

Taxonomic studies on the genus *Aorolaimus* Sher, 1963 (Nemata : Hoplolaimidae). 1. Bibliographic analysis and tentative key to species

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Summary – The bibliographic analysis of descriptions of species and populations within the genus *Aorolaimus* permitted evaluation of the intraspecific variability of 39 characters used for species diagnosis and relationships. Three characters (areolations at phasmid level in the lateral fields, position of the anterior phasmid and presence of males) are well defined and present a low intraspecific variability and a sufficient intrageneric variability for grouping the species in six groups inside which other morphological or biometrical characters did not permit an obvious separation of all the species. Several species in the genus appear doubtful and their study under light microscopy is a preliminary before taxonomical decision. *Peltamigratus regularis* Siddiqi, 1985 is transferred to the genus *Aorolaimus* as *Aorolaimus regularis* (Siddiqi, 1985) n. comb. *A. brevicaudatus*, *A. conicori*, *A. triticeus* are considered as junior synonyms of *A. longistylus* and *A. thornei* as junior synonym of *A. pachyurus*.

Résumé – Études taxonomiques sur le genre *Aorolaimus* Sher, 1963 (Nemata : Hoplolaimidae). 1. Analyse bibliographique et proposition d'une clef d'identification des espèces – L'analyse bibliographique des descriptions d'espèces ou de populations dans le genre *Aorolaimus* permet d'évaluer la variabilité intraspécifique des 39 caractères utilisés pour les diagnostics spécifiques ou les relations entre taxons dans ce genre. Trois caractères (aréolations au niveau de la phasmide dans les champs latéraux, position de la phasmide antérieure, existence de mâles) sont bien définis et présentent une variabilité intraspécifique faible et intragénérique suffisante pour proposer six groupes d'espèces à l'intérieur desquels les autres caractères morpho-biométriques ne permettent pas une séparation claire de toutes les espèces. Plusieurs espèces du genre *Aorolaimus* apparaissent donc douteuses et leur réexamen en microscopie optique est nécessaire. *Peltamigratus regularis* Siddiqi, 1985 est transféré au genre *Aorolaimus* comme *Aorolaimus regularis* (Siddiqi, 1985) n. comb. *A. brevicaudatus*, *A. conicori* et *A. triticeus* sont considérés comme synonymes mineurs de *A. longistylus* et *A. thornei* comme synonyme mineur de *A. pachyurus*.

Rashid *et al.* (1987) propose a tabular key for identification of species in the genus *Peltamigratus* Sher, 1964 considered since as a junior synonym of *Aorolaimus* by Fortuner (1987); the authors used seven key characters : *i*) lateral fields areolated at phasmid level, *ii*) males present, *iii*) number of incisures in lateral fields, *iv*) stylet length, *v*) form of cephalic region, *vi*) type of epiptygma, *vii*) tail shape and number of tail annules. However, they note that *i*) " epiptygma shows specific variations ", *ii*) distal tail annule form is a " greatly variable character at species level ", *iii*) " tail shows specific variation in shape and in number of annules ".

A more recent study (Baujard *et al.*, 1991) on intra- and interspecific variability of external cuticular structures in the genus *Aorolaimus* Sher, 1963 has shown the

great variability of some characters used for characterization and/or diagnosis of taxa at specific level in this genus; some other characters (number of cephalic annules, presence *vs* absence of areolations in lateral fields at phasmid level, ornamentations of lateral fields) showed little variation at both specific and generic levels; they noticed the separation of the 32 recognized species within the genus *Aorolaimus* in three groups based on *i*) position of anterior phasmid, *ii*) presence *vs* absence of areolations in lateral fields at phasmid level.

Siddiqi (1985) describes a new species of *Peltamigratus*, that was overlooked by Baujard *et al.* (1991); following the taxonomical considerations developed by Fortuner (1987), this species is transferred to the genus

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Aorolaimus as *Aorolaimus regularis* (Siddiqi, 1985) n. comb.

After these two studies, the characters used for the diagnosis of the species now included in the genus *Aorolaimus* need an accurate reevaluation. In this work, we have analysed all the descriptions of species and populations.

Material and methods

56 publications with original descriptions of species now belonging to the genus *Aorolaimus* and/or descriptions of populations found in other biotopes or at different times have been analysed; they constitute 33 original descriptions and 23 descriptions of populations (numbers from 1 to 55 refer to studied populations mentioned in Figures 1-4). Two descriptions (Nos 43 and 44) used in this work are unpublished data from one of the authors (P. C.). Additional information on external cuticular structures come from SEM studies on *A. helicus*, *A. longistylus*, *A. luci*, *A. macbethi*, *A. perscitus*, *A. striatus* (Baujard et al., 1991).

IDENTIFICATION OF POPULATIONS

- 1 – *A. amazonensis* (Bittencourt & Huang, 1986) Baujard, Castillo, Doucet, Martiny, Mounport & N'Diaye, 1991.
- 2 – *A. annulatus* (Mulk & Jairajpuri, 1982) Fortuner, 1987.
- 3 – *A. areolatus* (Bittencourt & Huang, 1986) Baujard, Castillo, Doucet, Martiny, Mounport & N'Diaye, 1991.
- 4 – *A. baldus* Thorne, 1968.
- 5 – *A. banoae* (Rashid, Geraert & Sharma, 1987) Baujard, Castillo, Doucet, Martiny, Mounport & N'Diaye, 1991.
- 6 – *A. brevicaudatus* (Doucet, 1984) Fortuner, 1987.
- 7 – *A. brevicaudatus* : population described by Bittencourt and Huang (1986).
- 8 – *A. browni* (Khan & Zakiuddin, 1968) Fortuner, 1987.
- 9 – *A. capsici* Jimenez-Millan, Arias-Delgado & Fijo, 1964.
- 10 – *A. cerradoensis* (Bittencourt & Huang, 1986) Baujard, Castillo, Doucet, Martiny, Mounport & N'Diaye, 1991.
- 11 – *A. christiei* (Golden & Taylor, 1956) Fortuner, 1987.
- 12 – *A. christiei* : redescription of paratypes by Sher (1963).
- 13 – *A. christiei* : population described by Bittencourt and Huang (1986).
- 14 – *A. conicori* (Doucet, 1984) Fortuner, 1987.
- 15 – *A. helicus* Sher, 1963.
- 16 – *A. holdemani* (Sher, 1964) Fortuner, 1987.
- 17 – *A. holdemani* : population described by Loof (1964).
- 18 – *A. holdemani* : population described by Bittencourt and Huang (1986).
- 19 – *A. ibiboca* (Monteiro & Choudhury, 1978) Fortuner, 1987.
- 20 – *A. ibiboca* : population described by Bittencourt and Huang (1986).
- 21 – *A. indicus* (Khan & Husain, 1973) Fortuner, 1987.
- 22 – *A. leiomerus* (de Guiran, 1963) de Guiran & Sher, 1969.
- 23 – *A. leiomerus* : population described as *A. israeli* Sher, 1963.
- 24 – *A. leipogrammus* Sher, 1963.
- 25 – *A. levicaudatus* (Bittencourt & Huang, 1986) Baujard, Castillo, Doucet, Martiny, Mounport & N'Diaye, 1991.
- 26 – *A. levicaudatus* : population “Bahia” described by Rashid et al. (1987).
- 27 – *A. levicaudatus* : population “Evergem” described by Rashid et al. (1987).
- 28 – *A. longistylus* (Doucet, 1980) Fortuner, 1987.
- 29 – *A. longistylus* : population “El Palmar” described by Doucet (1986).
- 30 – *A. longistylus* : population “El Durazno” described by Doucet (1986).
- 31 – *A. luci* (Sher, 1964) Fortuner, 1987.
- 32 – *A. luci* : population described by Van den Berg and Cadet (1991).
- 33 – *A. macbethi* (Sher, 1964) Fortuner, 1987.
- 34 – *A. macbethi* : population described by Loof (1964).
- 35 – *A. nigeriensis* (Sher, 1964) Fortuner, 1987.
- 36 – *A. nigeriensis* : population described by Rashid et al. (1987).
- 37 – *A. nigeriensis* : population described by Bittencourt and Huang (1986).
- 38 – *A. nigeriensis* : population described by Sakwe and Geraert (1991, 1992).
- 39 – *A. pachyurus* (Loof, 1964) Fortuner, 1987.
- 40 – *A. paraensis* (Bittencourt & Huang, 1986) Baujard, Castillo, Doucet, Martiny, Mounport & N'Diaye, 1991.
- 41 – *A. perscitus* (Doucet, 1980) Fortuner, 1987.
- 42 – *A. perscitus* : population described by Doucet (1986).
- 43 – *A. perscitus* : population “Sierra de Cazorra” described by Castillo (unpubl.).
- 44 – *A. perscitus* : population “Sierra Morena-Andujar” described by Castillo (unpubl.).
- 45 – *A. perscitus* : population “Martos” described by Peña Santiago and Geraert (1990).
- 46 – *A. perscitus* : population “Bailen” described by Peña Santiago and Geraert (1990).
- 47 – *A. perscitus* : population “Torredonjimeno” described by Peña Santiago and Geraert (1990).
- 48 – *A. raskii* (Bittencourt & Huang, 1986) Baujard, Castillo, Doucet, Martiny, Mounport & N'Diaye, 1991.
- 49 – *A. regularis* (Siddiqi, 1985) n. comb.

- 50 – *A. sheri* (Andrássy, 1968) Fortuner, 1987.
 51 – *A. striatus* (Smit, 1971) Fortuner, 1987.
 52 – *A. thornei* (Knobloch, 1969) Fortuner, 1987.
 53 – *A. torpidus* Thorne & Malek, 1968.
 54 – *A. triticeus* (Doucet, 1984) Fortuner, 1987.
 55 – *A. vigiae* (Rashid, Geraert & Sharma, 1987) Baujard, Castillo, Doucet, Martiny, Mounport & N'Diaye, 1991.

All the characters used in descriptions, comparisons and diagnosis are compiled for *i*) the definition of previously used characters in characterization and/or comparison of taxa, *ii*) the evaluation of intra- and interspecific variability of these characters in the genus, *iii*) the determination of available characters for diagnosis of taxa.

The following numerical data are noted or calculated for the species and the genus: minimal and maximal values, difference between minimal and maximal values, arithmetic mean (when this data is absent, the mean is estimated on maximal and minimal values); some morphological data (areolations in lateral fields, incisures in lateral fields, relative positions of hemizonid and excretory pore, overlap of rectum by the intestine, spermatheca filled with sperm or not, indentation of bursa, presence of males) are coded for numerical classification.

When some morphological characters are absent from descriptions, additional observations have been made on drawings.

Results and discussion

NUMBER OF SPECIES WITH SEVERAL POPULATIONS AND NUMBER OF SPECIMENS PER POPULATION STUDIED

Of the 32 species studied, eleven comprise two or more described populations: *A. brevicaudatus* (2), *A. christiei* (2), *A. holdemani* (3), *A. ibiboca* (2), *A. leiomermus* (2), *A. levicaudatus* (3), *A. longistylus* (3), *A. luci* (2), *A. macbethi* (2), *A. nigriensis* (4), *A. perscitus* (7).

The number of specimens studied in each description of species or population varies from 1 to 38 ($\bar{x} = 13$); for 5 populations (Nos 4, 9, 38, 50, 53), this number is unknown.

CHARACTERS USED

Thirty-nine characters have been used for species diagnosis and/or species comparison (Table 1; Fig. 1-4); they can be distributed in four categories: biometric and morphologic in females and males. These characters are discussed below in each category following the frequency of use in descriptions (Table 1).

Table 1. Frequency of use of 39 characters for diagnosis and relationships in descriptions of (A): new species and (B): populations [numbers into brackets are calculated from drawings when data are missing in the text; frequency for characters concerning males is calculated only on total number of species with males].

Characters	Frequency (%)	
	A	B
BIOMETRIC IN FEMALES		
stylet length	53	100
tail annules number	37.5	85 (93)
head annules number	28	41 (48)
number of incisures in lateral fields	25	80 (89)
body length	22	98
o ratio	16	48
position of anterior phasmid	12.5	96
number of incisures on basal cephalic annule	6	20
b ratio	6	98
c ratio	6	98
tail length	6	35
body width	3	2
phasmid diameter	3	2
a ratio	3	98
b' ratio	3	76
V ratio	3	98
BIOMETRIC IN MALES		
spicules length	4	91
gubernaculum length	0	91
MORPHOLOGIC IN FEMALES		
type of epiptygma	44	81
tail form	37.5	63
position of hemizonid and excretory pore	34	72
head form	31	81
areolations at phasmid level	31	35 (78)
presence of spermatheca	31	76
tail annules form	31	63
cephalic constriction	28	80
stylet knobs form	22	81
width of bands in lateral fields	16	3
presence of sperm in spermatheca	16	76
type of incisures in lateral fields on tail	12.5	9
habitus	12.5	83
development of labial disc	6	13
type of cuticle on tail tip	6	6
presence of post anal sac	3	37
longitudinal striations on head	3	44
MORPHOLOGIC IN MALES		
males presence	25	89
form of the bursa	26	37
presence of caudal papillae	8	2
form of spicules	4	2

Biometrical characters in females

Stylet length : population mean value varies from 23 to 36 μm ($\bar{x} = 30.4$) and absolute values vary from 22.5 to 38 μm within the genus. Intraspecific variation at population level fluctuates from 1 to 6 μm ; in species with several described populations, this variation remains constant (*A. brevicaudatus*, *A. ibiboca*, *A. levicaudatus*, *A. macbethi*) or increases (from 4 to 5.5 μm in *A. christiei*, 5.5 to 9 in *A. holdemani*, 5.5 to 6 in *A. longistylus*, 4 to 6 in *A. nigeriensis*, 4 to 8 in *A. perscitus*).

Number of tail annules : mean value varies from 6.5 to 13.5 ($\bar{x} = 10$) and absolute values vary from 4 to 16 within the genus. Intraspecific variation at population level fluctuates from 1 to 9; in species with several described populations, this variation remains constant (*A. holdemani*, *A. longistylus*, *A. luci*, *A. nigeriensis*, *A. macbethi*) or increases (from 5 to 10 in *A. brevicaudatus*, 4 to 6 in *A. christiei*, 5 to 7 in *A. ibiboca*, 4 to 5 in *A. levicaudatus*). For *A. torpidus*, there is a discrepancy between values in text (10 annules) and illustration (15 annules) of the description.

Number of head annules : this information is absent in more than 50 % of descriptions of population. When given, mean value varies from 0 to 7.5; the text of the descriptions often reflects the difficulty of observation : "with faint traces of two striae" (*A. baldus*), "difficult to establish" (*A. perscitus* population No. 45 to 47), "smooth at first view but actually with hardly visible annules" (*A. ibiboca*, population No. 19), "rarely with annules" (*A. paraensis*), "probably three striae, though these are very poorly developed and have been seen only on occasional specimens" (*A. christiei*, population No. 11), "rather indistinct" (*A. nigeriensis*, population No. 36), "number of lip annules probably 6-7" (*A. holdemani*, population No. 17), "smooth at first view, but actually with fine transverse striation" (*A. pachyurus*). SEM observations reveal the presence of 4 annules in *A. helicus*, 4-5 in *A. leiomerus*, 5 in *A. luci*, 5 in *A. macbethi* (where some specimens show no head annulation), 4-6 in *A. longistylus* and *A. perscitus* (Baujard et al., 1991).

Number of incisures in lateral fields : this character presents five states within the genus; species have been described *i*) with only two incisures, *ii*) with only two "true" incisures, two others marked by the interruption of transverse striation, *iii*) with between two and four incisures, *iv*) with four incisures, the two other sometimes fading away, *v*) with four incisures. Intraspecific variations are reported for two species : *A. thornei* and *A. christiei* (populations Nos 11, 12 and 13). High level of variation is noted in *A. macbethi* where these five conditions are seen under SEM (Baujard et al., 1991).

Body length : mean value varies from 540 to 1020 μm ($\bar{x} = 860$) and absolute values vary from 510 to 1210 μm within the genus. Intraspecific variation at

population level fluctuates from 70 to 380 μm ; considering species with several described populations, this variation remains constant (*A. leiomerus*) or increases (from 180 to 220 μm in *A. brevicaudatus*, from 200 to 320 μm in *A. christiei*, from 290 to 400 μm in *A. holdemani*, from 160 to 170 μm in *A. ibiboca*, from 230 to 370 μm in *A. levicaudatus*, from 250 to 300 μm in *A. nigeriensis*, and from 376 to 396 μm in *A. perscitus*).

Ratio o : this data is absent in more than 50 % of the descriptions. Mean value varies from 12 to 21.6 ($\bar{x} = 17$) and absolute values vary from 5.5 to 27 within the genus. Intraspecific variation at population level fluctuates from 0.8 to 14; considering species with several described populations, this variation remains constant (*A. luci*, *A. nigeriensis*) or increases (from 8.7 to 12.9 in *A. christiei*, from 14 to 16 in *A. holdemani*, from 9 to 15.9 in *A. perscitus*). In *A. striatus*, mean value (17) is outside the range delimited by minimal and maximal values (13-14).

Position of anterior phasmid : mean value varies from 30 to 89 % ($\bar{x} = 72$) and absolute values vary from 26 to 89.7 % within the genus. Intraspecific variation at population level fluctuates from 1 to 38 %; considering species with several described populations, this variation remains always constant except in *A. nigeriensis* where it increases from 9 to 11. It should be noted that in nine populations (Nos 6, 14, 17, 29, 30, 34, 39, 42, 54), positions of right/left phasmids are given instead of anterior/posterior phasmids. In *A. capsici*, minimal value (34) appears doubtful.

Number of longitudinal incisures on basal cephalic annule : presence of longitudinal incisures is mentioned only in thirteen descriptions; the number of incisures is given only in six descriptions (five with value 0 and one with value 30).

Ratio b : mean value varies from 5.7 to 11 ($\bar{x} = 7.8$) and absolute values vary from 5.2 to 11 within the genus. Intraspecific variation at population level fluctuates from 0.4 to 3.5; considering species with several described populations, this variation remains constant (*A. brevicaudatus*, *A. longistylus*) or increases (from 1.9 to 3 in *A. christiei*, from 2.9 to 3.6 in *A. holdemani*, from 1.5 to 2.2 in *A. ibiboca*, from 2.8 to 4 in *A. leiomerus*, from 3.5 to 4.8 in *A. levicaudatus*, from 1.6 to 2.2 in *A. luci*, from 2.3 to 2.6 in *A. macbethi*, from 2.3 to 2.9 in *A. nigeriensis*, from 2.8 to 3.9 in *A. perscitus*).

Ratio c : mean value varies from 41 to 75 ($\bar{x} = 57$) and absolute values vary from 32 to 107 within the genus. Intraspecific variation at population level fluctuates from 1.5 to 50; considering species with several described populations, this variation remains constant (*A. brevicaudatus*, *A. christiei*, *A. ibiboca*, *A. macbethi*) or increases (from 48 to 49 in *A. holdemani*, from 50 to 57 in *A. leiomerus*, from 39 to 44 in *A. levicaudatus*, from 22

to 43.5 in *A. luci*, from 23 to 34 in *A. nigeriensis*, from 42.5 to 52 in *A. perscitus*).

Tail length : mean value varies from 10.5 to 22 μm (\bar{x} = 16) and absolute values vary from 8 to 27.5 μm within the genus. Intraspecific variation at population level fluctuates from 0 to 10 μm ; considering species with several described populations, this variation remains constant (*A. levicaudatus*) or increases (from 10 to 11.5 μm in *A. longistylus* and from 10 to 13 μm in *A. perscitus*).

Body diameter : this character is used only once for species diagnosis; it never appears in descriptions of populations.

Phasmid diameter : this measurement is used once for species diagnosis; it appears also only once in descriptions of populations.

Ratio a : mean value varies from 23 to 34.7 (\bar{x} = 29.1) and absolute values vary from 18 to 39 within the genus. Intraspecific variation at population level fluctuates from 1 to 13.1; considering species with several described populations, this variation remains constant (*A. christiei*, *A. ibiboca*, *A. leiomerus*, *A. longistylus*, *A. perscitus*) or increases (from 2.7 to 6.2 in *A. brevicaudatus*, from 8.4 to 9 in *A. holdemani*, from 8.8 to 10 in *A. levicaudatus*, from 6 to 7 in *A. luci*, from 8 to 9 in *A. macbethi*, and from 10 to 11.2 in *A. nigeriensis*).

Ratio b' : mean value varies from 5.1 to 8.5 (\bar{x} = 6.5) and absolute values vary from 4.8 to 11.7 within the genus. Intraspecific variation at population level fluctuates from 0.1 to 3.7; considering species with several described populations, this variation does not increase.

Ratio V : mean value varies from 53.5 to 62 % (\bar{x} = 56.3) and absolute values vary from 41 to 67 within the genus. Intraspecific variation at population level fluctuates from 1 to 10; considering species with several described populations, this variation does not increase. In *A. capsici*, minimal value ($V = 41$) appears doubtful.

Biometrical characters in males

Spicules length : mean value varies from 18.5 to 38 μm (\bar{x} = 29.6) and absolute values vary from 18 to 38 μm within the genus. Intraspecific variation at population level fluctuates from 0.5 to 16 μm ; considering species with several described populations, this variation remains constant (*A. luci*) or increases (from 4.2 to 5 μm in *A. christiei*, from 4 to 7 in *A. holdemani*, from 3.5 to 4.5 in *A. levicaudatus*, from 6.5 to 9 in *A. nigeriensis*, from 6 to 7 in *A. perscitus*).

Gubernaculum length : mean value varies from 7 to 17.4 μm (\bar{x} = 13.6) and absolute values vary from 7 to 18.6 μm within the genus. Intraspecific variation at population level fluctuates from 0 to 5 μm ; considering species with several described populations, this variation remains constant (*A. christiei*) or increases (from 3 to 4 μm in *A. holdemani*, from 2.5 to 6 in *A. levicaudatus*,

from 2.6 to 3.1 in *A. luci*, from 3 to 5 in *A. nigeriensis*, and from 5 to 7.1 in *A. perscitus*).

Morphological characters in females

Type of epiptygma : this character presents several states. Epiptygma can be absent, simple, single or double, double; in the two last cases, it can be : inconspicuous, poorly developed, small, conspicuous, well developed, inside vagina, not projecting, projecting or not, generally projecting. Variation of type of epiptygma (single or double) is noted only in the type population of *A. levicaudatus*. This character appears to be highly variable in one population of *A. macbethi* originating from Senegal (Baujard *et al.*, 1991) as in other genera of the Hoplolaiminae (Baujard & Mounport, 1990; Baujard *et al.*, 1990; Mounport *et al.*, 1991).

Tail shape : observations of illustrations in the publications do not reveal any differences between tail types within the genus. Analysis of descriptions reveals the great diversity of terms used for description of the same situation : rounded, broadly rounded, rounded more curved dorsally, hemispherical, broadly hemispheroid, subcylindrical, conoid, conical (appears rounded on illustration), tapering, etc. Intra- and interspecific variations of tail form occur in *A. macbethi* and in *A. perscitus* (Baujard *et al.*, 1991).

Relative positions of hemizonid and excretory pore : hemizonid and excretory pore are always very close, the variation fluctuation from zero to four body annules. In sixteen descriptions, position of excretory pore is variable, at the same level or anterior/posterior to hemizonid.

Head shape : the descriptions reveal variations of head profile within the genus, from rounded to conical. In one species with several described populations, variation occurs with the same amplitude (*A. perscitus*, populations No. 41 to 47). SEM studies reveal variations of head form in *A. longistylus* and *A. perscitus* (Baujard *et al.*, 1991).

Areolations at phasmid level : this character presents two states (areolations present *vs* absent); no intraspecific variation is reported.

Presence of spermatheca : this character presents also two states (present *vs* absent); no intraspecific variation is reported.

Type of tail terminus annules : this character presents five states : *i*) annules absent (terminus smooth), annules present and *ii*) of the same width, *iii*) narrower, *iv*) wider, *v*) separated by deep constrictions. Intraspecific variation is reported for numerous populations (Nos. 3, 7, 25, 26, 45, 46, 47, 50, 52, 55).

Cephalic constriction : this character presents three states (*i*) distinctly set off, *ii*) slightly set off, *iii*) continuous); intraspecific variation appears between different populations of the same species (*A. christiei*, *A. holdemani*, *A. longistylus*, *A. striatus*) and within the same

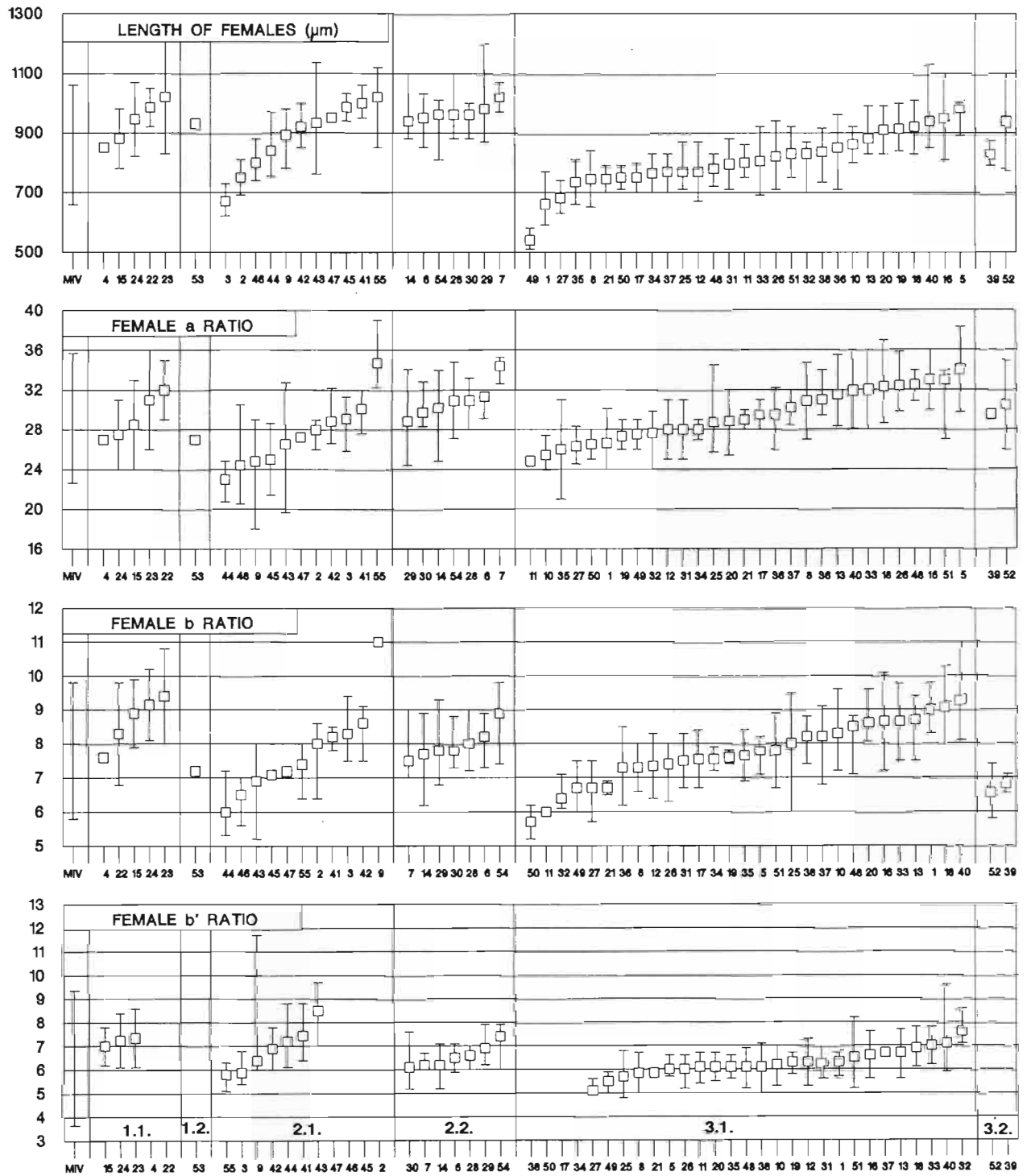


Fig. 1. Biometrical characteristics of females : length, ratio a, ratio b, ratio b'. (MIV = maximal intraspecific variation; 1-55 = species or population studied; 1.1.-3.2. = sub-groups of species; □ = mean; bar = minimal and maximal values).

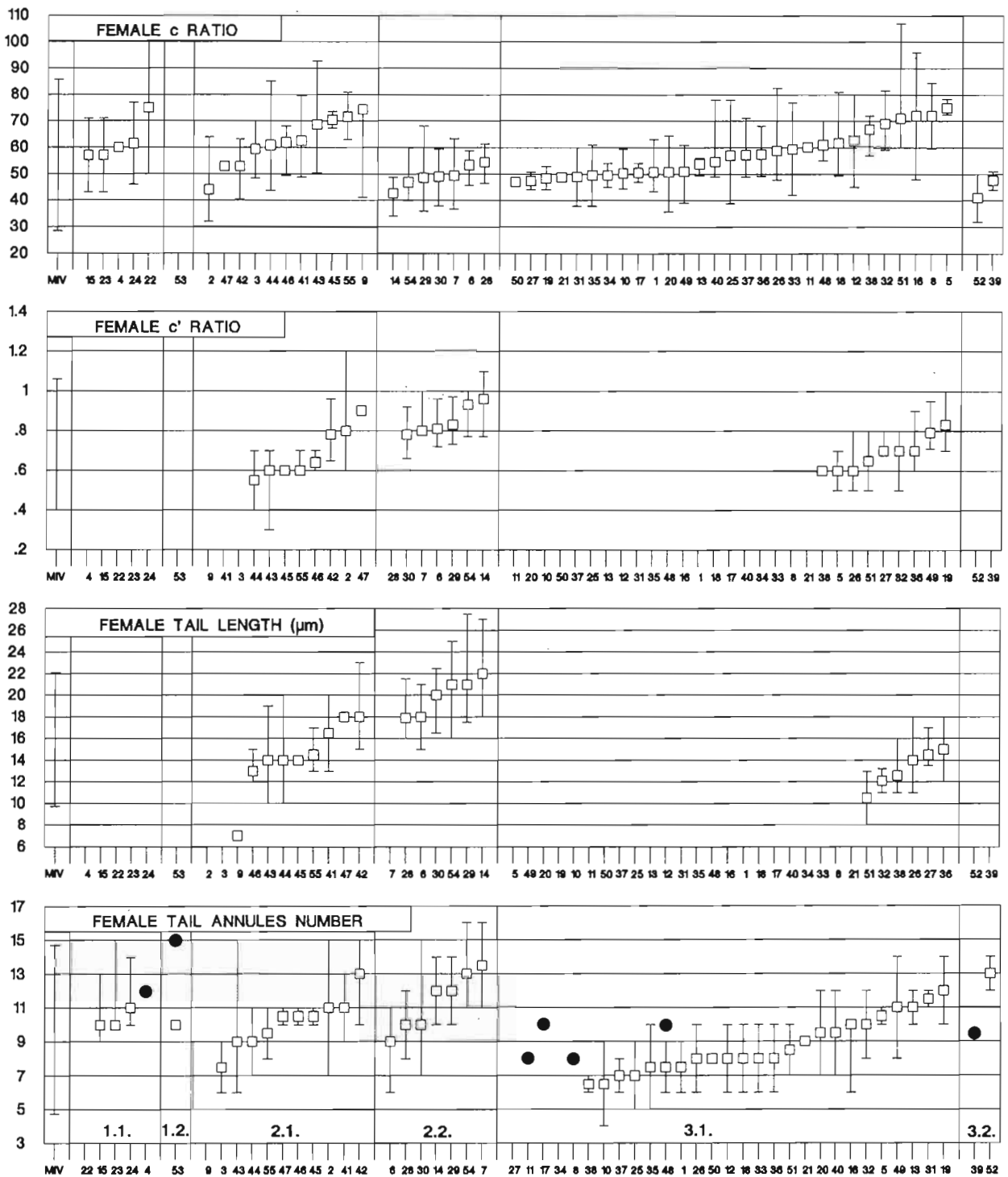


Fig. 2. Biometrical characteristics of females : ratio c , ration c' , tail length number of tail annules. (MIV = maximal intraspecific variation; 1-55 = species or population studied; \square = mean; bar = minimal and maximal values; 1.1.-3.3. = sub-groups of species; \bullet = values calculated on drawings).

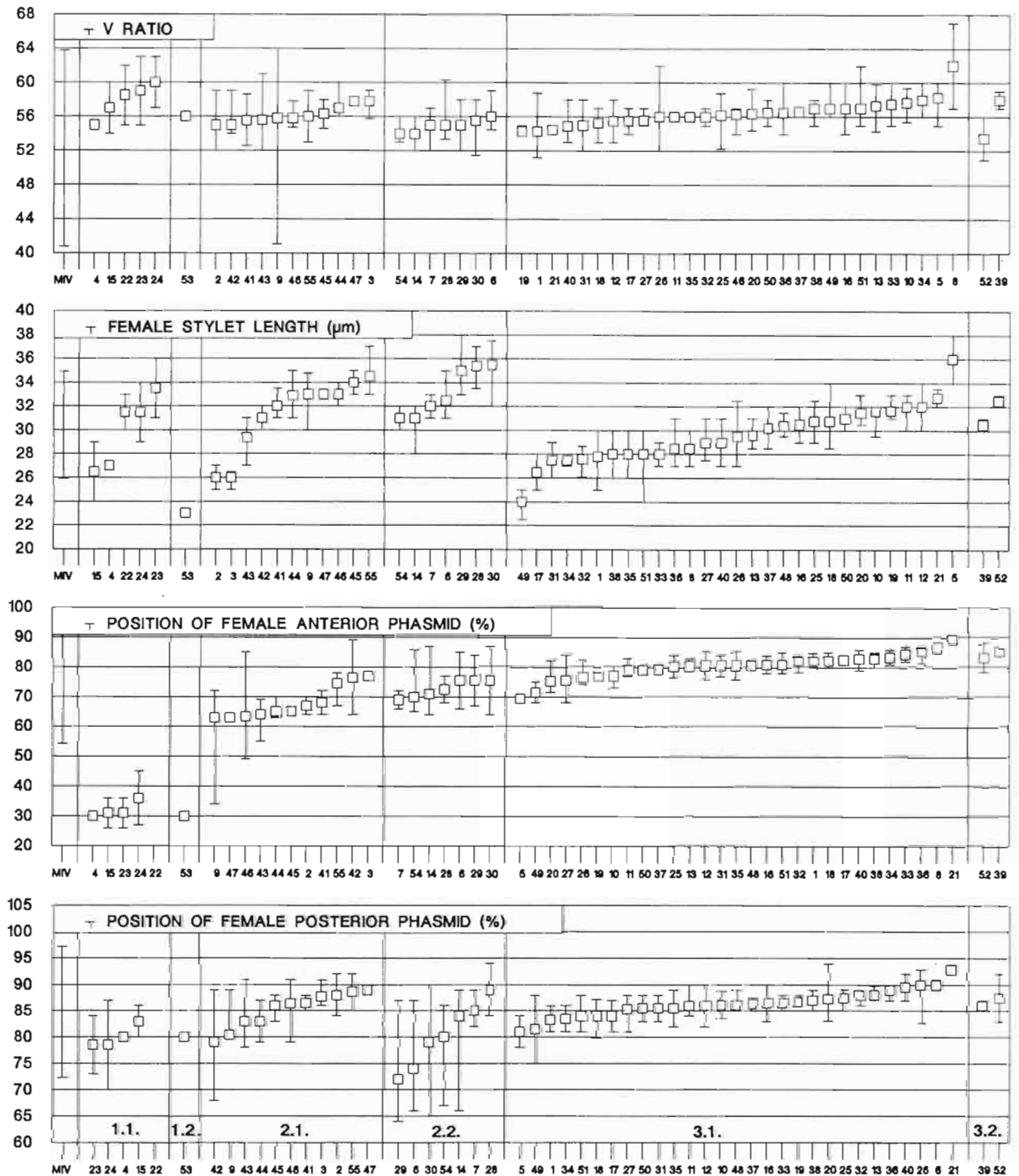


Fig. 3. Biometrical characteristics of females : ratio V, stylet length, position of anterior phasmid, position of posterior phasmid. (MIV = maximal intraspecific variation; 1-55 = species or population studied; 1.1.-3.2. = sub-groups of species; □ = mean; bar = minimal and maximal values).

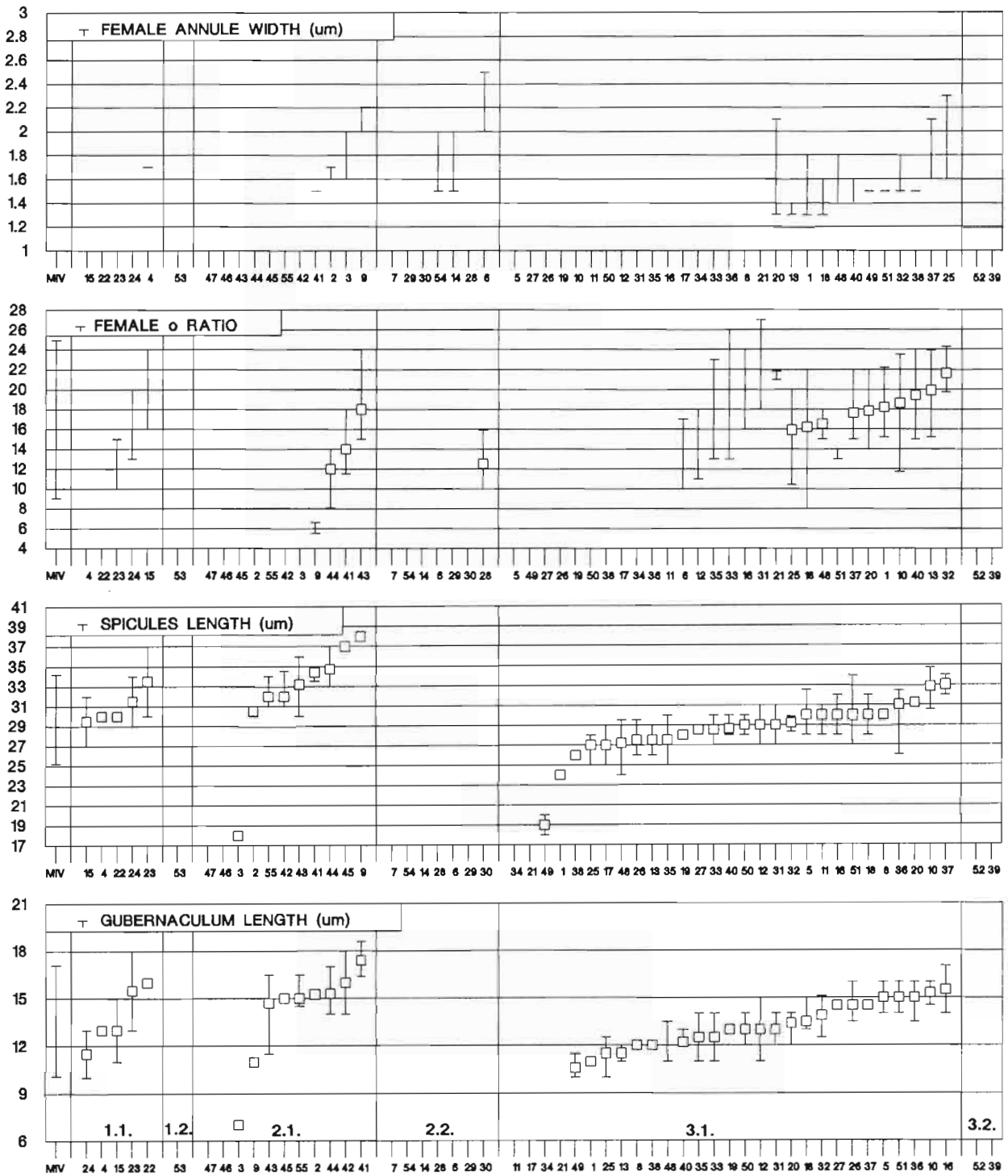


Fig. 4. Biometrical characteristics of males and females; Males : spicules length, gubernaculum length; Females : annule width, ratio o. (MIV = maximal intraspecific variation; 1-55 = species or population studied; 1.1.-3.2. = sub-groups of species; □ = mean; bar = minimal and maximal values).

population for *A. longistylus* and *A. perscitus* (Baujard et al., 1991).

Stylet knobs form : it appears very difficult to compare stylet knobs form on published descriptions. Knob forms vary in descriptions proposed for species of this genus from rounded to oval; several descriptions specify the form of anterior surface (from rounded to cupped, flattened, concave or anteriorly sloping) and posterior surface (always rounded). In some populations (*A. banoae*, *A. christiei* population No. 12, *A. leipogrammus*, *A. nigeriensis* population No. 36), intraspecific variation is reported.

Width of bands in lateral fields : this character presents two states (bands of same width *vs* internal band being wider than external bands). No intraspecific variation is reported in the different descriptions of populations; data obtained by SEM observations do not confirm those of light microscope in *A. longistylus* (Baujard et al., 1991).

Sperm in spermatheca : this character presents two states (present *vs* absent); no intraspecific variation is reported.

Type of incisures in lateral fields on tail : this character presents two states (inner lines of lateral fields joining in "U" *vs* "Y"); intraspecific variation is reported (*A. conicori*, population No. 14) as for *A. helicus*, *A. longistylus* and *A. perscitus* under SEM (Baujard et al., 1991).

Habitus : it varies from a "J" shape to a spiral shape within the genus. Intraspecific variation is often (46 % of the descriptions of populations) reported for this character.

Development of labial disc : the disc is either prominent or not prominent; no intraspecific variation is reported in the descriptions but both states have been observed under SEM for *A. perscitus* (Baujard et al., 1991).

Type of cuticle on tail tip : this character presents two states (thickened and composed of two layers *vs* unthickened, number of layers being not reported). No variation is reported within populations; both states of this character have been described in different populations considered to belong to the same species (*A. holdemani*, *A. nigeriensis*).

Presence of post-anal sac : the sac is either present or absent; no intraspecific variation is reported.

Longitudinal striations on head : longitudinal striations occur *i)* on the whole head, *ii)* only on the first anterior head annules, *iii)* only on the basal cephalic annule; intraspecific variation is mentioned in descriptions for some populations (Nos. 42, 43); the same variation is found under SEM for *A. helicus*, *A. leiomerus*, *A. longistylus* and *A. perscitus* (Baujard et al., 1991).

Morphological characters in males

Presence of males : this character presents two states (present *vs* absent); no intraspecific variation is reported. In one case (*A. indicus*), no males were found although sperm was found in spermatheca; males are considered as present in this species.

Shape of the bursa : the bursa can be slightly, deeply or not indented. No intraspecific variation is reported in the descriptions of populations but some variation was observed under SEM in *A. macbethi* and *A. perscitus* (Baujard et al., 1991).

Presence of caudal papillae : caudal papillae have been reported only in three species, *A. banoae*, *A. sheri*, *A. vigiae*; this character has never been reported in Tylenchina. They are probably artefacts.

Shape of spicules : description of spicule shape is rarely given, reporting only that spicules are ventrally curved or arcuate.

IDENTIFICATION OF SPECIES

Using two characters (areolations present *vs* absent at phasmid level in lateral field; anterior phasmid at less *vs* more than 45 % of body length), the 33 species described in the genus can be split in three groups; using a third character (presence *vs* absence of males), each group can be split in two sub-groups. The first character (areolations in lateral fields at phasmid level) used for splitting the species of the genus *Aorolaimus* into groups has never been reported to vary at specific level. For the second character (position of anterior phasmid), there is a distinct gap around the value 45 %; only one species presents a range of variation exceeding this value : *A. capsici* with values ranging from 34 to 72 %. The third character appears less reliable since the lack of males in the soil sample and absence of sperm in female spermatheca do not mean obligatory absence of males in the population.

Inside all the subgroups, there are no relevant differences in biometric and/or morphologic characters between numerous species.

Group 1. (areolations present at phasmid level, anterior phasmid at less than 45 %).

Subgroup 1.1. (males present) with four species : *baldus*, *helicus*, *leiomerus*, *leipogrammus*. *A. baldus* is poorly described and differentiated from the three other species of this subgroup by the faint (*vs* strong) head annulation; the striation of the basal head annule is not reported. *A. leipogrammus* differs from *A. helicus* and *A. leiomerus* by the absence (*vs* presence) of striations on the basal head annule. *A. leiomerus* was said to differ from *A. helicus* by *i)* the distance between the base of the stylet and the opening of the dorsal oesophageal gland, *ii)* the broadly well set-off lip region, *iii)* longer spear, *iv)* the habitus of the female, *v)* the number of striations on the basal head annule (20-22 *vs* 16-20) (Sher, 1963). Measurements of the distance between the base of the

stylet and the opening of the dorsal oesophageal gland on drawings (Figs 7, A; 6, A) give the same distance (5 μm in *A. leiomerus*, 5.5 μm in *A. helicus*); the head of *A. leiomerus* appeared well set off to no set off under SEM (Fig. 1 : P, Q, T, U in Baujard *et al.*, 1991); the stylet is slightly shorter in *A. helicus* (24-29 μm) than in *A. leiomerus* (30-36 μm); the number of longitudinal striae on the basal head annule appears variable for *A. leiomerus* (20-22 in the population Nos 23 and 26-30 in the population No. 22 studied under SEM by Baujard *et al.*, 1991). Careful study of these two species will probably conduct to their synonymization.

Subgroup 1.2. (males absent) with one species : *A. torpidus*. Its original description is incomplete, especially regarding the presence/absence of longitudinal incisures on the basal head annule. *A. torpidus* can be characterized by *i*) the short stylet (23 μm) and *ii*) the absence of males.

Group 2. (areolations present at phasmid level, anterior phasmid at more than 45 %).

Subgroup 2.1. (males present) with five species : *annulatus*, *areolatus*, *capsici*, *perscitus*, *vigiæ*. *A. aerolatus* can be distinguished from all other species of this subgroup by the combination of *i*) a short stylet (25-26.5 μm), *ii*) short spicules (18 μm) and *iii*) presence of 1-2 head annules (*vs* 4-6 in the other species of the sub-group. The four other species, *A. annulatus*, *A. capsici*, *A. perscitus* and *A. vigiæ* cannot be differentiated since the stylet length, the single differentiating character, shows a great variability in the different populations (Nos 43, 42, 41, 44, 46, 45) of *A. perscitus*: 27-31, 30-33.5, 31-35, 32-34, 33-35 μm respectively; *A. vigiæ* was said to differ from *A. perscitus* by the length of the stylet (33-37 μm); *A. annulatus* exhibits a shorter stylet (25-27 μm) but only four specimens have been measured; *A. capsici* has been described from Spain where several populations of *A. perscitus* were found. Synonymization of these four species cannot be proposed without examination of specimens of the different nominal species, some of them being poorly described in the publications.

Subgroup 2.2. (males absent) with four species : *brevicaudatus*, *conicori*, *longistylus*, *triticeus*. Four species are present in this group, all separated in the original descriptions by the stylet length, width of the bands of the lateral fields, pattern of incisures on tail terminus and number of tail annules, shape of the head, prominence of the labial disc and shape of the stylet knobs. In this subgroup, stylet lengths vary from 28 to 38 μm with large overlap between nominal species and/or described populations; the other characters exhibit great variations at species level. Therefore, *A. brevicaudatus*, *A. conicori* and *A. triticeus* are considered as junior synonyms of *A. longistylus*.

Group 3. (areolations absent at phasmid level, anterior phasmid at more than 45 %).

Subgroup 3.1. (males present) with seventeen species : *amazonensis*, *banoae*, *browni*, *cerradoensis*, *christiei*, *holdemani*, *ibiboca*, *indicus*, *levicaudatus*, *luci*, *macbethi*, *nigeriensis*, *paraensis*, *raskii*, *regularis*, *striatus*, *sheri*. In this subgroup, *A. indicus* is described on a small population of only six specimens without males but with spermatheca filled with sperm; it is also placed in subgroup 3.1. *A. regularis* is separated from the other species of the subgroup by *i*) the length of the stylet (22.5-25 μm *vs* 25-38 μm), *ii*) the body length (0.51-0.58 mm *vs* 0.59-1.13 mm), *iii*) the length of the spicules (18-20 μm *vs* 25-35 μm). The 17 other species are identified on the basis of one biometrical character (stylet length) and seven morphological characters (ornamentations in the lateral field, shape of the tail annules, type of epiptygma, tail shape, head shape, relative positions of hemizonide and excretory pore). The stylet length ranges from 22.5 to 38 μm with great overlap between species and/or populations except for *A. banoae* (stylet length : 34-38 μm). The other characters are variable at the specific level and do not allow separation of the species except for *A. luci* with cuticular spines on the edges of the bursa. The fourteen remaining species cannot be separated on the basis of the published descriptions; the synonymization of *A. amazonensis*, *A. browni*, *A. cerradoensis*, *A. holdemani*, *A. ibiboca*, *A. indicus*, *A. levicaudatus*, *A. macbethi*, *A. nigeriensis*, *A. paraensis*, *A. raskii*, *A. regularis*, *A. sheri* and *A. striatus* under *A. christiei* calls for the reexamination of the types of these nominal species.

Subgroup 3.2. (males absent) with two species : *pachyurus*, *thornei*. In these two closely related species, the spermatheca was not seen. *A. thornei* was said to differ from *A. pachyurus* by the type of epiptygma and type of tail annulation, two characters considered here without diagnostic value at specific level. *A. thornei* is therefore considered as a junior synonym of *A. pachyurus*.

Tentative key to the species

- 1 - Lateral fields areolated at phasmid level 2
 - Lateral fields not areolated at phasmid level 9
- 2 - Anterior phasmid under 45 % of the body length 3
 - Anterior phasmid above 45 % of the body length 7
- 3 - Stylet length under 24 μm ; males absent *A. torpidus*
 - Stylet above 24 μm ; males present 4
- 4 - Head annulation weak; 3 heads annules present
 - *A. baldus*
 - Head annulation strong; 4 to 5 head annules present . 5
- 5 - Basal head annule without longitudinal striations
 - *A. leipogrammus*
 - Basal head annule with longitudinal striations6
- 6 - Stylet length 24-29 μm *A. helicus*
 - Stylet length 30-36 μm *A. leiomerus*
- 7 - Males present 8
 - Males absent *A. longistylus*
(= *A. brevicaudatus*, *A. conicori*, *A. triticeus*)

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