

## Scanning electron microscopy observations on Telotylenchinae SIDDIQI, 1960 (Nemata : Belonolaimidae).

### 3. The genus *Tylenchorhynchus* COBB, 1913.

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#### Abstract

Ten species of the genus *Tylenchorhynchus* were studied under SEM. Observations showed the great heterogeneity of the genus according to the head pattern and confirmed the absence of validity of some characters at the taxonomic level (number of incisures in the lateral field, presence vs absence of longitudinal ridges, presence vs absence of notch on the bursa). Four to five different head patterns can be recognized, corresponding to the cuticle ultrastructure patterns previously defined. *Bitylenchus* is considered as a junior synonym of *Tylenchorhynchus*, and *B. pratensis* and *B. serranus* are transferred to the genus *Tylenchorhynchus*.

**Keywords :** Nemata, Belonolaimidae, *Tylenchorhynchus*, morphology, scanning electron microscopy.

#### Résumé

Dix espèces du genre *Tylenchorhynchus* ont été étudiées en microscopie électronique à balayage. Les observations révèlent une hétérogénéité considérable des structures céphaliques externes et confirment l'absence de validité de certains caractères morphologiques au niveau taxonomique (nombre d'incisures dans les champs latéraux, présence vs absence de crêtes longitudinales, présence vs absence d'échancrure sur la bursa). Les structures céphaliques externes peuvent être groupées en quatre à cinq types différents qui correspondent à ceux définis précédemment sur l'ultrastructure de la cuticule. *Bitylenchus* est considéré comme un synonyme mineur du genre *Tylenchorhynchus*, et les espèces *B. pratensis* et *B. serranus* sont transférées au genre *Tylenchorhynchus*.

**Mots-clé :** Nemata, Belonolaimidae, *Tylenchorhynchus*, morphologie, microscopie électronique à balayage.

#### Introduction

Recent studies on the taxonomy of the genus *Tylenchorhynchus* (SIDDIQI, 1986, FORTUNER & LUC, 1987) are principally based on morphological and biometrical characters observed in light microscopy. Of the 130 species listed in the genus *Tylenchorhynchus* (FORTUNER & LUC, 1987), little is known on their morphology as seen under scanning electron microscopy (SEM). Previous studies (SHER & BELL, 1975; LEWIS & GOLDEN, 1981; VOVLAS & CHAM, 1981; JAIRAJPURI & HUNT, 1984; SAUER, 1985; LOPEZ & SALAZAR, 1987; VOVLAS &

CHENG, 1988; RASHID & HEYNS, 1990; ZEIDAN & Geraert, 1990; LAL & HINES, 1991; GOMEZ BARCINA *et al.*, 1992) reveal great differences, particularly in the head face view, between species of *Tylenchorhynchus*. More recently, MOUNPORT *et al.*, (1993) compared the ultrastructure of the cuticle of nine species of the genus concluding that it might be composed of several genera which must be redefined on the basis of light and scanning electron microscopy.

This work presents the results of observations on ten species belonging to the genus *Tylenchorhynchus*, some of them previously described and/or transferred in genera presently considered as synonyms of *Tylenchorhynchus* (see FORTUNER & LUC, 1987): *Bitylenchus* FILIP'EV, 1934, *Telotylenchus* SIDDIQI, 1960, *Dolichorhynchus* MULK & JAIRAJPURI, 1974, *Neodolichorhynchus* JAIRAJPURI & HUNT, 1984. Nine of these species were studied by MOUNPORT *et al.* (1993).

#### Material and methods

##### SPECIES STUDIED

- Tylenchorhynchus annulatus* (CASSIDY, 1930) GOLDEN, 1971.  
syn. *Tylenchorhynchus martini* FIELDING, 1956.  
*Tylenchorhynchus germanii* FORTUNER & LUC, 1987.  
syn. *Dolichorhynchus (Dolichorhynchus) elegans* GERMANI & LUC, 1984.  
*Tylenchorhynchus elegans* (GERMANI & LUC, 1984) FORTUNER & LUC, 1987 (nec *T. elegans* SIDDIQI, 1961).  
*Tylenchorhynchus gladiolatus* FORTUNER & AMOUGOU, 1973.  
syn. *Dolichorhynchus (Neodolichorhynchus) gladiolatus* (FORTUNER & AMOUGOU, 1973) MULK & SIDDIQI, 1982.  
*Neodolichorhynchus gladiolatus* (FORTUNER & AMOUGOU, 1973) JAIRAJPURI & HUNT, 1984.  
*Tylenchorhynchus indicus* (SIDDIQI, 1960) FORTUNER & LUC, 1987.  
syn. *Telotylenchus indicus* SIDDIQI, 1960.  
*Tylenchorhynchus mashhoodi* SIDDIQI & BASIR, 1959.  
*Tylenchorhynchus microphasmis* LOOF, 1960.  
syn. *Dolichorhynchus (Neodolichorhynchus) microphasmis* (LOOF, 1960) MULK & SIDDIQI, 1982.

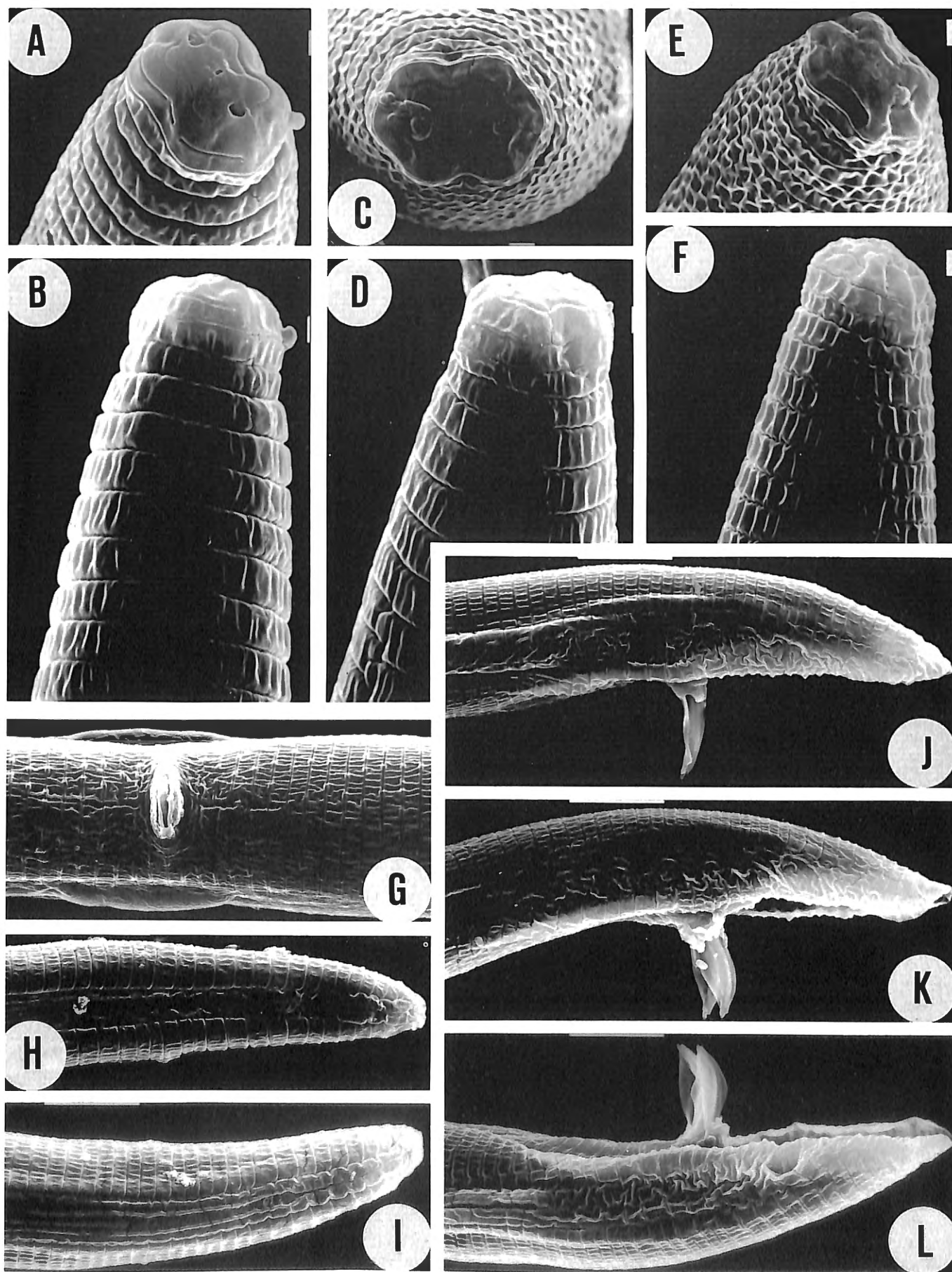


Fig. 1 – *Tylenchorhynchus mashhoodi* females (A-D, G-I) and males (E-F, J-L). A and B, C and D, E and F : respectively in face and lateral view of the same specimen; G : vulvar region; H-L : tails; A-F : scale bar = 1  $\mu$ m; G-L : scale bar = 10  $\mu$ m.

*Neodolichorhynchus microphasmis* (LOOF, 1960) JAI-RAJPURI & HUNT, 1984.

*Tylenchorhynchus sulcatus* DE GUIRAN, 1967.

syn. *Dolichorhynchus* (*Neodolichorhynchus*) *sulcatus* (de Guiran, 1967) MULK & SIDDIQI, 1982.

*Neodolichorhynchus sulcatus* (DE GUIRAN, 1967) JAI-RAJPURI & HUNT, 1984.

*Tylenchorhynchus ventralis* (LOOF, 1963) FORTUNER & LUC, 1987.

syn. *Telotylenchus ventralis* LOOF, 1963.

*Tylenchorhynchus vulgaris* UPADHYAY, SWARUP & SETHI, 1972.

syn. *Bitylenchus vulgaris* (UPADHYAY, SWARUP & SETHI, 1972) SIDDIQI, 1986.

*Tylenchorhynchus phaseoli* SETHI & SWARUP, 1968.

syn *Dolichorhynchus* (*Dolichorhynchus*) *phaseoli* (SETHI & SWARUP, 1968) MULK & JAIRAJPURI, 1974.

= *Tylenchorhynchus* sp. in MOUNPORT *et al.*, 1993.

#### ORIGIN OF SPECIMENS

*T. annulatus*: two populations originating from Richard-Toll, Senegal in 1982 ("CSS" population) and from samples taken along the road Kaffrine-Koungheul, Senegal ("KK" population) in 1984 and paratypes of *T. martini* originating from the Riverside Nematode Collection, University of California, U.S.A.

*T. germanii*: topotypes from Patar, Senegal in 1984.

*T. gladiolatus*: Nebe, Senegal in 1986.

*T. indicus*: Thienaba, Senegal in 1988.

*T. mashhoodi*: Tara, Niger in 1990.

*T. microphasmis*: The Netherlands (sent by Dr. F.C. ZOON).

*T. sulcatus*: N'Dindy, Senegal in 1982.

*T. ventralis*: Louga, Senegal in 1982.

*T. vulgaris*: Agadez region, Niger in 1987.

*T. phaseoli*: Aogadut region, Niger in 1987.

#### PREPARATION OF SPECIMENS FOR SEM STUDIES

Except for the paratypes of *T. martini* and specimens of *T. microphasmis*, the other species were cultured at constant soil temperature and soil moisture (Table 1) on *Sorghum vulgare* L. in the laboratory since the sampling date, extracted by elutriation (SEINHORST, 1962), killed by gentle heating (60° C) during 30 seconds and then processed without fixation for SEM as described by BAUJARD and PARISELLE (1987). Specimens of *T. microphasmis* were obtained in fixative and processed by the same technique. Paratypes of *T. martini* and some specimens of *T. indicus* and *T. ventralis* were processed for SEM and photographed by Dr. BELL as described by SHER & BELL (1975).

In order to evaluate a possible variability in the morphological characters, several specimens extracted at different times were studied for each species from laboratory cultures (Table 1).

Table 1 :

Laboratory culture conditions and number of specimens observed under SEM.

| Species               | Soil temperature and moisture | Extraction date                        | Number of specimens observed (females-males) |
|-----------------------|-------------------------------|--|--|
| <i>T. annulatus</i>   |                               |  |  |
| "KK" population       | 34°-10 %                      | 28.02.1986<br>11.05.1987<br>21.01.1991 | 30<br>42<br>30                               |
| "CSS" population      | 34°-10 %                      | 05.03.1986<br>13.12.1986<br>23.01.1991 | 30<br>30<br>30                               |
| <i>T. germanii</i>    | 34°-10 %                      | 20.11.1986<br>14.02.1991               | 22-30<br>30-30                               |
| <i>T. gladiolatus</i> | 30°-10 %                      | 01.12.1986<br>25.05.1987<br>27.03.1990 | 29-21<br>26-23<br>30-30                      |
| <i>T. indicus</i>     | 34°-10 %                      | 08.12.1986                             | 28-30  |
| <i>T. mashhoodi</i>   | 34°-10 %                      | 19.03.1991                             | 30-30  |
| <i>T. sulcatus</i>    | 34°-10 %                      | 24.11.1986<br>26.03.1991<br>24.01.1992 | 20-20<br>30-30<br>30-30                      |
| <i>T. ventralis</i>   | 34°-10 %                      | 12.12.1986<br>12.03.1990               | 15-4<br>30-30                                |
| <i>T. vulgaris</i>    | 30°-10 %                      | 26.05.1988<br>24.01.1992<br>13.07.1992 | 30<br>30<br>30                               |
| <i>T. phaseoli</i>    | 36°-10 %                      | 25.04.1988<br>10.06.1988<br>08.03.1991 | 30<br>30<br>30                               |

#### Results

##### HEAD

*T. mashhoodi* (Fig.1, A-F), the two Senegalese populations of *T. annulatus* and *T. martini* paratypes (Fig. 2, A-I): head square like in lateral view; cephalic constriction absent; in front view, head rounded to laterally elongated with six more or less pronounced longitudinal depressions, two dorso-ventral and four submedial; three to four cephalic annuli present; oral aperture a dorso-ventral slit surrounded by a small rim itself surrounded by six labial sensilla; labial disc not prominent, squarish to four lobed, demarcated by an incisure interrupted by the amphid apertures; first cephalic annulus not differentiated into lip sectors; amphid aperture laterally situated at the edge of the labial disc, circular (occurrence: 27 % in the "CSS" population and 17 % in the "KK" population) to ovoid, the longer axis being dorso-ventrally orientated (occurrence: 73 % in the

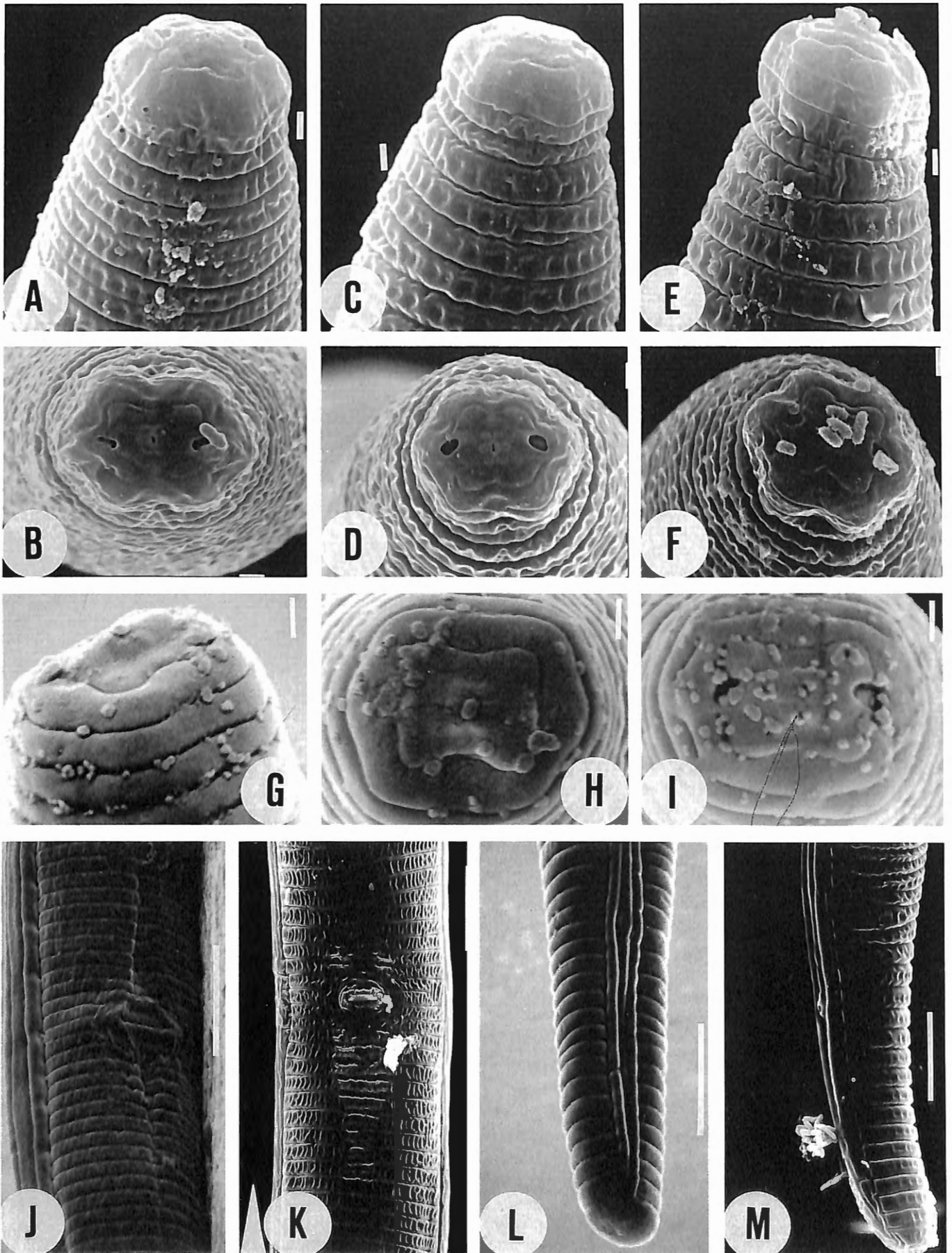


Fig. 2 – *Tylenchorhynchus annulatus*, females; A-F : “CSS” population, G-J, L : paratypes of *T. martini*; K, M : “KK” population. A-I : heads (A and B, C and D, E and F, G and H : respectively lateral and in front view of the same specimen); J-K : vulvar region (the white arrow shows the direction of the anterior region); L-M : tails; A-I : scale bar = 1  $\mu\text{m}$ ; J-M : scale bar = 10  $\mu\text{m}$ .



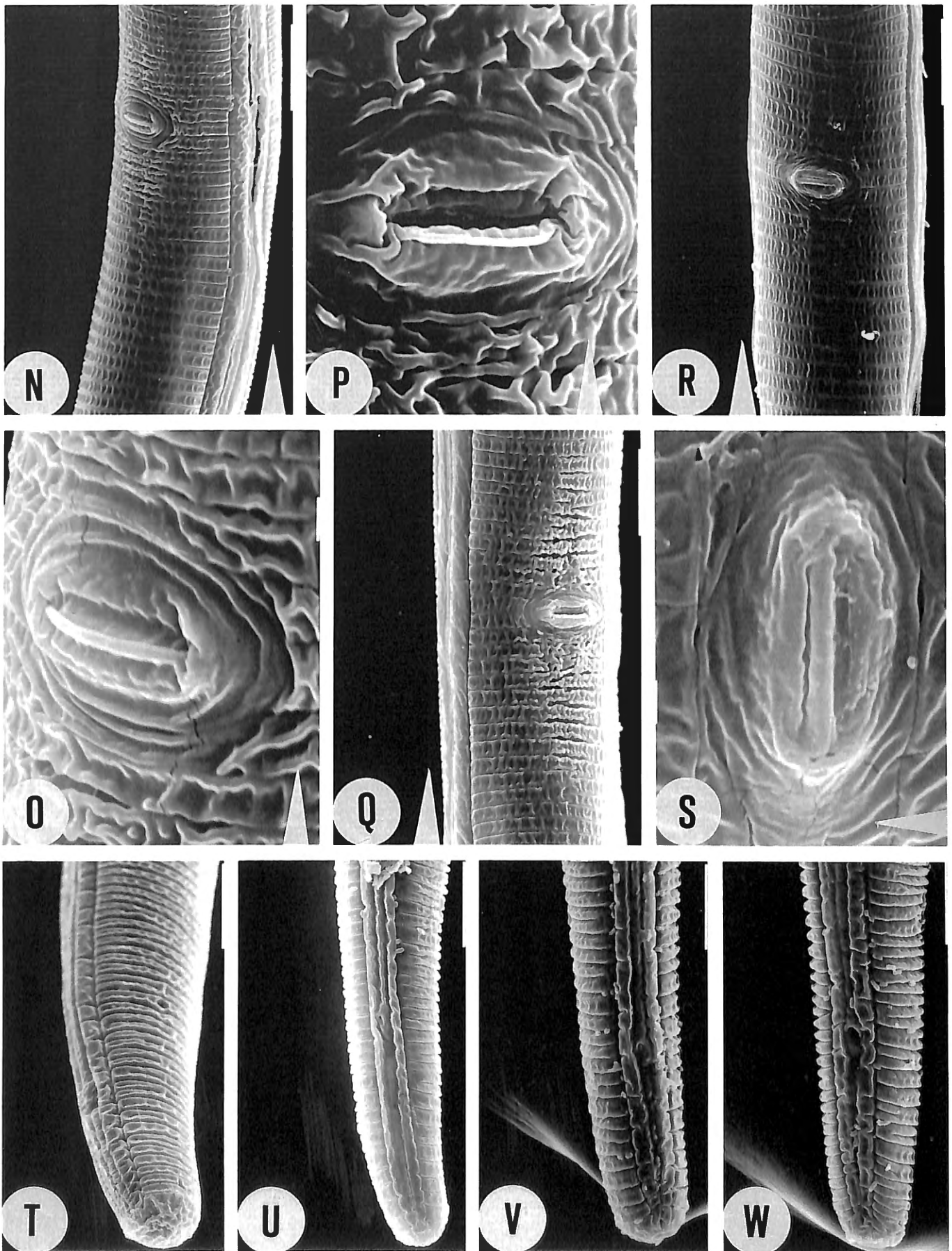


Fig. 3 – *Tylenchorhynchus annulatus*, females of the “CSS” population. N and O, Q and P, R and S : respectively vulvar region and vulva of the same specimen (the white arrow shows the direction of the anterior region); T-W : tails; N, Q, R-W : scale bar = 10  $\mu$ m; O, P, S : scale bar = 1  $\mu$ m.

“CSS” population and 83 % in the “KK” population). No sexual dimorphism in head morphology.

*T. gladiolatus* (Fig. 4) and *T. vulgaris* (Fig. 6) : head rounded in lateral view; cephalic constriction present; in front view, head rounded to laterally elongated with or without two dorso-ventral longitudinal depressions giving a bilobed appearance when present and two lateral longitudinal slits below the amphid aperture; six to ten cephalic annuli present; oral aperture circular surrounded by a small rim itself surrounded by 6 labial sensilla; labial disc non prominent, four lobed, demarcated by an incisure interrupted by the amphid apertures; in some specimens, this incisure is also interrupted ventrally and/or dorsally; some supplementary incisures present on the lobes of the labial disc giving the appearance of differentiated submedial lip sectors; first cephalic annulus not differentiated into lip sectors; amphid aperture circular, with a contour more or less convoluted, laterally situated at the edge of the labial disc, prolonged by a longitudinal incisure until the cephalic constriction.

*T. indicus* (Fig. 8), *T. ventralis* (Figs. 10 : A-H, 11 : O-T) : head rounded in lateral view; cephalic constriction present; in front view, head rounded with two slight dorso-ventral longitudinal depressions giving a bilobed appearance and with two to seven short longitudinal slits below the amphids up to the fifth cephalic annulus; the transverse annulation disappears between these longitudinal slits; seven to eight cephalic annuli present; oral aperture dorso-ventrally elongated, without rim, surrounded by six labial sensilla; labial disc slightly demarcated, not prominent, squarish; first cephalic annulus without lateral sectors and with submedial sectors partially fused to the labial disc; amphid aperture circular, laterally situated at the edge of the labial disc. Sexual dimorphism present in head morphology : male heads with the four submedial lip sectors prominent separated or not from the labial disc by an incisure (Figs 8 : C, E, G; 11 : O-T); head face asymmetrical, the ventral side being wider than the dorsal one (Figs 8 : E-G; 11 : Q, P-T).

*Tylenchorhynchus microphasmis* (Figs. 12 : A-D; 13 : O-R) : head morphology similar to that observed in *T. indicus* and *T. ventralis* except *i*) two dorso-ventral longitudinal depressions more pronounced (Fig. 12 : B, D) and sometimes transformed into a deep incisure (Fig. 12 : C) and *ii*) submedial lip sectors more prominent (Fig. 12 : B-D) with a partial (Fig. 12 : B) to complete incisure (Fig. 12 : C-D) separating them from the labial disc. Sexual dimorphism as in *T. indicus* and *T. ventralis* with sometimes a complete disorganization of the labial disc and first cephalic annulus (Fig. 13 : Q).

*T. phaseoli* (Fig. 14 : A-D) : head morphology similar to

that of *T. microphasmis* except *i*) two dorso-ventral longitudinal depressions never transformed into incisures, *ii*) absence of longitudinal slits below the amphid apertures, *iii*) presence of a small cuticular rim around the amphid apertures, forming the two lateral lip sectors (Fig. 14 : C-D), *iv*) rounded appearance of the labial disc demarcated by a circular groove (Fig. 14 : B-D).

*T. germanii* (Fig. 16 : A-K), *T. sulcatus* (Figs. 19 : A-D; 20 : O-R) : head morphology similar to that of *T. microphasmis* except for *i*) small circular labial disc, *ii*) complete separation of the submedial lip sectors from the labial disc and *iii*) discrete dorso-ventral deformation of the male heads.

#### LONGITUDINAL ORNAMENTATIONS OUTSIDE THE LATERAL FIELD

No longitudinal ornamentations outside the lateral fields are observed in *T. annulatus* (Figs. 2 : L-M; 3 : N, Q, T-W), *T. indicus* (Fig. 9), *T. mashhoodi* (Fig. 1 : G-L) and *T. ventralis* (Figs. 10 : I-N; 11 : U-V). In *T. vulgaris*, longitudinal incisures are observed only in the anterior region of the body, between the head and the beginning of the lateral fields (Figs. 6, 7). In *T. germanii*, *T. gladiolatus*, *T. microphasmis*, *T. sulcatus* and *T. phaseoli*, longitudinal ridges are observed all along the body; these ridges are contiguous in *T. gladiolatus* and well separated in the four other species (Figs. 4, 5, 12-20).

#### LATERAL FIELD

Three bands are observed in the lateral field of all these species except in *T. phaseoli* where the lateral field is constituted by a unique ridge not demarcated by incisures (Fig. 15 : J-L, O-T); four incisures delimit the three contiguous bands in *T. annulatus* (Figs. 2 : L-M; 3 : N, T-W), *T. gladiolatus* (Fig. 5), *T. indicus* (Fig. 9), *T. mashhoodi* (Fig. 1 : H-L), *T. ventralis* (Figs. 10 : I-N; 11 : U-V), *T. vulgaris* (Fig. 7) and the ridges in *T. germanii* (Fig. 17 : M, R, U), *T. microphasmis* (Figs. 12 : E, G; 13 : S-T), *T. sulcatus* (Figs. 19 : E-H; 20 : S-T).

The central band/ridge ends on tail at or immediately posterior to phasmid level in all the species (Figs. 1 : H-L, 2 : L-M; 3 : T-W; 5 : J-M; 7 : J-K; 9 : K-L; 10 : M-N; 13 : K-M; 17 : S-V; 19 : K-N) except in *T. phaseoli* (Fig. 15 : O-T) where the unique ridge of the lateral field reaches the tail end.

Areolations in the lateral fields : they are few, erratic and present only on the two outer bands in *T. annulatus* (Figs. 2 : L-M; 3 : N, T-W) and *T. mashhoodi* (Fig. 1 : H-L); in *T. gladiolatus* (Fig. 5), *T. indicus* (Fig. 9), *T. ventralis* (Figs. 10 : I-N; 11 : U-V), *T. vulgaris* (Fig. 7), *T. germanii* (Fig. 17 : M, R, U), *T. microphasmis* (Figs. 12 : E, G; 13 : S-T) and *T. sulcatus* (Figs. 19 : E-H; 20 : S-T), the three bands are regularly areolated, the areola-

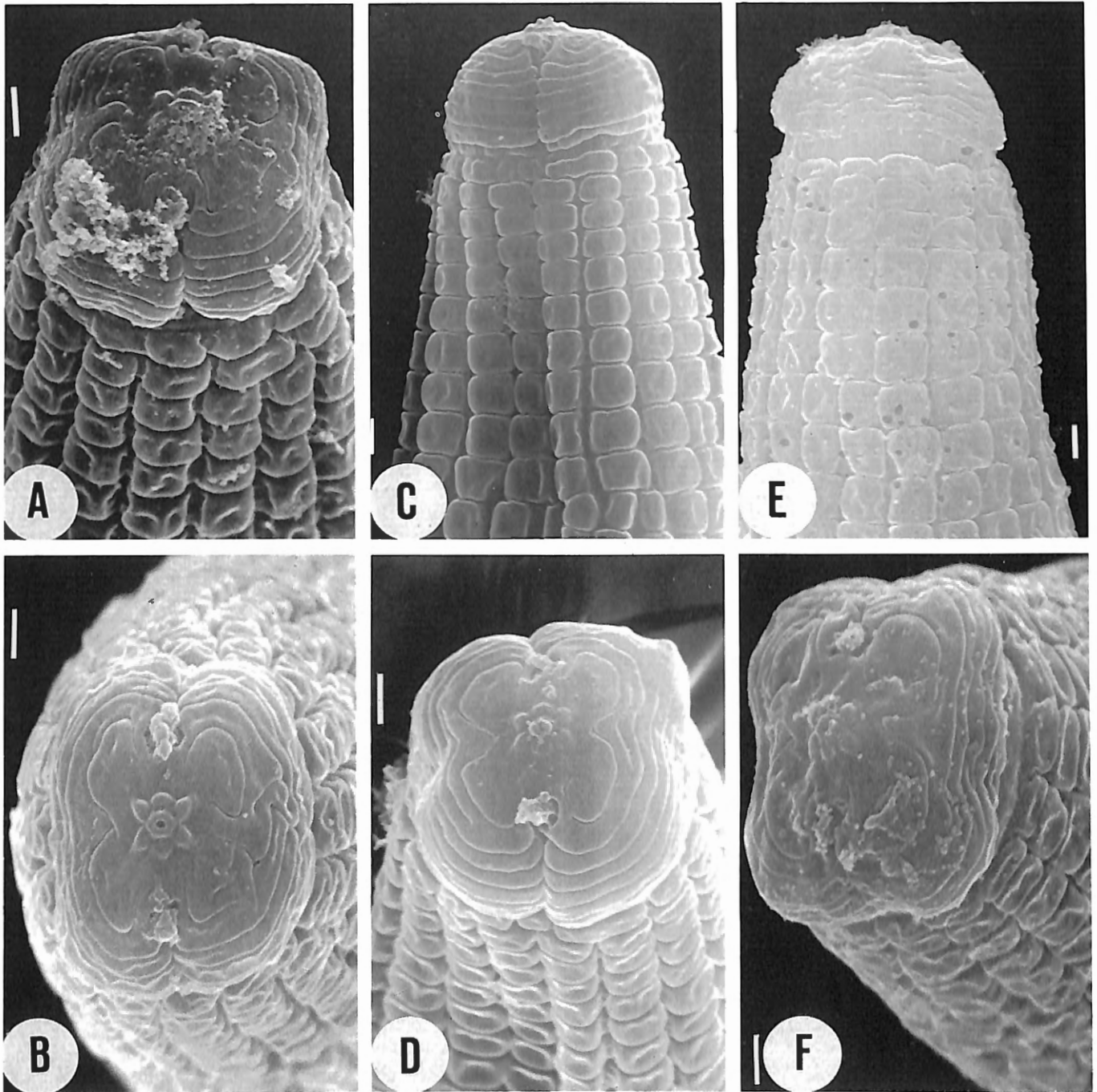


Fig. 4 – *Tylenchorhynchus gladiolatus*, females (A-D) and males (E-F) heads. A, B : in front views; C and D, E and F : respectively lateral and in front view of the same specimen; scale bar = 1  $\mu\text{m}$ .

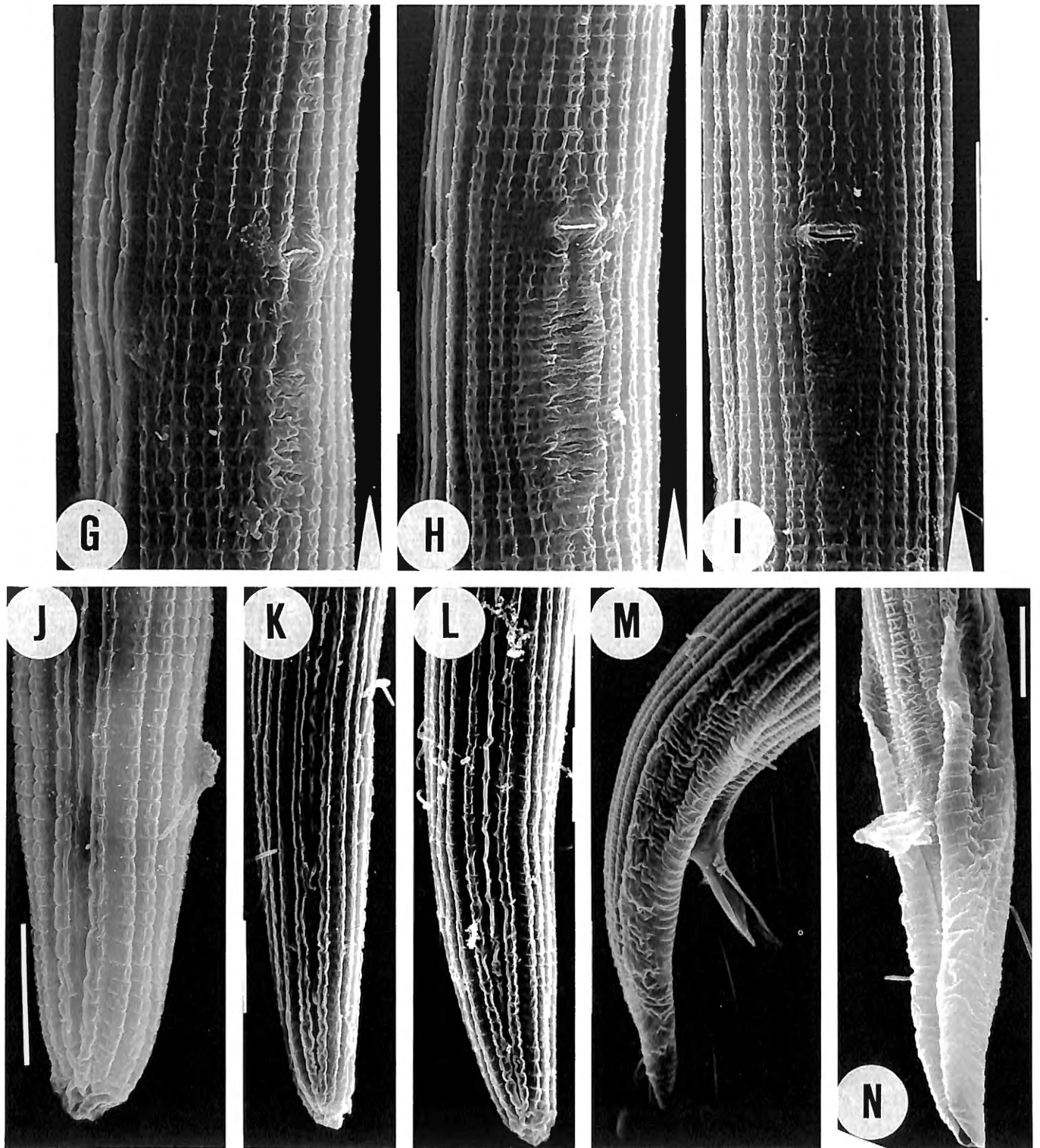


Fig. 5 – *Tylenchorhynchus gladiolatus*, females (G-L) and males (M-N). G-I : vulvar region (the white arrow shows the direction of anterior region); J-N : tails; scale bar = 10  $\mu$ m.



tions being two times more spaced than the transverse body annulation.

#### VULVA AND VENTRAL ORNAMENTATIONS IN THE VULVAR REGION

In all the species studied, the vulva appeared as a transverse slit with two slightly prominent anterior and posterior lips; in some specimens of all these species, one or two non prominent lips (epiptygma) appearing

white on SEM photographs are observed inside the vulvar slit (Figs. 1 : G; 2 : K; 3 : N-S; 5 : G-I; 7 : F-I; 9 : H-J; 10 : I-L; 12 : F, H-I; 15 : H-K; 17 : N-Q; 19 : G). Lateral vulvar membranes (flaps) are absent in all the species; in the species with ridges, the transverse vulvar opening is always lined by two slightly indented longitudinal ridges : *T. gladiolatus* (Fig. 5 : G-I), *T. microphasmis* (Figs. 12 : F, H-I; 13 : J), *T. phaseoli* (Fig. 15 : J-K), *T. germanii* (Fig. 17 : N-Q), *T. sulcatus* (Fig. 19 : G, I).

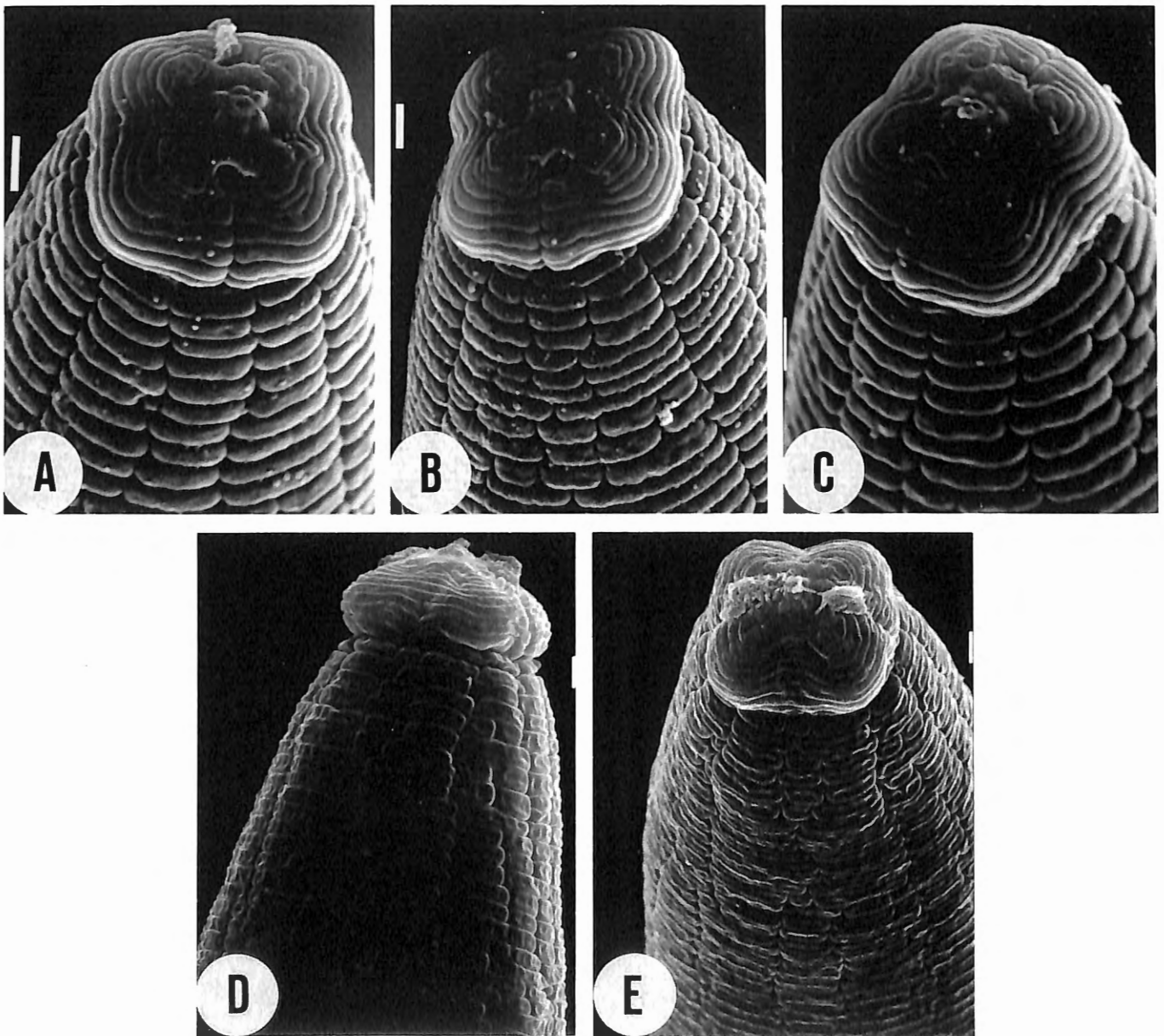


Fig. 6 – *Tylenchorhynchus vulgaris*, females heads. A, B, C : in front view; D : lateral view; D and E : respectively lateral and in front view of the same specimen; scale bar = 1  $\mu$ m.

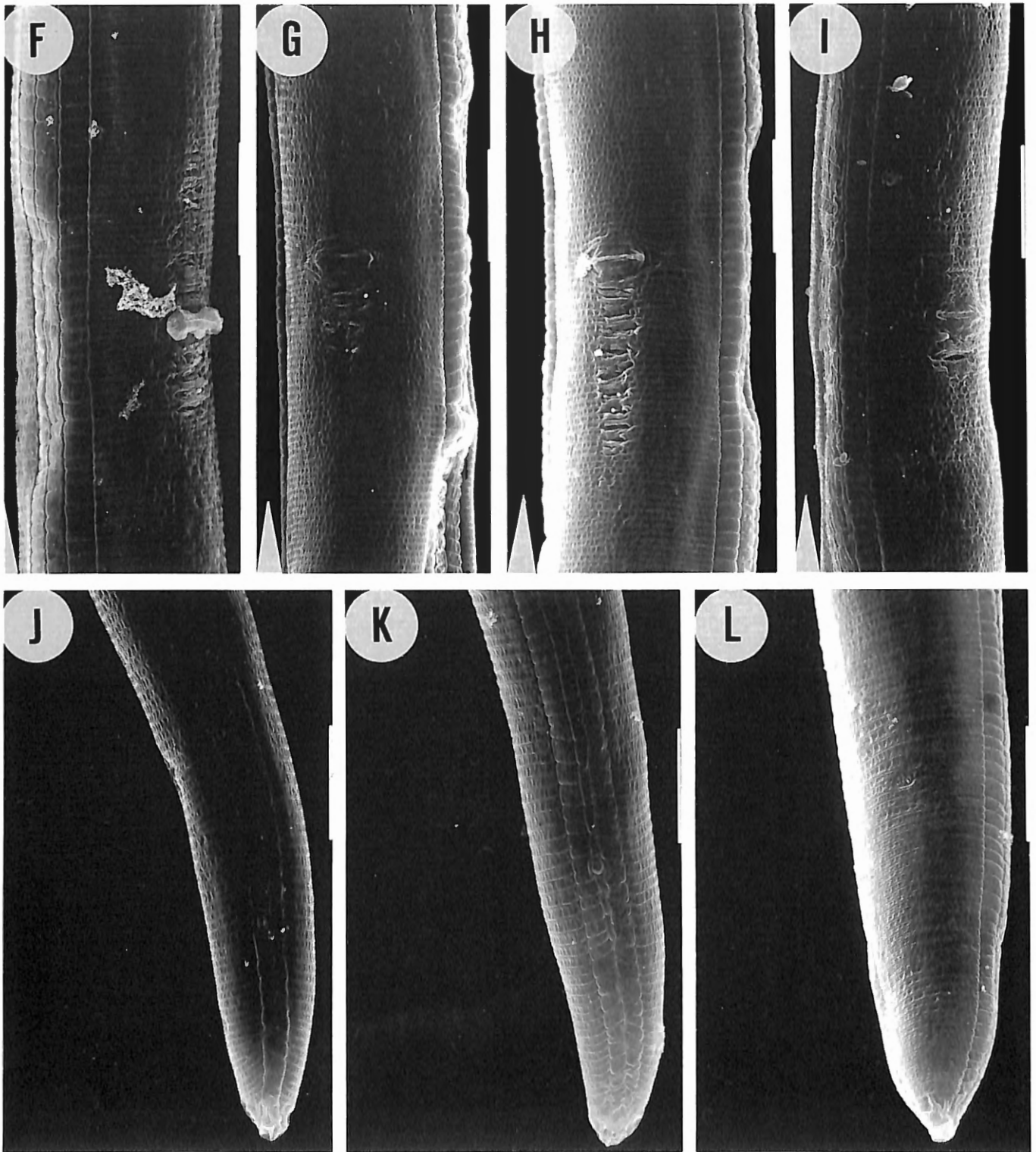


Fig. 7 – *Tylenchorhynchus vulgaris*, females. F-I : vulvar region (the white arrow shows the direction of anterior region); J-L : tails; scale bar = 10  $\mu$ m.

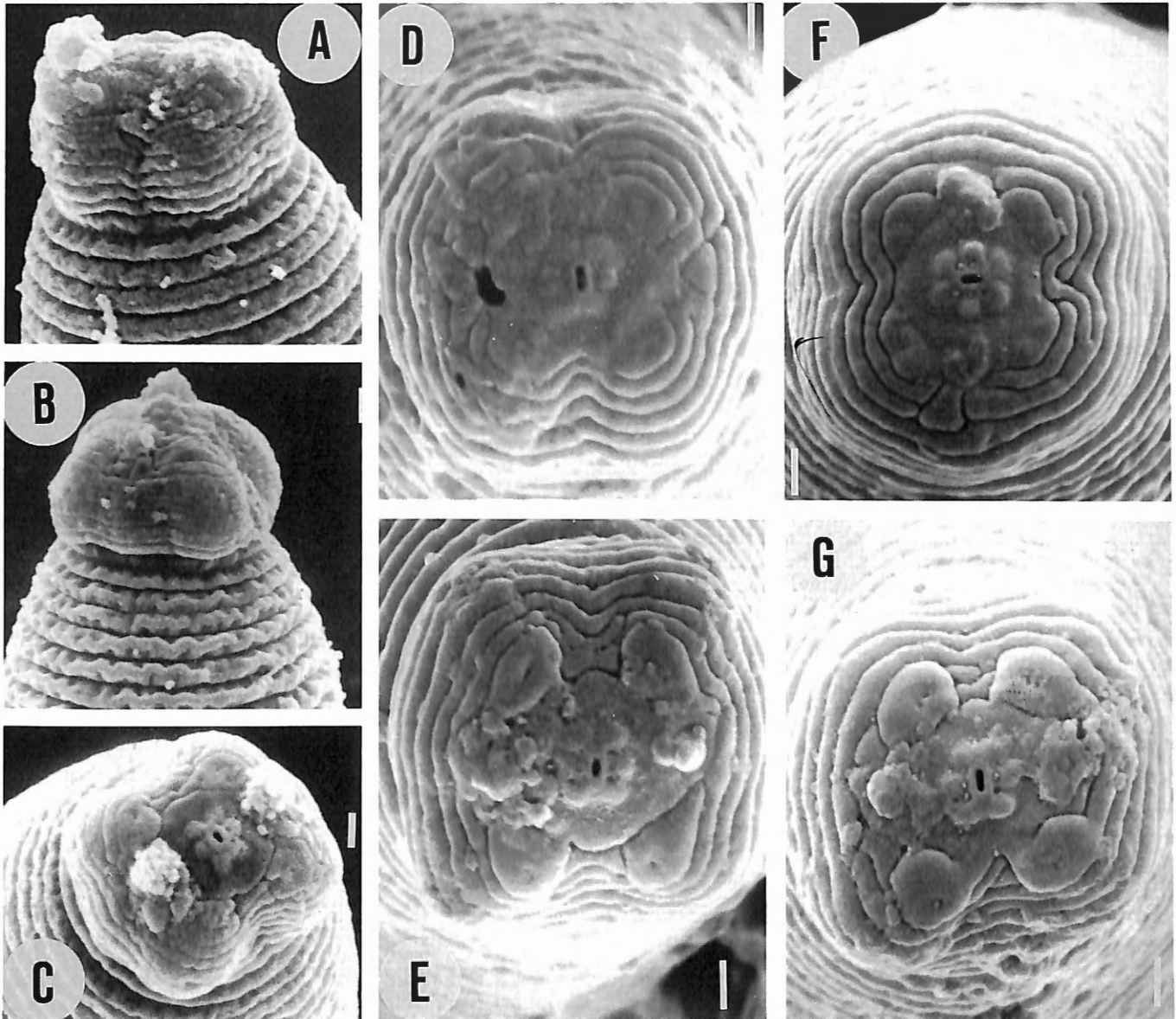


Fig. 8 – *Tylenchorhynchus indicus*, female (A, D, F) and male (B, C, E, G) heads. A, B : lateral view; C-G : in front view; scale bar = 1  $\mu$ m.

Ventral ornamentations in the vulvar region are present in all the species studied except in *T. phaseoli* where the ventral ridge reaches the vulva without any modification. These ornamentations showed great variation in *i*) their occurrence in each species (absent or present in the same species or always present), *ii*) their pattern (variation of body width, longitudinal incisure or disorganization of the transverse annulation, *iii*) their localization (in front and/or behind vulva) :

*T. annulatus* : ornamentations can be absent (Fig. 3 : R) or present as a longitudinal incisure in front and behind vulva (Fig. 2 : J) or alteration of the transverse body annulation only behind (Fig. 2 : K) or behind and in front of the vulva (Fig. 3 : N, Q).

*T. germanii* : the ventral ridge subdivided in front of the vulva into two subventral ridges, the two previous subventral ridges being interrupted (Fig. 17 : N-Q); behind

vulva, the same situation is present (Fig. 17 : O-Q) or not, the ventral ridge ending just in front of the vulva (Fig. 17 : N, P); alterations of the transverse body annulation occurred sometimes just behind the vulva on a short length (Fig. 17 : N-P).

*T. gladiolatus* : anomalies of the transversal body annulation are always present but only behind the vulva (Fig. 5 : G-I).

*T. indicus* : ornamentations can be absent (Fig. 9 : J) or present as alterations of the transverse body annulation in front and behind the vulva (Fig. 9 : H-I).

*T. mashhoodi* : a longitudinal incisure is present in front and behind the vulva (Fig. 1 : G).

*T. microphasmis* : ventral ridge subdivided into two subventral ridges in front and behind the vulva, the two previous subventral ridges being interrupted (Figs. 12 : H-I; 13 : J); no other ornamentations occurred ventrally.

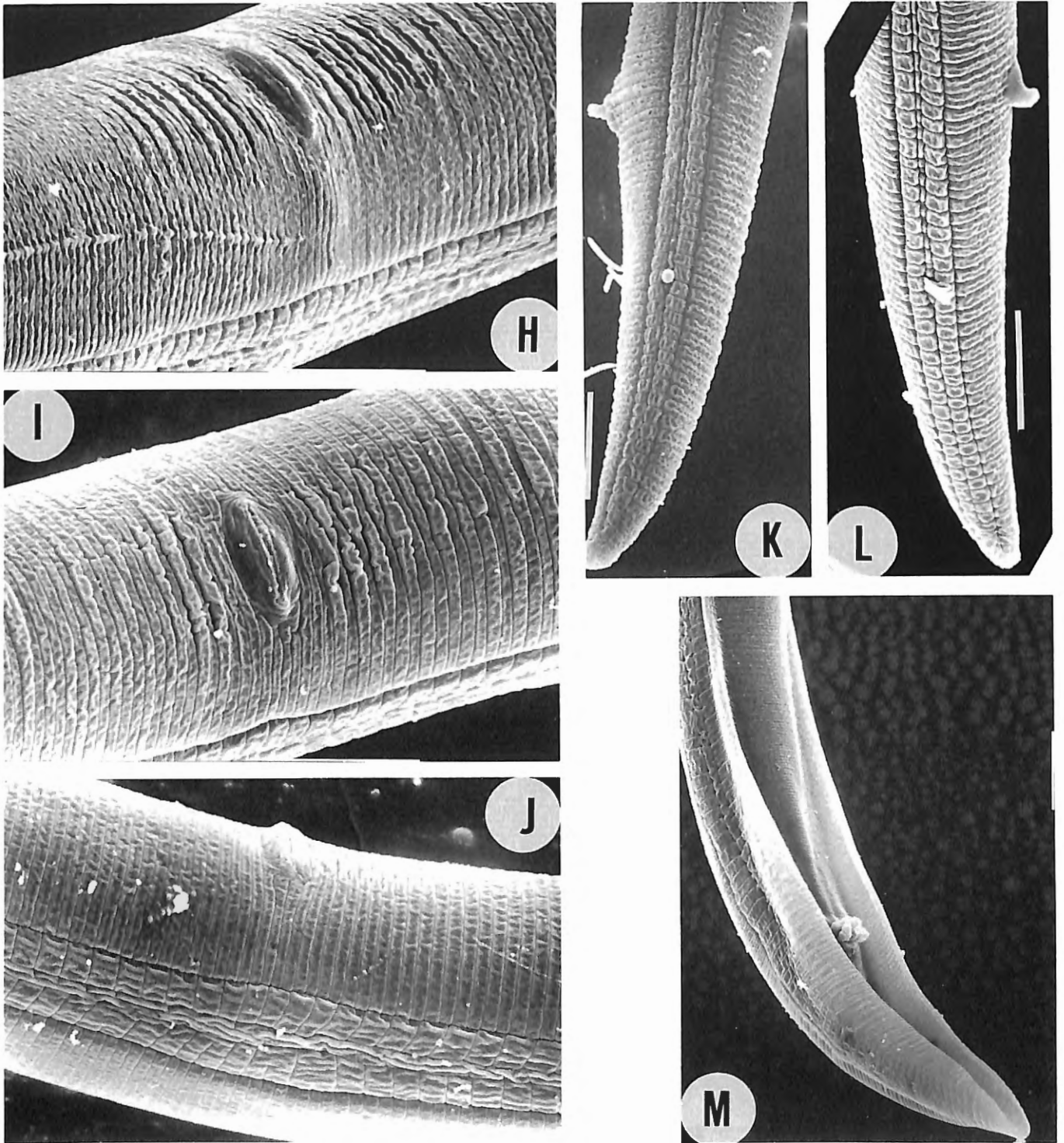


Fig. 9 – *Tylenchorhynchus indicus*, females (H-L) and males (M). H-J : vulvar region; K-M : tails; scale bar = 10  $\mu$ m.



*T. sulcatus*: ventral ridge subdivided in front of the vulva into two subventral ridges, the two previous subventral ridges being interrupted; behind the vulva, the ventral ridge ends just in front of the vulva (Fig. 19 : J); alterations of the transverse body annulation occurred both in front and behind the vulva (Fig. 19 : I) or only behind the vulva (Fig. 19 : J).

*T. ventralis*: in lateral view the body shows a widening in front of the vulva and a narrowing behind the vulva (Fig. 10 : I-J); in ventral view, two groups (one in front and one behind the vulva) of ridges are longitudinally placed (Fig. 10 : K-L); they correspond probably to the underlying musculature of the vagina (*dilatatores vaginae*); alterations of the transverse body annulation occurs on a short length just behind the vulva.

*T. vulgaris*: alterations of the transverse body annulation are always present (Fig. 7 : F-I), variations occurring both in length (from 5 to 15  $\mu\text{m}$  long) and in position (in front and/or behind the vulva).

#### FEMALE TAIL

Tail conoid to cylindrical with a rounded terminus in *T. mashhoodi* (Fig. 1 : H-I), *T. annulatus* (Figs. 2 : L-M; 3 : T-W), *T. gladiolatus* (Fig. 5 : J-L) or with a rounded to acute terminus in *T. vulgaris* (Fig. 7 : J-L); tail conical with a rounded terminus in *T. indicus* (Fig. 9 : K-L), *T. ventralis* (Fig. 10 : M-N), and *T. phaseoli* (Fig. 15 : O-T); with an acute terminus in *T. microphasmis* (Fig. 13 : K-L), *T. germanii* (Fig. 17 : S-V) and *T. sulcatus* (Fig. 19 : K-N).

#### PHASMID

Phasmids punctiform in *T. mashhoodi* (Fig. 1 : H-I), *T. annulatus* (Figs. 2 : L-M; 3 : U-W), *T. gladiolatus* (Fig. 5 : J-L), *T. indicus* (Fig. 9 : K-L), *T. ventralis* (Fig. 10 : M), *T. microphasmis* (Fig. 13 : K), *T. germanii* (Fig. 17 : S, U, V) and *T. sulcatus* (Fig. 19 : M-N). Phasmids wider in *T. vulgaris* (Fig. 7 : J-K) and variable in diameter in *T. phaseoli*, from punctiform (Fig. 15 : S-T) to wide (Fig. 15 : O-P) with intermediate widths (Fig. 15 : Q-R).

#### MALE COPULATORY APPARATUS

Bursa peloderan without distal notch in *T. mashhoodi* (Fig. 1 : J-L), *T. gladiolatus* (Fig. 5 : M-N), *T. indicus* (Fig. 9 : M), *T. ventralis* (Fig. 11 : U-V), *T. microphasmis* (Fig. 13 : M), *T. sulcatus* (Fig. 20 : T-V). Notchs present or absent in the first extracted population of *T. germanii*, variable in depth when present (Fig. 18 : W-AB); in the second extracted population, notch always absent.

Spicules never protruding on SEM observed specimens of *T. indicus* and *T. ventralis*; for the other bisexual species, spicules protruding with large velum and without

peculiar characteristics except in *T. mashhoodi* where a short distal process is present at the distal end giving a bifid appearance to spicule tip (Fig. 1 : K-L) and in *T. gladiolatus* where a minute notch is present ventrally at the distal end of the spicules (Fig. 5 : M-N).

Gubernaculum only seen in bisexual species with protruding spicules. Protrusion of gubernaculum variable in *T. mashhoodi* (six males with protruded gubernaculum in ten males observed) and constant in *T. gladiolatus*, *T. microphasmis*, *T. germanii* and *T. sulcatus*. Gubernaculum in *T. mashhoodi*, *T. microphasmis*, *T. germanii*, *T. sulcatus* with three knobs, one distal and central, flattened, supporting the dorsal shaft of the spicule and two subdistal and lateral, rounded, inserted in a longitudinal groove present on the dorsal side of the velum (Figs. 16 : L; 17 : W, Z, AA; 20 : S, U, V); in *T. gladiolatus*, only the distal knob, triangular in shape, protruding from the cloaca is observable.

#### MISCELLANEOUS OBSERVATIONS

In *T. phaseoli*, excretory pore in variable position, on or along the ventral ridge (Fig. 14 : E-G); anus surrounded by a circle of cuticular blocks (Fig. 15 : M-N).

#### Discussion

The head patterns observed in this study can be grouped into five types (Table 2) :

Table 2 :

Characterizations of the five groups of species according to longitudinal body ornamentations and head features (+ = present; - = absent, \* = ventral and dorsal depressions strong; ? = undetermined).

| Characters  | Species groups |     |     |     |     |
|---|----------------|-----|-----|-----|-----|
|   | 1              | 2   | 3   | 4   | 5   |
| longitudinal ornamentations on the cuticle outside the lateral fields | -/+            | -/+ | -/+ | -/+ | -/+ |
| head profil – squarish  | +              |     |     |     |     |
| – rounded   |                | +   | +   | +   | +   |
| head – continuous   | +              |     |     |     |     |
| – set off   |                | +   | +   | +   | +   |
| head annuli number  | <5             | >5  | >5  | >5  | >5  |
| longitudinal depressions on head                                      | 6              | 4   | 6*  | 6*  | 6*  |
| lateral incisures on head   | -              | +   | -   | -   | -   |
| labial disc – rectangular   | +              | +   | +   |     |     |
| – rounded   |                |     |     | +   | +   |
| lip sectors – submedial   | -              | -/+ | -/+ | +   | +   |
| – lateral   | -              | -   | -   | -   | +   |
| head sexual dimorphism  | -              | -   | +   | +   | ?   |

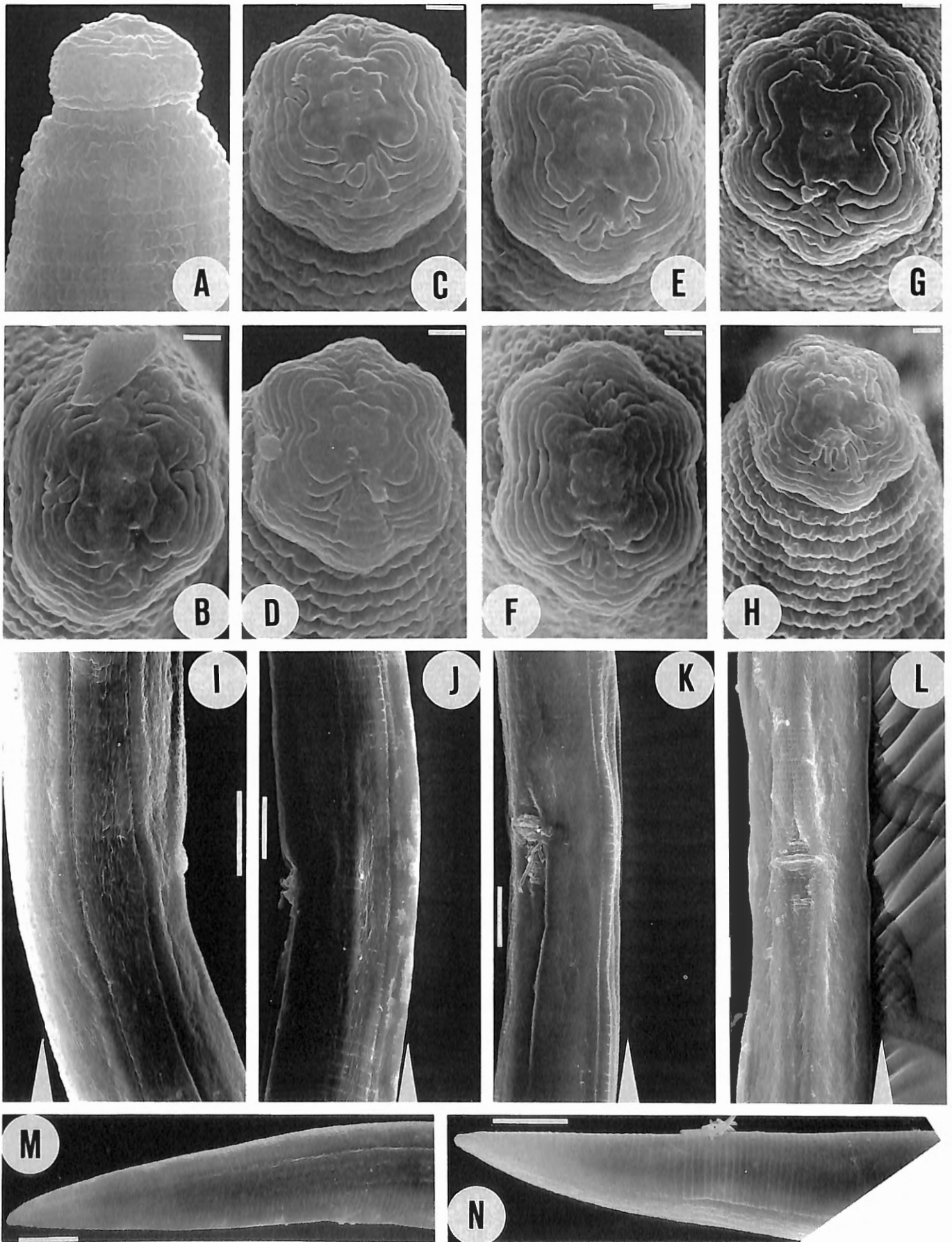


Fig. 10 – *Tylenchorhynchus ventralis*, females. A-H : heads (A, C : respectively lateral and in front view of the same specimen); I-L : vulvar region (the white arrow shows the direction of anterior region); M-N : tails; A-H : scale bar = 1  $\mu$ m; I-N : scale bar = 10  $\mu$ m.

Type 1 : head profile squarish; head continuous; five or less cephalic annuli; six longitudinal depressions slightly pronounced; no lateral incisure; labial disc rectangular with submedial lip sectors completely fused; no lateral lip sectors; no sexual dimorphism in head morphology. This type is observed here for *T. annulatus* (see also LOPEZ & SALAZAR, 1987) and *T. mashhoodi* and also in other species of the genus : *T. cylindricus*, type species of the genus (Fig. 5, A in SHER & BELL, 1975), *T. lamelliferus* (Fig. 3, C, D in SHER & BELL, 1975), *T. aduncus* (Fig. 1, A-D in VOVLAS & CHAM, 1981), *T. clarus* (Figs. 1, 2, p. 7 in SAUER, 1985), *Tylenchorhynchus* sp. (Fig. 1, 2, p. 8 in SAUER, 1985) *T. crassicaudatus* (Fig. 7, A in ZEIDAN & Geraert, 1990), *T. clathrocutis* (Figs. 9, 10 in LEWIS & GOLDEN, 1981).

Type 2 : head profile rounded; head set off; more than five cephalic annuli; four longitudinal depressions slightly pronounced; lateral incisures below the amphid aperture present; labial disc rectangular with submedial lip sectors more or less demarcated by an incomplete incisure; no lateral lip sectors; no sexual dimorphism in head morphology. This type is observed here for *T. gladiolatus* and *T. vulgaris* and also in other species and genera : *T. goffarti* (Fig. 5, B in SHER & BELL, 1975), *T. tobari* (Fig. 5-6, p. 8 in SAUER, 1985), *T. brevilineatus* (Fig. 3, A-D in ZEIDAN & GERAERT, 1990; Fig. 6, B in RASHID & HEYNS, 1990), *Bitylenchus serranus* (Figs. 9-11 in GOMEZ BARCINA *et al.*, 1992).

Type 3 : head profile rounded; head set off; more than five cephalic annuli; six longitudinal depressions present, the four submedial slightly pronounced and the dorsal and ventral ones well pronounced up to a complete incisure; lateral incisures absent; labial disc rectangular with submedial lip sectors not demarcated in females, more or less demarcated by an incomplete incisure in males; no lateral lip sectors; sexual dimorphism present in head morphology with a dorso-ventral deformation of the head and submedial lip sectors being more individualised. This type is observed here for *T. indicus*, *T. microphasmis* and *T. ventralis* and also in other species of the genus : *T. acutus* (Fig. 4, A, B in SHER & BELL, 1975), *T. parvus* (Fig. 2 in LAL & HINES, 1991), *T. prophasmis* (Fig. 1, A-B in JAIRAJPURI & HUNT, 1984), and *T. teeni* (Fig. 5, A-D in ZEIDAN & GERAERT, 1990).

Type 4 : head profile rounded; head set off; more than five cephalic annuli; six longitudinal depressions present, the four submedial slightly pronounced and the dorsal and ventral ones well pronounced up to a complete incisure; lateral incisures absent; labial disc rounded with submedial lip sectors demarcated and completely separated; no lateral lip sectors; sexual dimorphism present in head morphology with a dorso-ventral deformation of the head. This type is observed

here for *T. germanii* and *T. sulcatus* and also in other species of the genus : *T. aff. obregonus* (Fig. 9, A-B in ZEIDAN & GERAERT, 1990).

Type 5 : head profile rounded; head set off; more than five cephalic annuli; six longitudinal depressions present, the four submedial slightly pronounced and the dorsal and ventral ones well pronounced up to a complete incisure; lateral incisures absent; labial disc rounded with submedial lip sectors well demarcated completely or incompletely separated from the labial disc by a incisure; lateral lip sectors present; sexual dimorphism not determined (males absent). This type is observed here for *T. phaseoli* and also in other species and genera : *Tylenchorhynchus* sp. (Fig. 1-4, p. 9 in SAUER, 1985), *T. velatus* (Fig. 5-6, p. 9 in SAUER, 1985), *Tylenchorhynchus maximus* (Fig. 537 in DE GRISSE, 1977; Fig. 36-38 in GOMEZ BARCINA *et al.*, 1992), *Bitylenchus pratensis* (Fig. 27 in GOMEZ BARCINA *et al.*, 1992). The population of *T. phaseoli* studied by SHER & BELL (1975; Fig. 3, A, B) shows submedial lip sectors slightly less developed than in the Niger population and longitudinal body ridges fused at the anterior end just below the head vs separated in the Niger population.

Several species of the genus *Bitylenchus* redefined by GOMEZ BARCINA *et al.* (1992) show great differences in head morphology. The emendation of the genus states "cephalic region ... with lateral longitudinal indentations on annuli behind amphidial apertures ... and anteriormost lip annulus 6-sectored". At least three species did not share the first character, *B. maximus* (ALLEN, 1955) SIDDIQI, 1986, *B. pratensis* GOMEZ BARCINA *et al.*, 1992, *B. velatus* (SAUER & ANNELS, 1981) GOMEZ BARCINA *et al.*, 1992; whereas *B. serranus* GOMEZ BARCINA *et al.*, 1992 did not possess the second character. *Bitylenchus* FILIP'EV, 1934 is then considered a junior synonym of *Tylenchorhynchus*; *B. pratensis* and *B. serranus* are transferred to the genus *Tylenchorhynchus* as *T. pratensis* (GOMEZ BARCINA *et al.*, 1992) n. comb. and *T. serranus* (GOMEZ BARCINA *et al.*, 1992) n. comb.

This study supports the statements of FORTUNER & LUC (1987) regarding the validity of some characters currently used for identification purposes in the taxonomy of the genus : *T. phaseoli* showed only two lines (one ridge) in the lateral field, a unique feature in the Telotylenchinae confirmed by TEM (MOUNPORT *et al.*, 1993); longitudinal ridges are present in several species (*T. gladiolatus*, *T. germanii*, *T. microphasmis*, *T. sulcatus*, *T. phaseoli*, *T. lamelliferus*) which showed strong differences in head morphology; lateral membranes at vulva did not exist, being confused under light microscopy with subventral longitudinal ridges; presence of notches on caudal alae appeared to be a variable character at the species level (*T. germanii*).

The SEM observations on the head morphology in the

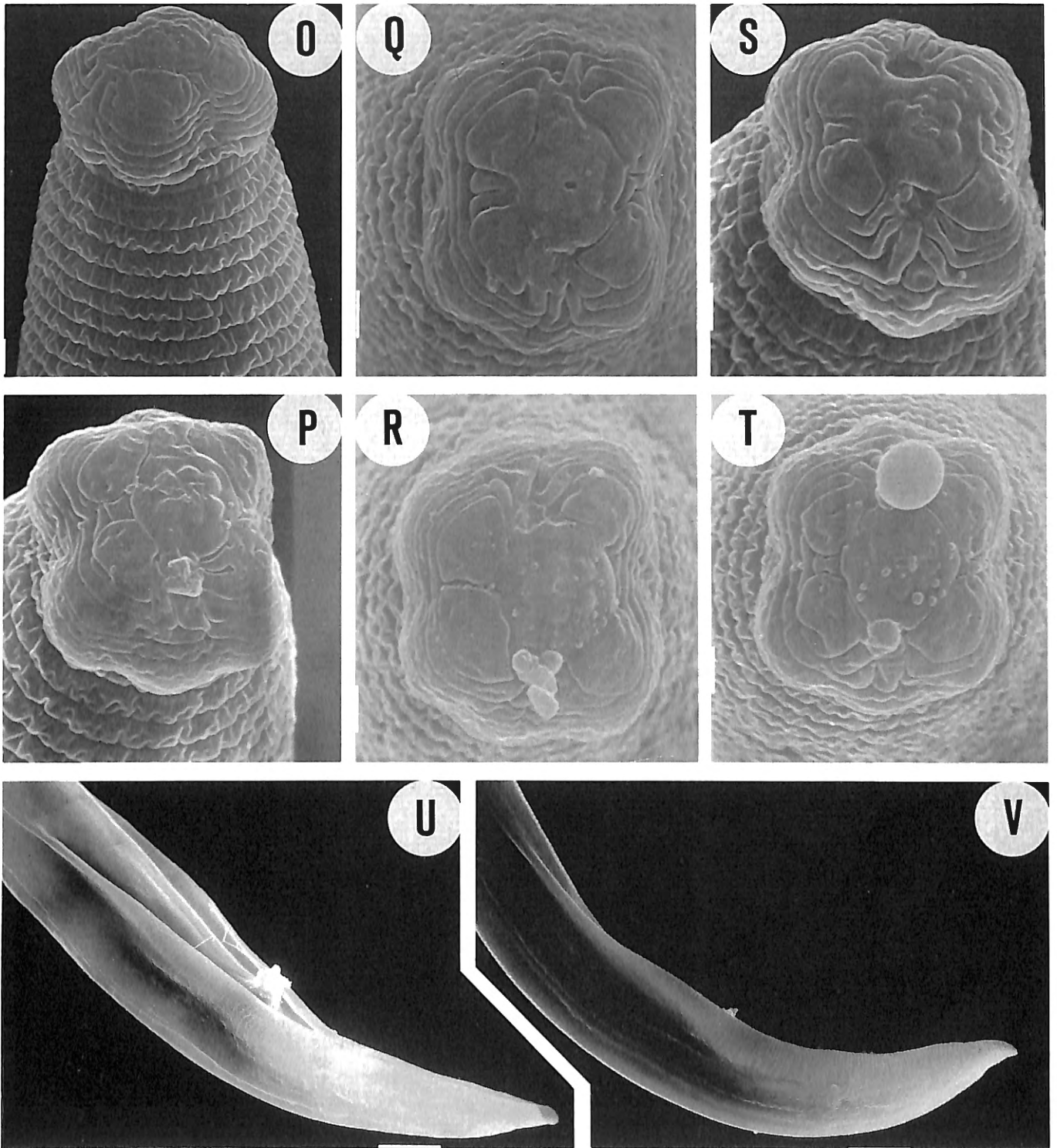


Fig. 11 – *Tylenchorhynchus ventralis*, males. O-T : heads (O, Q : respectively lateral and in front view of the same specimen); U-V : tails; O-T : scale bar = 1  $\mu$ m; U-V : scale bar = 10  $\mu$ m.



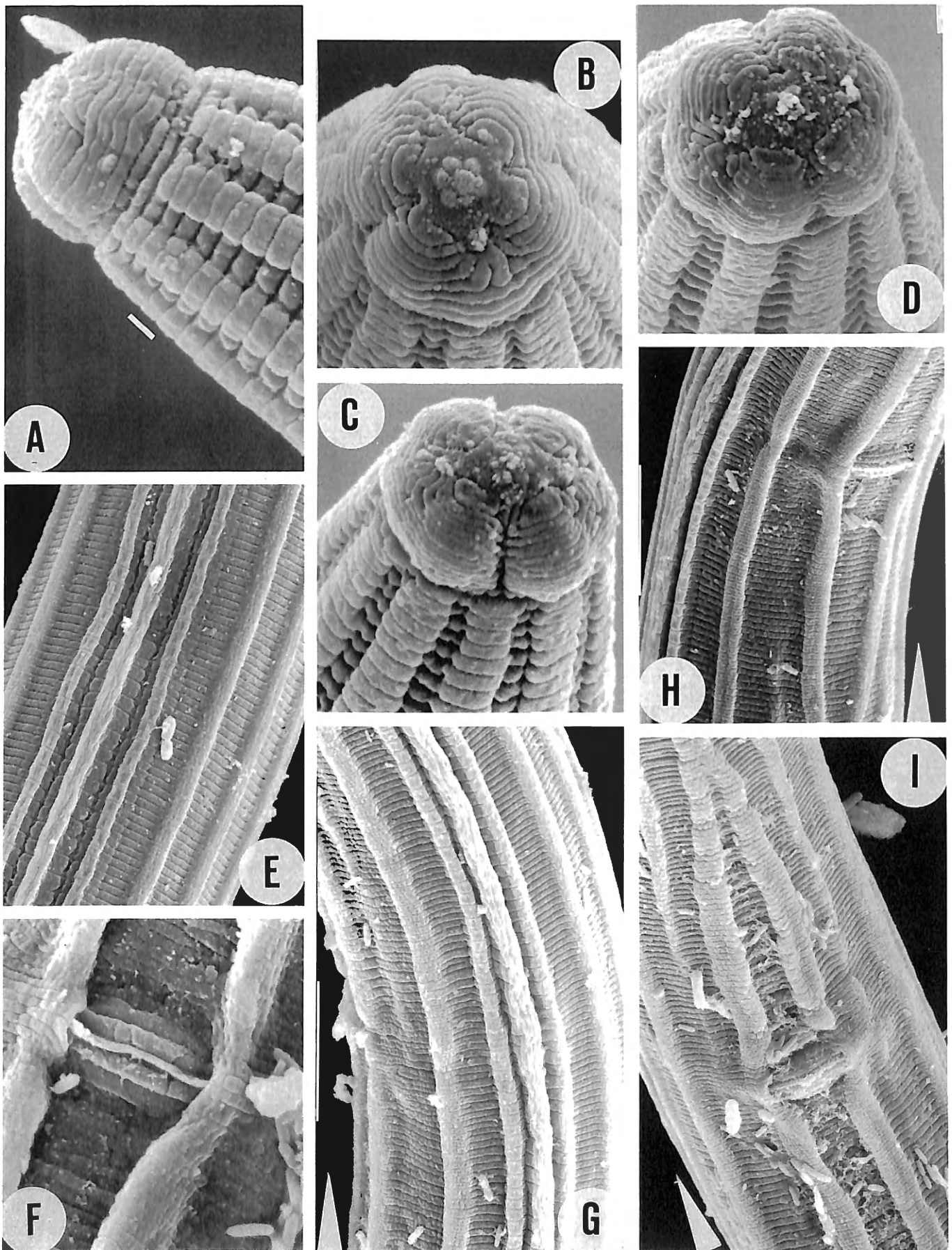


Fig. 12 – *Tylenchorhynchus microphasmis*, females. A-D : heads (A, B : respectively lateral and in front view of the same specimen); E-G : excretory pore : A-D : scale bar = 1  $\mu$ m; E-G : scale bar = 10  $\mu$ m.

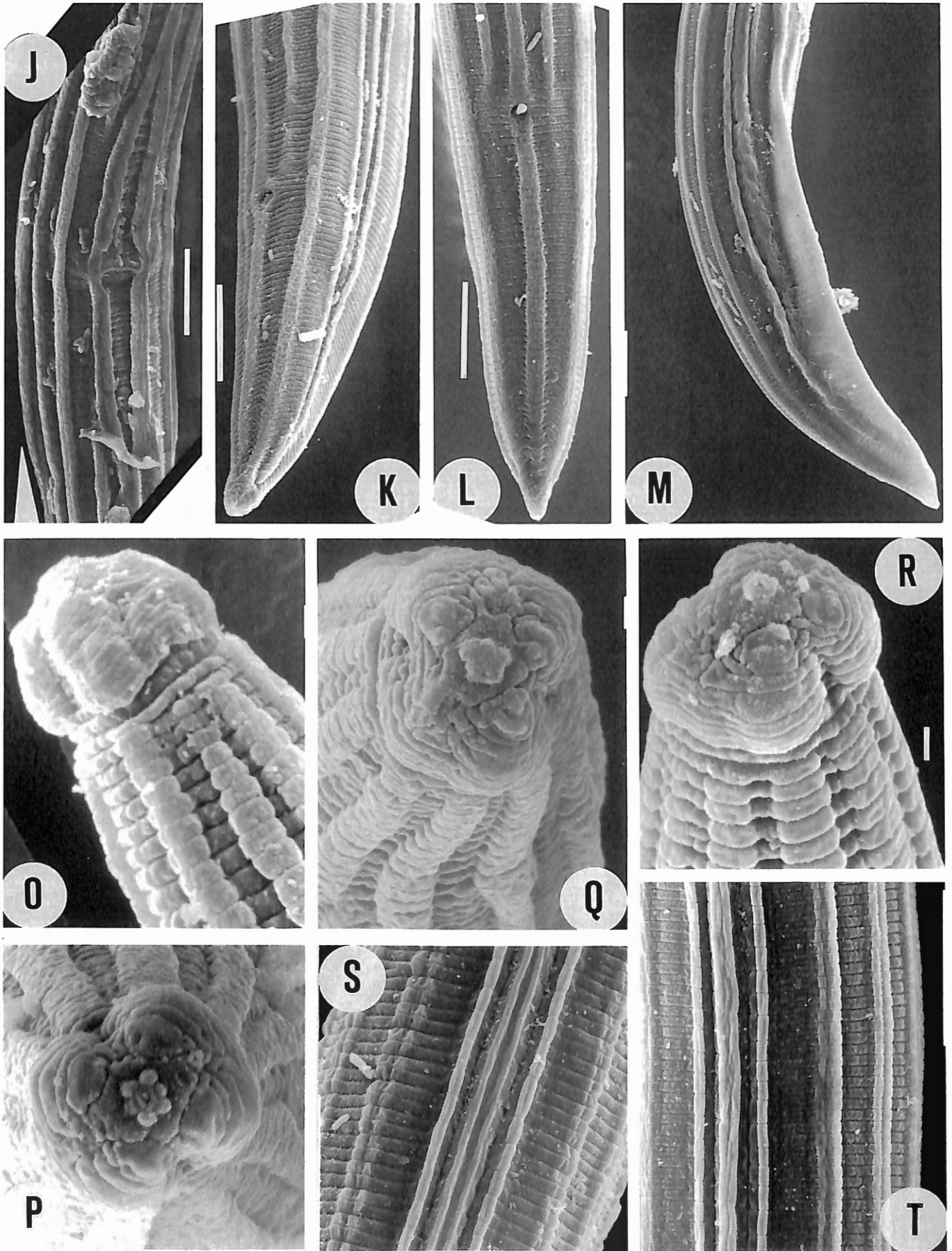


Fig. 13 – *Tylenchorhynchus microphasmis*, females (J-M) and males (O-T). J : vulvar region (the white arrow shows the direction or anterior region); K-M : tails; O-Q : heads; S-T : lateral field; O-R : scale bar = 1  $\mu\text{m}$ ; J-M, S-T : scale bar = 10  $\mu\text{m}$ .

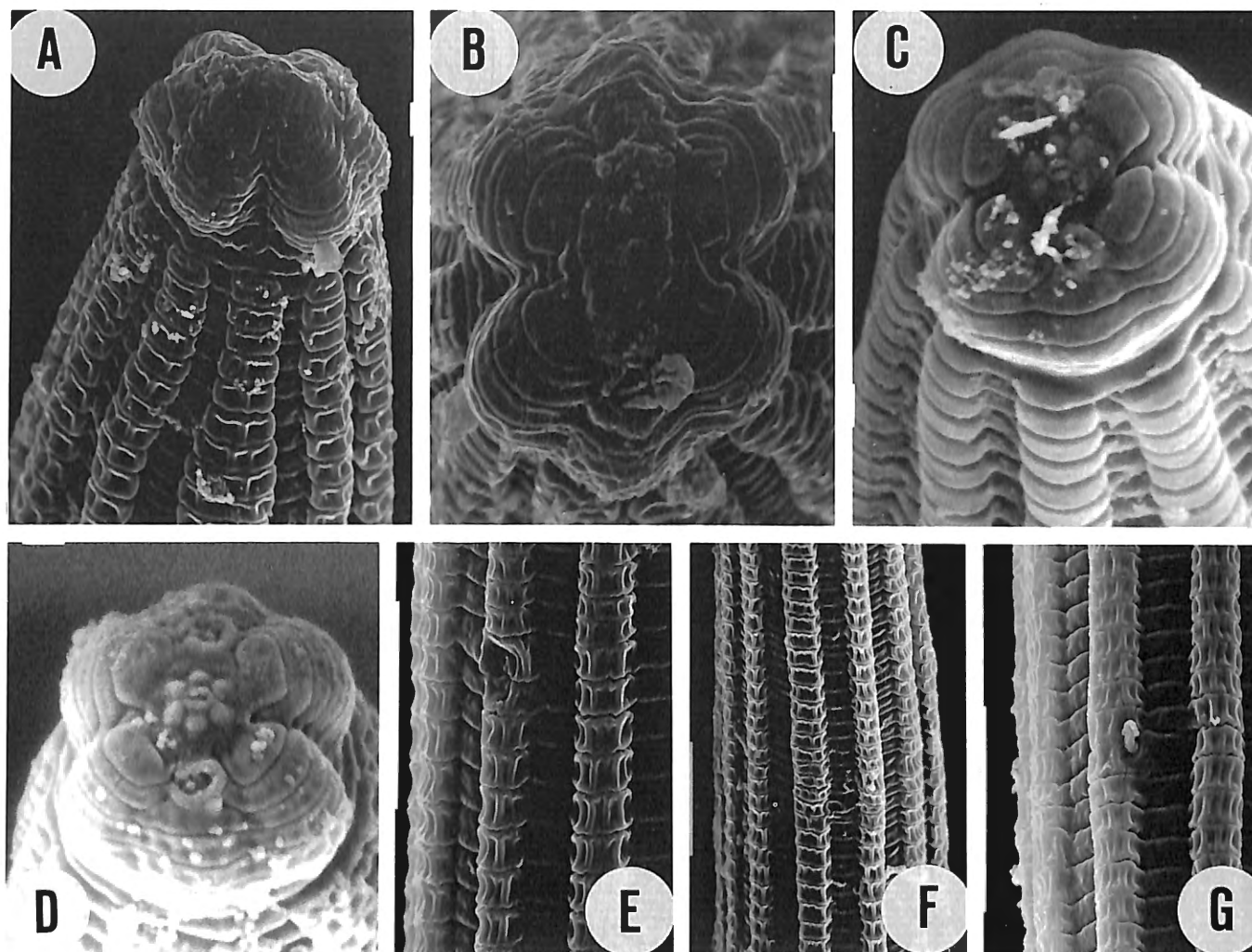


Fig. 14 – *Tylenchorhynchus phaseoli*, females. A-D : heads (A, B : respectively lateral and in front view of the same specimen); E-G : excretory pore; A-D : scale bar = 1  $\mu$ m; E-G : scale bar = 10  $\mu$ m.

genus *Tylenchorhynchus* revealed the great heterogeneity of this group; it is now possible to recognize at least four different types (five if the complete separation of the submedial lip sectors from the labial disc is considered as a stable characteristic) which might need a generic status; the grouping of the studied species according to the head morphology correspond to that proposed by MOUNPORT *et al.* (1993) on the basis of the ultrastructure of the cuticle. More than 130 species are described in the genus *Tylenchorhynchus* as defined by FORTUNER & LUC (1987); the SEM studies of the morphological characteristics and the reexamination of the species under light microscopy constitute a preliminary before any taxonomical changes in the genus could be proposed.

#### Acknowledgements

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#### References

- BAUJARD, P. & PARISELLE, A. (1987). Fabrication de microtamis et préparation des nématodes pour l'observation au microscope électronique à balayage. *Revue de Nématologie*, 10 : 477-481.
- DE GRISSE, A. T. (1977). De Ultrastructuur van het zenuwstelsel in de kop van 22 soorten plantenparasitaire Nematoden, behorende tot 19 genera (Nematoda : Tylenchida). Rijksuniversiteit Gent, Belgium, 420 p.
- FORTUNER, R. & LUC, M. (1987). A reappraisal of Tylenchina (Nemata). 6. The family Belonolaimidae Whitehead, 1960. *Revue de Nématologie*, 10 : 183-202.
- GOMEZ BARCINA, A., SIDDIQI, M.R. & CASTILLO, P. (1992). The genus *Bitylenchus* Filip'ev, 1934 (Nematoda : Tylenchida) with description of two new species from Spain. *Journal of the Helminthological Society of Washington*, 59 : 96-110.

- JAIRAJPURI, M. S. & HUNT, D. J. (1984). The taxonomy of Tylenchorhynchinae (Nematoda : Tylenchida) with longitudinal lines and ridges. *Systematic Parasitology*, 6 : 261-268.
- LAL, A. & HINES, S. (1991). Redescription of *Tylenchorhynchus* (*Bitylenchus*) *parvus* Allen, 1955 with SEM observations. *Nematologia mediterranea*, 19 : 241-245.
- LEWIS, S. A. & GOLDEN, A. M. (1981). Description of *Trilineellus clathrocutis* n. g., n. sp. (Tylenchorhynchinae : Tylenchida Thorne, 1949) with a key to species and observations on *Tylenchorhynchus* sensu stricto. *Journal of Nematology*, 13 : 135-141.
- LOPEZ, R. & SALAZAR, L. (1987). Nematodos asociados al arroz (*Oriza sativa* L.) en Costa Rica. III. Microscopi electronica de rastreo de *Meloidogyne* y *Tylenchorhynchus annulatus*. *Turrialba*, 37 : 77-83.
- MOUNPORT, D., BAUJARD, P. & MARTINY, B. (1993). Cuticle fine structure of nine species in the genus *Tylenchorhynchus* Cobb, 1913 (Nemata : Belonolaimidae). *Fundamental and applied Nematology*, 16 : 137-149.
- RASHID, F. & HEYNS, J. (1990). *Tylenchorhynchus* species from Namibia (Nematoda : Belonolaimidae). *Phytophylactica*, 22 : 403-412.
- SAUER, M.R. (1985). A scanning electron microscope study of plant and soil nematodes. C.S.I.R.O. Division of Horticultural Research, 64 p.
- SEINHORST, J.W. (1962). Modifications of the elutriation method for extracting nematodes from soils. *Nematologica*, 8 : 117-128.
- SHER, S.A. & BELL, A.H. (1975). Scanning electron micrographs of the anterior region of some species of Tylenchoidea (Tylenchida : Nematoda). *Journal of Nematology*, 7 : 73-77.
- SIDDIQI, M.R. (1986). Tylenchida Parasites of Plants and Insects. Slough, UK, Commonw. Inst. Parasit., x + 645 p.
- VOVLAS, N. & CHAM, S. (1981). Scanning electron microscope observations on the morphology of *Tylenchorhynchus aduncus*. *Nematologia mediterranea*, 9 : 91-97.
- VOVLAS, N. & CHENG, H. (1988). Morpho-anatomy of *Tylenchorhynchus leviterminalis* from the People's Republic of China. *Nematologia mediterranea*, 16 : 149-152.
- ZEIDAN, A. B. & GERAERT, E. (1990). The genus *Tylenchorhynchus* in Sudan (Nematoda : Tylenchida). *Mededelingen van de Fakuliteit Landbouwwetenschappen Universiteit Gent*, 55 : 761-778.

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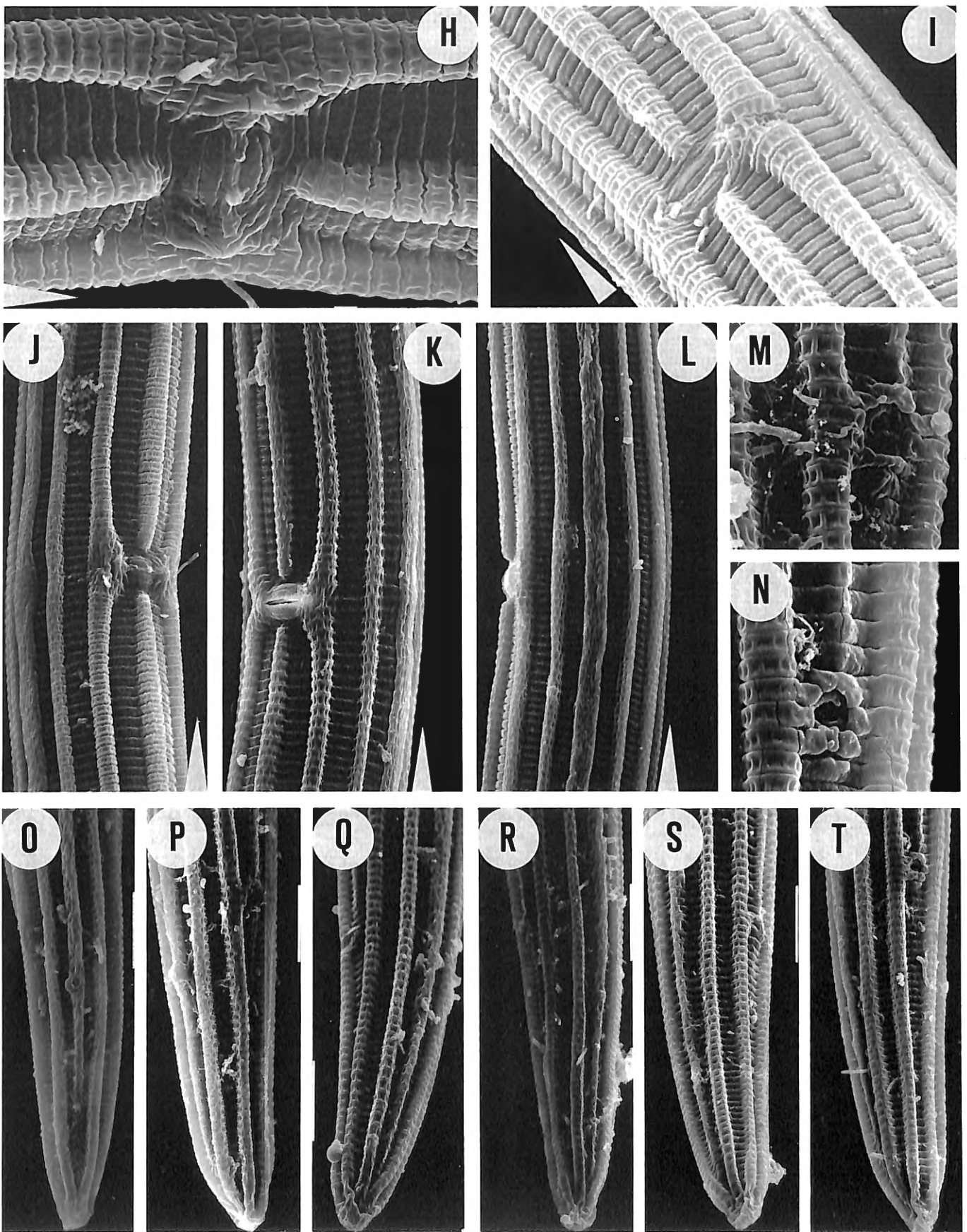


Fig. 15 – *Tylenchorhynchus phaseoli*, females. H-L : vulvar region (the white arrow shows the direction or anterior region); M-N : anus; O-T : tails; H-L, O-T : scale bar = 10  $\mu$ m; M-N : scale bar = 1  $\mu$ m.

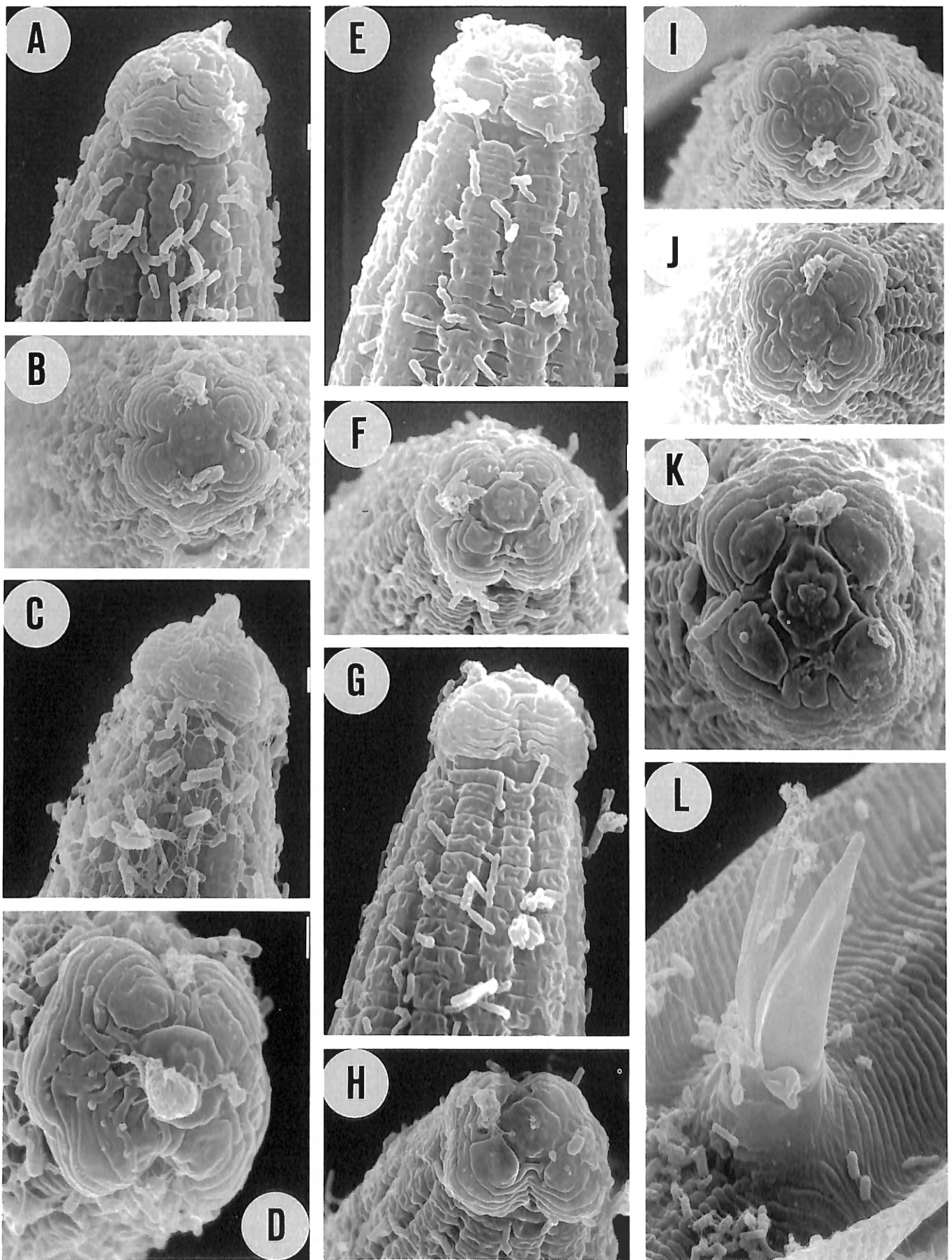


Fig. 16 – *Tylenchorhynchus germanii*, females (A-F) and males (G-L). A-K : heads (A-B, C-D, E-F, G-H : respectively lateral and in front view of the same specimen); L : spicules; scale bar = 1  $\mu$ m.

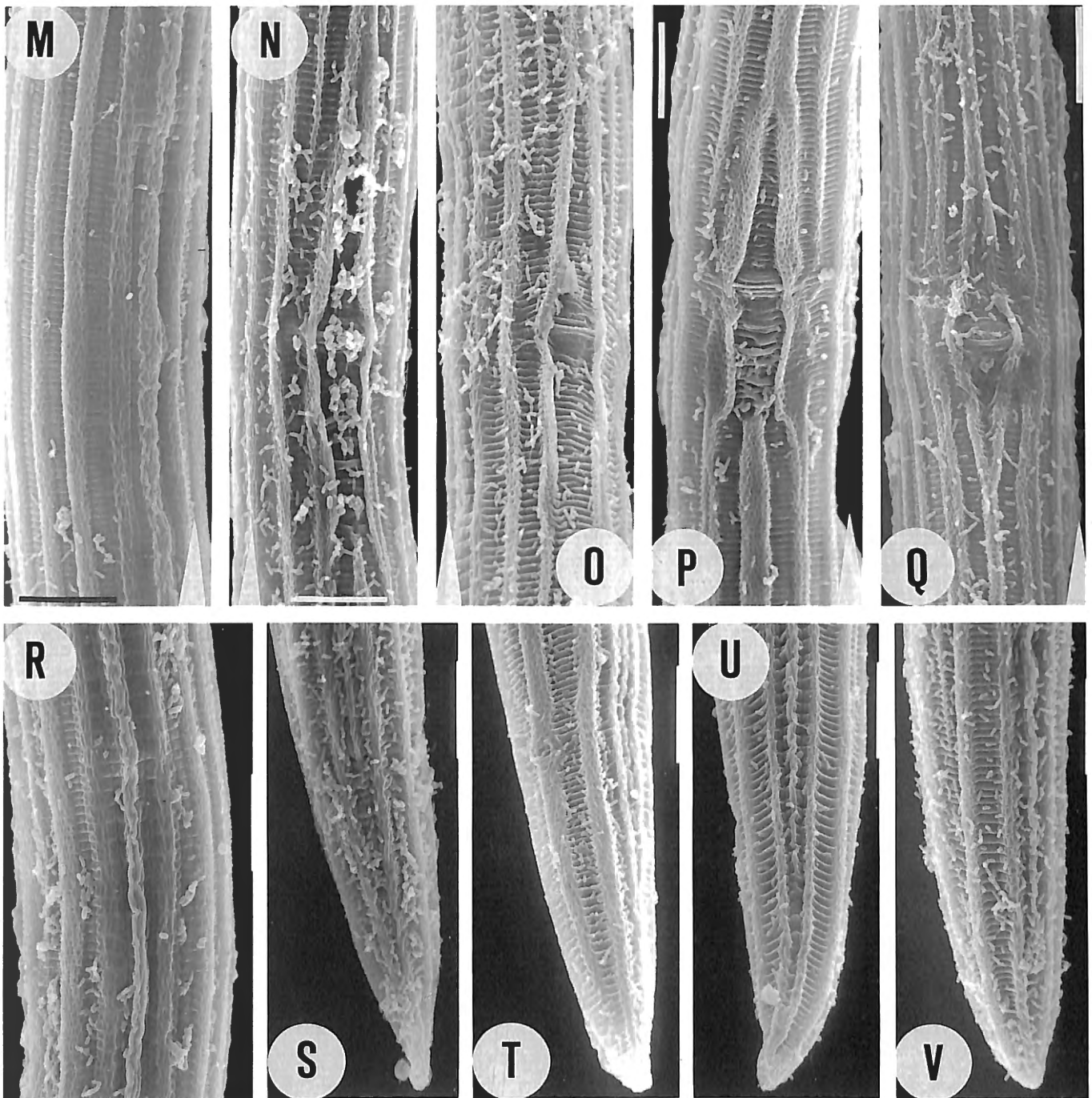


Fig. 17 – *Tylenchorhynchus germanii*, females. M-R : vulvar region (the white arrow shows the direction or anterior region); S-V : tails; M-V : scale bar = 10  $\mu$ m.



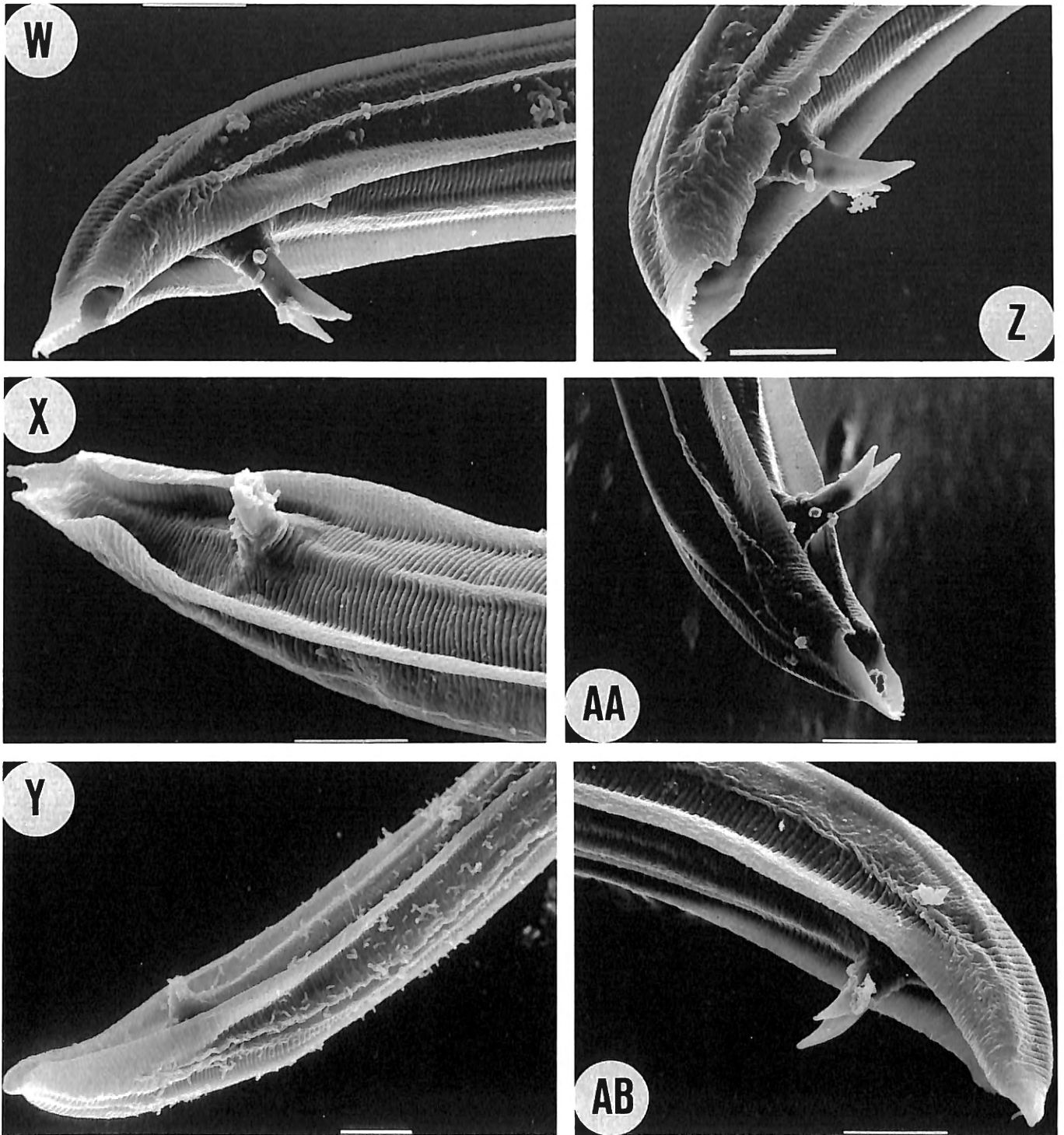


Fig. 18 – *Tylenchorhynchus germanii*, males. W-AB : tails; scale bar = 10  $\mu$ m.



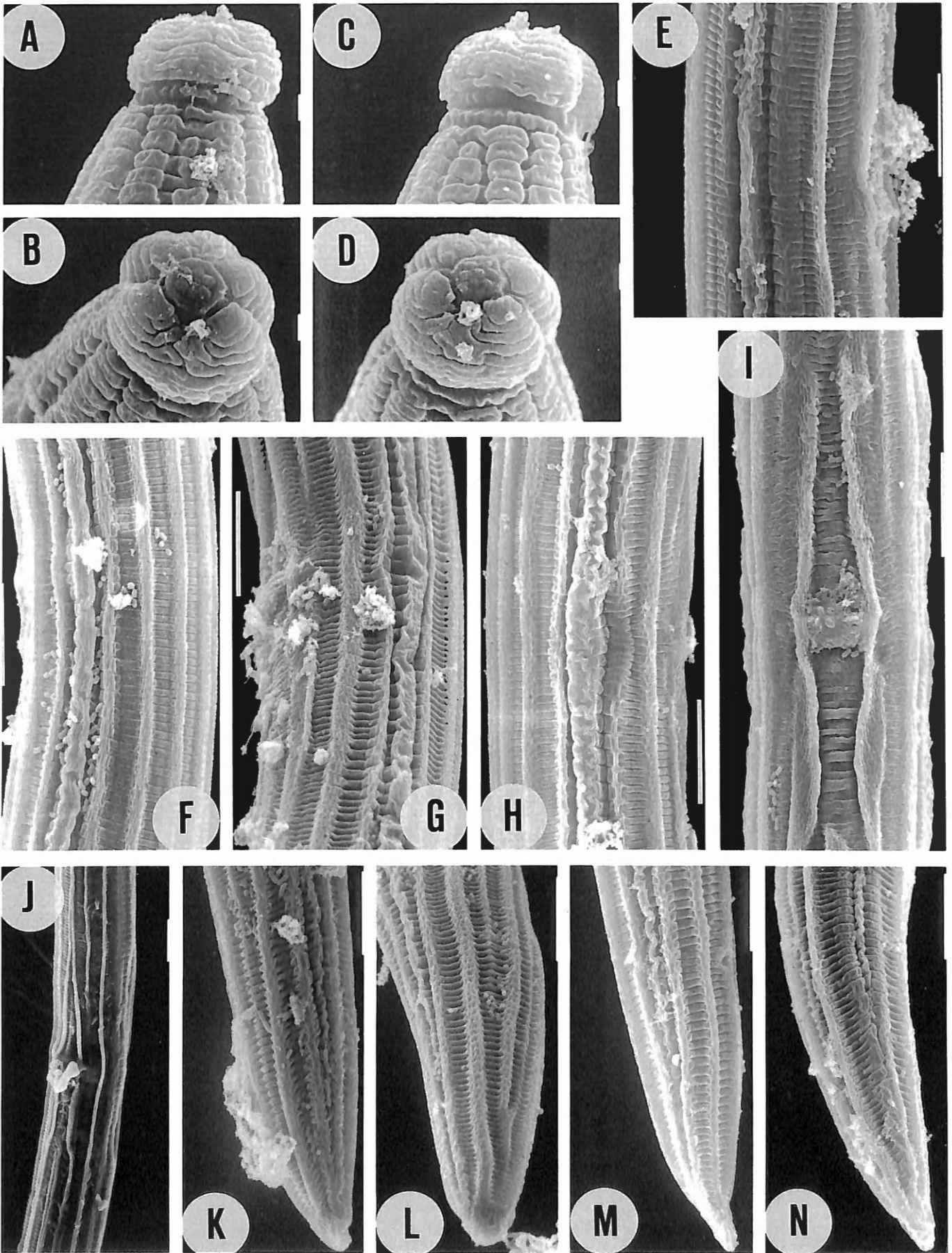


Fig. 19 – *Tylenchorhynchus sulcatus*, females. A-D : heads (A-B, C-D : respectively, lateral and in front view of the same specimen); E-J : vulvar region (the white arrow shows the direction or anterior region); K-N : tails; A-D : scale bar = 1  $\mu$ m; E-N : scale bar = 10  $\mu$ m.

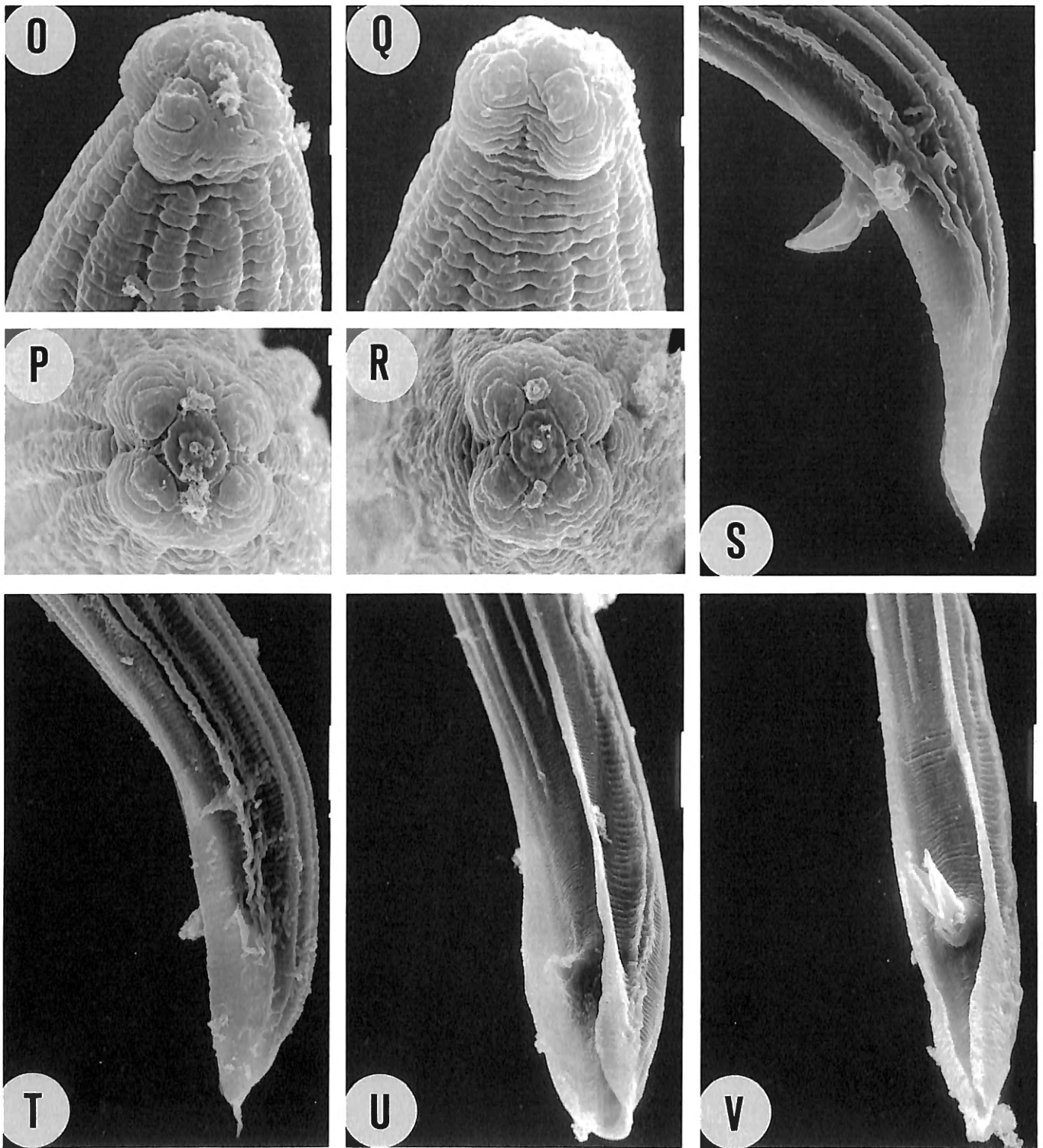


Fig. 20 – *Tylenchorhynchus sulcatus*, males. O-R : heads (O-P, Q-R : respectively lateral and in front view of the same specimen); S-T : tails; O-R : scale bar = 1  $\mu\text{m}$ ; S-V : scale bar = 10  $\mu\text{m}$ .