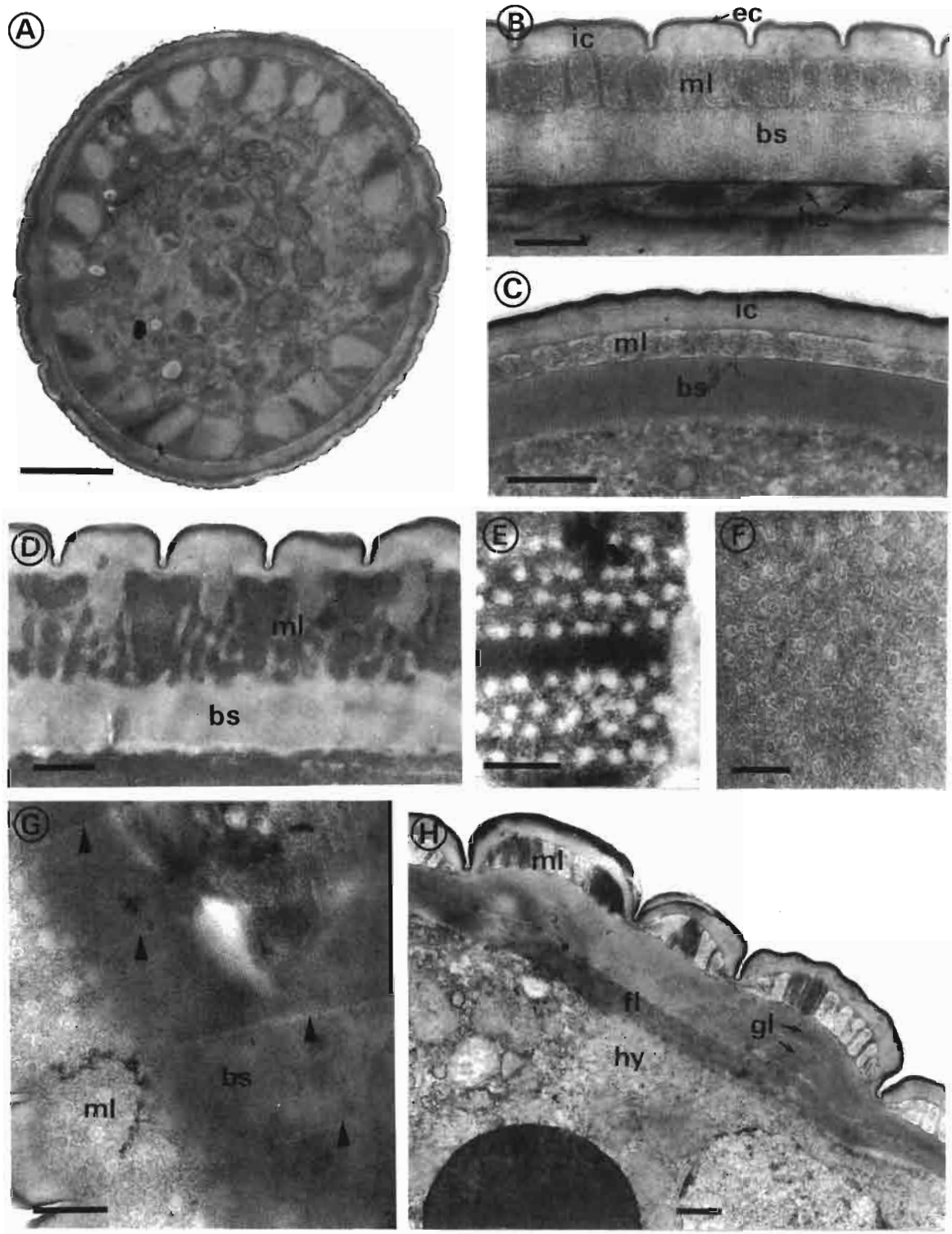

Fig. 2. Cuticle fine structure of *Tylenchorhynchus ventralis* females in longitudinal (LS), cross (CS) and tangential (TS) sections. A : CS near mid-body; B : LS at mid-body; C : CS at mid-body; D : LS of the prevulvar zone; E, F : TS showing median layer; G : TS of striated layer, showing transverse bands (arrowheads) without striae; H : CS of a lateral field. *(Bars : A = 5 µm; B-H = 0.5 µm).* Abbreviations : see Fig. 1.

The basal zone, whose basal striated layer becomes forked in cross-section in all species at the level of the two outer incisures. In *T. annulatus* this layer is replaced by two fibrillar layers and averages 1.20 μm in thickness. In *T. indicus* and *T. ventralis* it is replaced by two outer granular and two inner fibrillar layers and averages 1.00 μm (Fig. 2 H). In *T. vulgaris* five layers are present; the granular and fibrillar layers are separated by an electron-lucent layer; the total thickness of these five layers is about 0.60 μm (Fig. 3 E, F). The fibres in each fibrillar layer are oriented obliquely, forming an angle of about 30° with the longitudinal axis in *T. annulatus* (Fig. 1 F).

SPECIES WITH LONGITUDINAL RIDGES AND INCISURES OUTSIDE LATERAL FIELDS

In *T. gladiolatus*, the only species examined in this group, cross-sections at mid-body reveal 28 longitudinal incisures (Fig. 5 A); areas between these incisures appear in cross-section as ridges and *T. gladiolatus* should be considered as a species with adjacent longitudinal ridges : the cuticle thickness ranges from 0.16 μm at the level of incisures to 0.50 μm between them.

The cuticle outside lateral fields is composed of the following elements :

The cortical zone, consists of an external (0.03 μm) and an internal granular layer, ranging from 0.03 μm under the incisures to 0.13 μm between them (Fig. 5 B-D).

The median zone, is represented by an electron dense vacuolar layer of 0.20 μm in thickness (Fif. 5 B, D); the layer is absent under the incisures (Fig. 5 C, D).

The basal zone, consists of a striated layer averaging 0.13 μm in thickness; striations are radial and the layer is attached to somatic muscles by hemidesmosomes (Fig. 5 B, D).

The cuticle at the level of the lateral fields (Fig. 5 E-G; Fig. 4) shows thickness and incisures deepness identical to those outside lateral fields.

The cortical zone, is similar to previous observations outside lateral fields.

The median zone, remains unchanged.

The basal zone, shows a striated layer in cross-sections that becomes forked under the two outer incisures of the

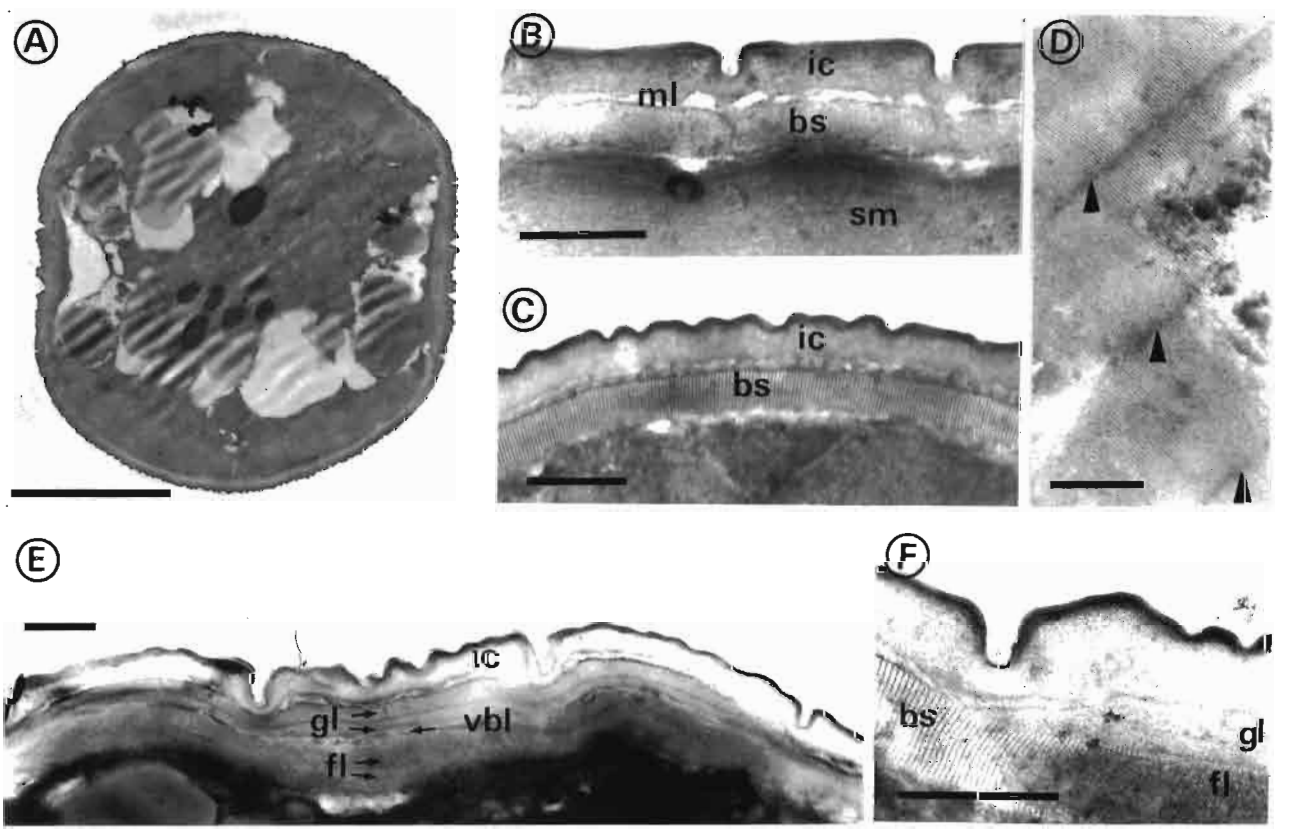

Fig. 3. Cuticle fine structure of *Tylenchorhynchus vulgaris* females in longitudinal (LS), cross (CS) and tangential (TS) sections. A : CS near mid-body; B : LS at mid-body level; C : CS at mid-body level; D : TS of basal striated layer; E : CS of a lateral field; F : CS showing an enlargement of the first incisure. *(Bars : A = 5 μm; B-F = 0.5 μm).*

Abbreviations : see Fig. 1.

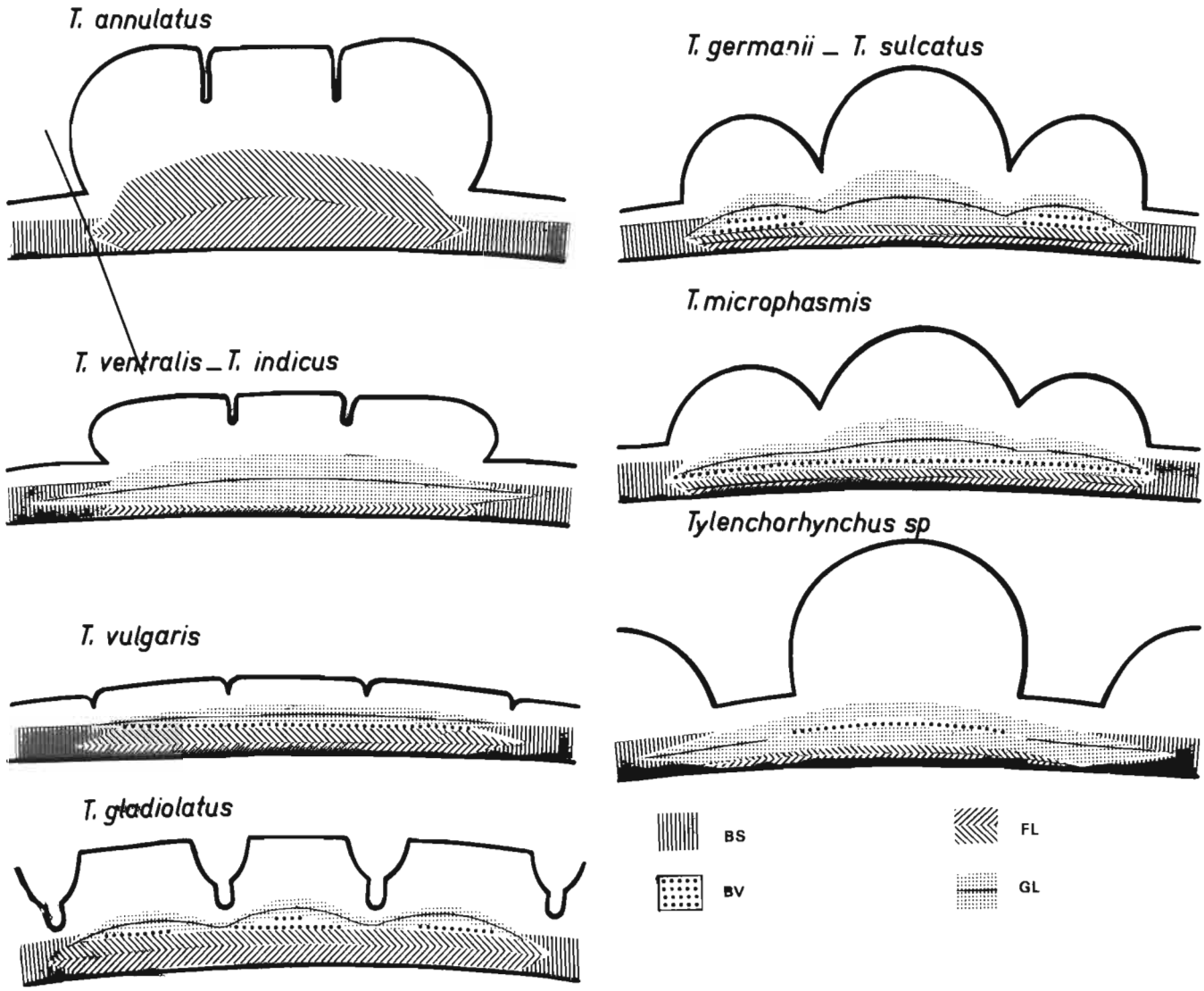

Fig. 4. Diagrams of lateral fields cross sections in females of the nine examined *Tylenchorhynchus* species showing the ultrastructure of the basal zone.

Abbreviations : see Fig. 1.

lateral fields; there it is replaced by five layers : two outer granular layers, an intermediate vacuolar layer appearing only between incisures and two fibrillar layers that join the hypodermis (Fig. 5 F, G).

SPECIES WITH LONGITUDINAL RIDGES OUTSIDE LATERAL FIELDS

The ultrastructure of the cuticle will be described for : *i)* areas between ridges outside lateral fields, *ii)* the ridges outside lateral fields, *iii)* the ridges of the lateral fields. Cuticle ultrastructure and thickness of *T. germanii* and *T. sulcatus* are similar and observations on the former species will be presented. *T. germanii, T. microphasmis* and *T. sulcatus* have sixteen longitudinal ridges extending over the entire body. Three ridges form each lateral field, the median one being larger than the two outer ones. The dorsal and ventral ridges are bordered on both sides by two sublateral ridges (Fig. 6 A; Fig. 7 A). Cross-sections of *Tylenchorhynchus* sp. at mid-body reveal twelve longitudinal ridges (Fig. 8 A). Only one ridge occurs in each lateral field.

T. germanii and *T. sulcatus*

Cross-sections at the level of the anterior part of the intestine show that the two ridges bordering immediately the dorsal and ventral ridges on both sides are less

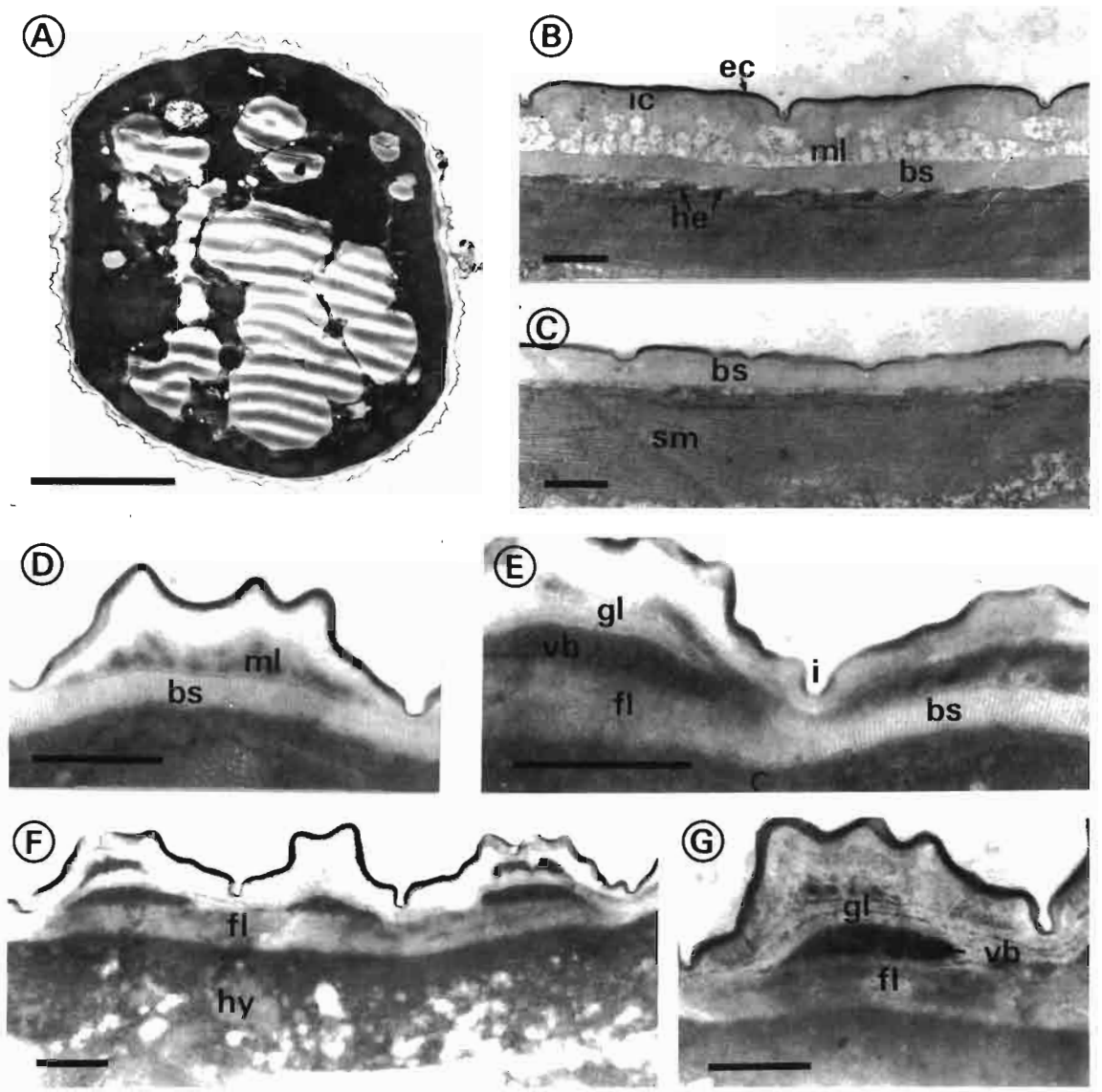

Fig. 5. Cuticle fine structure of *Tylenchorhynchus annulatus* females in longitudinal (LS), cross (CS) and tangential (TS) sections. A : CS near mid-body; B : LS at mid-body; C : CS at mid-body; D : CS of a lateral field showing two basal fibrillar layers; E : CS showing an enlargement of the first incisure; F : TS in fibrillar layers. *(Bars : A = 5 µm; B-F = 0.5 µm).*

Abbreviations : see Fig. 1.

prominent than the other ridges (Fig. 6 A). Near the vulva (Fig. 6 B), the ventral ridge disappears and all ridges are of more or less equal size. The cuticle thickness ranges from 0.40 µm to 2.20 µm at the level of ridges.

The cuticle between ridges outside lateral fields (Fig. 6 C, D) consists of : *i)* a trilaminate external and a granular internal cortical layer of respectively 0.03 µm and 0.13 µm in thickness; *ii)* a vacuolar median layer, averaging 0.12 µm in thickness and appearing in longitudinal sections as two electron-lucent ovoid structures under each annule (Fig. 6 D); *iii)* a basal striated layer, ranging from 0.22 µm to 0.33 µm in the middle of the annules. The periodicity of the striae in longitudinal and cross-sections is 0.02 µm and 0.03 µm respectively and the layer is attached to underlying somatic muscles by hemidesmosomes (Fig. 6 C, E).

The cuticle of the ridges outside lateral fields (Fig. 6 E-G)

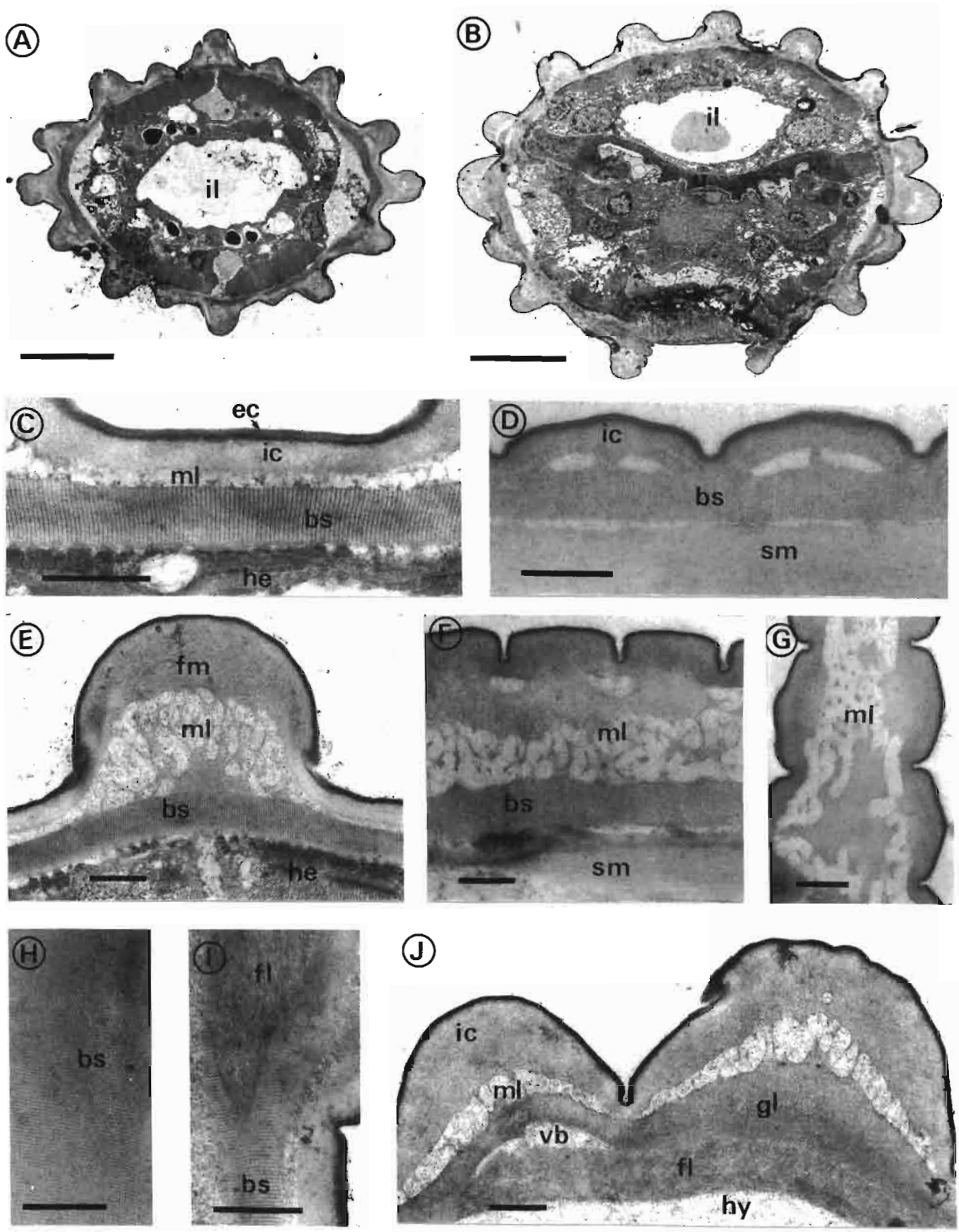

Fig. 6. Cuticle fine structure of *Tylenchorhynchus germanii* females in longitudinal (LS), cross (CS) and tangential (TS) sections. A : CS through anterior part of intestine; B : CS near vulva; C : CS between two ridges; D : LS between two ridges; E : CS of ridge; F : LS of a ridge; G : TS of a ridge; H : TS of basal striated layer; I : CS showing an enlargement of forked striated layer; J : CS of the median (at right) and one outer ridge of a lateral field. *(Bars : A, B = 5 µm; C-J = 0.5 µm).*

Abbreviations : see Fig. 1.

consists of : *i)* an external and internal cortical layer; *ii)* a median zone with an outer fibrillar layer of 0.50 µm in thickness and an inner vacuolar layer, averaging 0.95 µm. Cross and tangential sections (Fig. 6 E-G) show electron-lucent structures in a fibrillar matrix; *iii)* a basal striated layer as previously described between ridges.

The cuticle of the ridges of lateral fields (Fig. 4; Fig. 6 I, J) consists of : *i)* a typical cortical zone; *ii)* a vacuolar median layer, averaging 0.27 µm in the outer ridges and 0.50 µm in the middle one; *iii)* a basal zone, which under both the outer incisures, becomes forked in cross-sections and is replaced by five layers : two outer granular layers averaging 0.23 µm in thickness in the outer ridges and 0.70 µm in the median one; an intermediate vacuolar layer of 0.20 µm, appearing only in the outer ridges and two inner fibrillar layers averaging 0.42 µm in thickness and in contact with the hypodermis.

T. microphasmis

The cuticle thickness ranges from 0.90 µm between the ridges to 1.80 µm at their level; the longitudinal ridges are less prominent than in *T. germanii* and *T. sulcatus* (Fig. 7 A). The median ridge of each lateral field averages 2.30 µm in thickness. The cuticle ultrastructure outside lateral fields is similar to that of *T. germanii* and *T. sulcatus* females. A slight difference in the basal zone of the lateral fields is revealed by the continuity of the intermediate vacuolar layer along the three ridges (Fig. 4, Fig. 7 G); this layer appears embedded in one of the granular layers (Fig. 7 F, G).

Tylenchorhynchus sp.

The cuticle thickness ranges from 0.65 µm between the ridges to 2.50 µm at the level of the prominent longitudinal ridges (Fig. 8 A).

The cuticle between ridges outside lateral fields (Fig. 8 B, D) consists, as in *T. germanii,* of : *i)* an external and inner cortical layer, averaging 0.30 µm in thickness in the middle of the annules; *ii)* a discontinuous electronlucent median layer and *iii)* a striated basal layer, ranging from 0.18 µm to 0.35 µm in the middle of annules.

The cuticle of the ridges outside lateral fields (Fig. 8 C, E-G) can be distinguished into two types :

The cuticle of the dorsal and ventral ridges and their bordering ridges on both sides (total = 6) consists of : *i)* a typical cortical zone; *ii)* a median zone with a thick outer electron lucent fibrillar layer (1.00 µm) and an inner osmophilic layer whose thickness ranges from 0.12 µm in the middle of annules to 1.00 µm between them (Fig. 8 C); *iii)* a basal striated layer as previously described between ridges.

The ultrastructures of the cortical and median zone of the four ridges adjacent to the two single ridges of the lateral fields (Fig. 8 F) are similar to those of the other ridges; the basal striated layer, however, is forked in cross-section and replaced by two granular and two fibrillar layers (Fig. 4; Fig. 8 H).

The cuticle of lateral fields ridges (Fig. 4; Fig. 8 H). The main difference concerns the basal zone which consists of *i)* two outer granular layers separated by a thin electron-dense layer; *ii)* an intermediate electron-dense fibrillar layer; *iii)* an inner electron-lucent fibrillar layer in contact with hypodermis.

Discussion

The cuticle ultrastructure outside lateral fields in the four *Tylenchorhynchus* species without longitudinal ridges and incisures corresponds to previous observations on *T. annulatus* (Ibrahim, 1967) and *T. dubius* (Byers & Anderson, 1972) but parallel bands without striae in the basal striated layer occuring in *T. indicus, T. ventralis* and *T. vulgaris* were not observed by the previous authors.

Granular and fibrillar layers replacing the basal striated layer beneath the lateral fields were not observed in other phytoparasitic nematodes belonging to the Tylenchida (Kiesel *et al.,* 1972; Durnez *et al.,* 1973; B'Chir, 1979; Mounport *et al.,* 1991*b*) except in Hoplolaiminae (Mounport *et al.,* 1991*a*). However, few studies are reported on the ultrastructure of the lateral fields of Tylenchina. In belonolaimids, Ibrahim (1967) did not examine their fine structure in *T. annulatus* and Byers and Anderson (1972) observed an electron-lucent fibrillar layer in the basal part of the lateral fields of *T. dubius.*

T. gladiolatus, a species with longitudinal adjacent ridges, is distinct from the four other species with longitudinal ridges by *i)* the uniformity of the cuticle thickness all around the body, *ii)* the absence of the median layer beneath incisures and *iii)* the absence of the median fibrillar layer beneath ridges. Cross-sections of species with longitudinal ridges show in *T. germanii* two incisures in the lateral fields which are composed of three ridges instead of one (Germani & Luc, 1984). In *T. sulcatus* the longitudinal ridges are not adjacent but isolated from each other as in *T. germanii* and *T. microphasmis.* These ridges result from a thickening of the median zone of the cuticle. *Tylenchorhynchus* sp. is distinct from the three other species with longitudinal ridges by *i)* the fine structure of the median layer of the cuticle, *ii)* the basal layers of the lateral fields and *iii)* the absence of incisure in the lateral fields. In most phytoparasitic nematodes belonging to Tylenchida, lateral fields are marked in cross-sections by an interruption of the basal striated layer under both outer incisures (Johnson *et al.,* 1970; Byers & Anderson, 1972; Johnson, 1981; Mounport *et al.,* 1990). Only one ridge occurs in each lateral field of *Tylenchorhynchus* sp. and the basal striated layer in cross-sections stops under both ridges next to the lateral ridge. The fibrillar layers observed in the basal part of the lateral fields in *Tylenchorhynchus* sp. are different from those in the other species; these layers re-

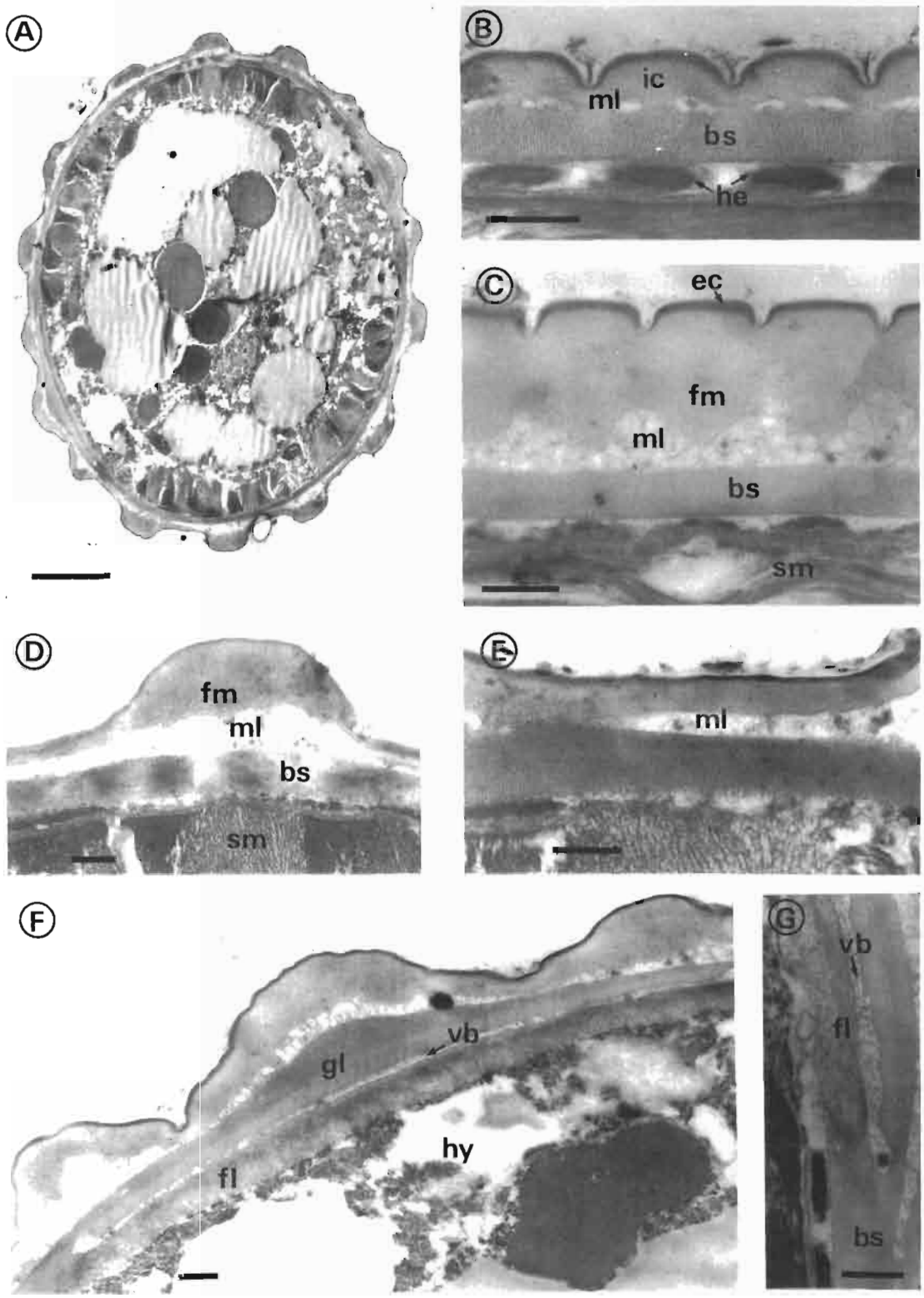

Fig. 7. Cuticle fine structure of *Tylenchorhynchus microphasmis* females in longitudinal (LS), and cross (CS) sections. A : CS at mid-body; B : LS between two ridges; C : LS of a ridge; D : CS of a ridge; E : CS between two ridges; F : CS of a lateral field; G : CS at the level of the first incisure showing the forked striated layer. *(Bars = A = 5 μm; B-G = 0.5 μm).*
Abbreviations : see Fig. 1.

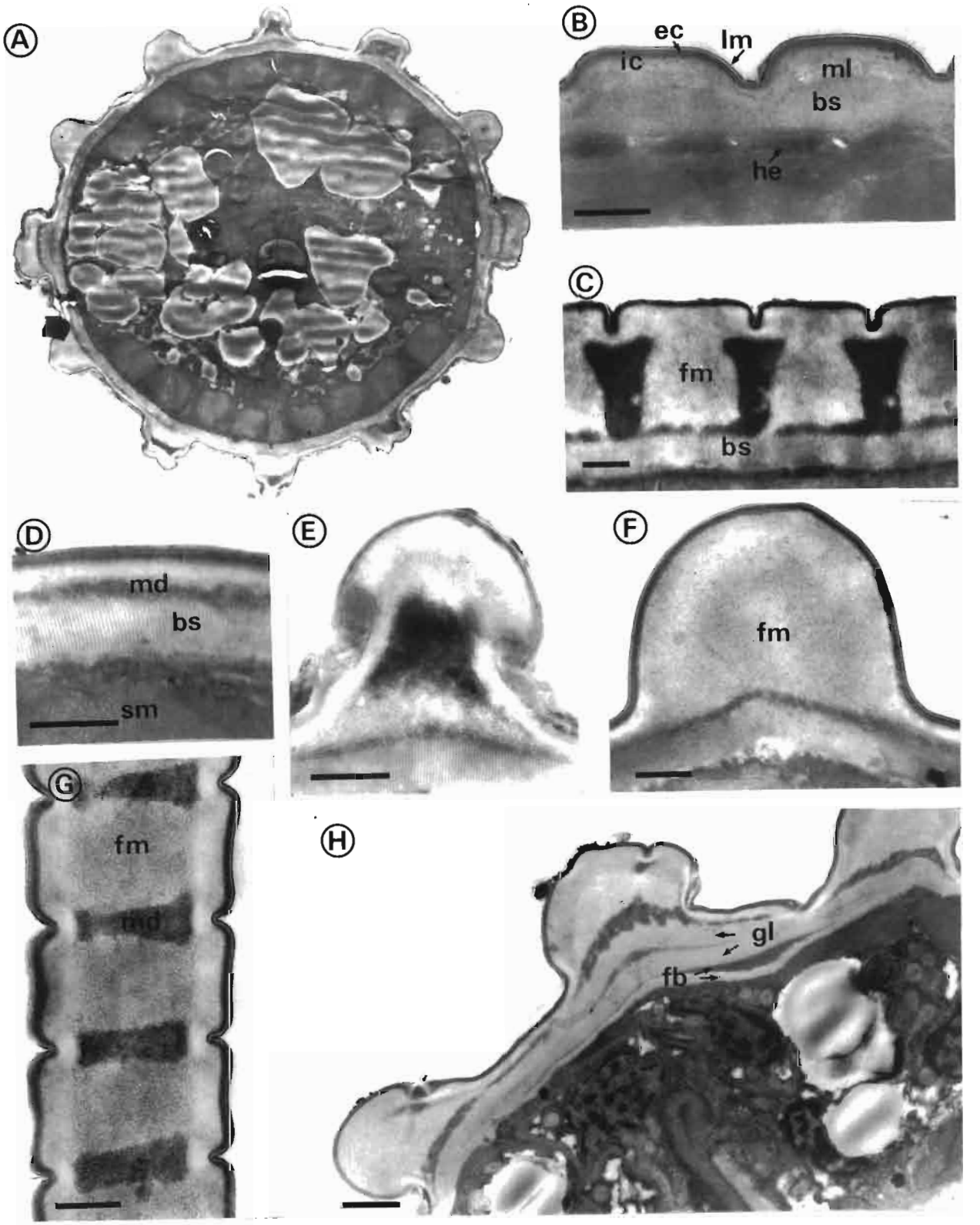

Fig. 8. Cuticle fine structure of *Tylenchorhynchus* sp. females in longitudinal (LS), cross (CS) and tangential (TS) sections. A : CS at mid-body; B : LS between two ridges; C : LS of a ridge; D : CS between two ridges; E : CS of a ridge between two annules; F : CS of a ridge in the middle of an annule; G : TS of a ridge; H : CS of a lateral field. *(Bars : A = 5 μm; B-H = 0.5 μm).*

Abbreviations : see Fig. 1.

semble those observed in the basal part of Hoplolaiminae, such as in *Helicotylenchus* and *Pararotylenchus* (unpubl.).

Conclusion

Five groups (Table 1) may be defined from the nine species studied on the basis of : *i)* number of layers in the median zone outside lateral fields; *ii)* pattern of the basal striated layer and *iii)* number and ultrastructure of layers replacing the striated basal layer under the lateral fields. Species of the first three groups were originally described in three different genera; species of two other groups include species whose generic diagnosis was modified several times during the last years *(Tylenchorhynchus → Dolichorhynchus → Neodolichorhynchus → Tylenchorhynchus).*

Previous studies on phytoparasitic nematodes belonging to the Tylenchida reported a constancy of cuticle layering at the generic level (Kisiel *et al.*, 1972; Shepherd *et al.*, 1972; De Grisse & Roose, 1975; Mounport *et al.*, 1990, 1991*a*, *b*). Several genera were synonymized with the genus *Tylenchorhynchus* by Fortuner and Luc (1987) based on the use of invalid criteria in the original descriptions. The present observations on nine species of *Tylenchorhynchus* let us suppose that the genus *Tylenchorhynchus* (Cobb, 1913) Fortuner & Luc (1987) might be composed of several genera which must be redefined. Morpho-biometrical criteria from light microscopic studies and morphological criteria from scanning electron microscopy are currently used in taxonomy, but little SEM information is available on the genus *Tylenchorhynchus* (Sher & Bell, 1975). Additional criteria obtained from transmission electron microscope (e.g. ultrastructure of the intestine, reproductive system, cuticle) may be usefully considered for a better diagnosis of the genera in the Belonolaimidae.

Table 1. Groups of species identified on the basis of the cuticule fine structure. (* = one layer between the ridges and two layers under the ridges; ** = hoplolamid pattern of the basal fibrous layers).

Group	Species	Number of layers in the median zone outside the lateral field	Number of layers in the basal zone the level of lateral fields	Pattern of the striated basal layer
1	*T. annulatus*	1	2	continuous
2	*T. indicus* *T. ventralis*	1	4	discontinuous
3	*T. vulgaris*	1	5	discontinuous
4	*T. gladiolatus*	1	5	continuous
5	*T. germanii* *T. sulcatus* *T. microphasmis*	1*, 2*	5	continuous
6	*T.* sp.	1*, 2*	5**	continuous

References

B'Chir, M. M. (1979). *Contribution à l'étude morphologique, anatomique et bioécologique de quelques espèces du genre* Aphelenchoides *(Nematoda : Aphelenchoidea).* Thèse, Univ. Montpellier, 206 p.

Byers, J. R. & Anderson, R. V. (1972). Ultrastructural morphology of the body wall, stoma and stomatostyle of the nematode *Tylenchorhynchus dubius* (Buetschli, 1873) Filip'ev, 1936. *Canad. J. Zool.*, 50 : 457-465.

De Grisse, A. & Roose, D. (1975). The ultrastructure of the vulva region in *Scutellonema cavenessi* Sher, 1964 (Nematoda : Hoplolaimidae). *Meded. Fac. Landbouww. Rijksuniv. Gent,* 40 : 501-510.

Durnez, C., De Grisse, A. & Gillard, A. (1973). Elektronen mikroskopische studie van de cuticulastruktur van de lichaamswand bij *Rotylenchus robustus* (Nematoda : Hoplolaimidae). *Meded. Fac. Landbouww. Rijksuniv. Gent,* 38 : 1329-1350.

Fortuner, R. & Luc, M. (1987). A reappraisal of Tylenchina (Nemata). 6. The family Belonolaimidae Whitehead, 1960. *Revue Nématol.*, 10 : 183-202.

Germani, G. & Luc, M. (1984). Description de *Dolichorhynchus elegans* n. sp. et *Aphasmatylenchus variabilis* n. sp. (Nematoda : Tylenchida). *Revue Nématol.*, 7 : 81-86.

Ibrahim, I. K. A. (1967). Morphological differences between the cuticle of swarming and non-swarming *Tylenchorhynchus martini. Proc. helminth. Soc. Wash.*, 34 : 18-20.

Jairajpuri, M. S. & Hunt, D. J. (1984). The taxonomy of Tylenchorhynchinae (Nematoda : Tylenchida) with longitudinal lines and ridges. *Syst. Parasitol.*, 6 : 261-268.

Johnson, P. W. (1981). Observations on the cuticle ultrastructure of *Meloidogyne hapla* males. *J. Nematol.*, 13 : 231-233.

Johnson, P. W., Van Gundy, S. D. & Thomson, W. W. (1970). Cuticle ultrastructure of *Hemicycliophora arenaria, Aphelenchus avenae, Hirschmanniella gracilis* and *Hirschmanniella belli. J. Nematol.*, 2 : 42-58.

Kisiel, M., Himmelhoch, S. & Zuckerman, B. M. (1972). Fine structure of the body wall and vulva area of *Pratylenchus penetrans. Nematologica,* 18 : 234-238.

Maggenti, A. R. (1979). The role of cuticle strata nomenclature in the systematics of Nemata. *J. Nematol.*, 11 : 94-98.

Mounport, D., Baujard, P. & Martiny, B. (1990). Étude ultrastructurale de la cuticule de *Pratylenchus brachyurus, P. loosi* et *P. sefaensis* (Nemata : Pratylenchidae). *Revue Nématol.*, 13 : 249-254.

Mounport, D., Baujard, P. & Martiny, B. (1991*a*). Ultrastructure de la cuticule et de la région vaginale de *Scutellonema bradys, S. cavenessi* et *S. clathricaudatum* (Nemata, Hoplolaimidae). *Revue Nématol.*, 14 : 291-297.

MOUNPORT, D., BAUJARD, P. & MARTINY, B. (1991*b*). Cuticle ultrastructure of *Criconemella curvata* and *Criconemella sphaerocephala* (Nemata : Criconematidae). *J. Nematol.,* 23 : 99-103.

MULK, M. M. & JAIRAJPURI, M. S. (1974). Proposal of a new genus *Dolichorhynchus* and a new species *Dolichorhynchus nigericus* (Nematoda : Dolichodoridae). *Indian J. Zool.,* 2 : 15-18.

REYNOLDS, E. S. (1963). The use of lead citrate at high pH as an electron-opaque stain in electron microscopy. *J. Cell Biol.,* 17 : 208-212.

SHEPHERD, A. M., CLARK, S. A. & DART, P. J. (1972). Cuticle structure in the genus *Heterodera. Nematologica,* 18 : 1-17.

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.

SPURR, A. R. (1969). A low-viscosity epoxy resin embedding medium for electron microscopy. *J. Ultrastr. Res.,* 26 : 31-43.