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A revised polytomous key for the identification of species of the genus *Xiphinema* Cobb, 1913 (Nematoda: Longidoridae) with exclusion of the *X. americanum*-group

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Abstract

The species of the genus *Xiphinema* Cobb, 1913 are listed and their current status is indicated. A revised polytomous key to the 172 valid species (excluding the *X. americanum*-group) is presented. Because of the very large number of species the key is split into eight groups on the basis of development of the anterior female genital branch, uterine differentiation and tail shape. In accordance with the opinion of Cohn & Sher (1972) *X.vulgare* Tarjan, 1964 is considered a synonym of *X. setariae* Luc, 1968. *X. cubense* Razzhivin, 1973 is placed in *species inquirendae*. *Longidorella chappuisi* (Schneider, 1935) is transferred to *Xiphinema* and its possible identity with *X. hygrophilum* Southey & Luc, 1974 is discussed.

Introduction

In 1975 Luc & Dalmasso (1975a,b) published a polytomous key (colloquially referred to as a "lattice") for the identification of the 74 valid species of *Xiphinema* known at that time. Because of the large morphological diversity of the species this genus is particularly suitable for such a key. Since 1975 a few species have been synonymised with others, and a large number of new species were described. The genus now contains 172 species considered valid. In addition, new morphological data about certain species have been brought to light. A new, revised, up-to-date key is therefore required.

The total number of nominal *Xiphinema* species is now 213, including 172 valid species, 25 synonymised species, 13 *species inquirendae/dubiae*, and 3 transferred to other genera. Four species have been renamed because of homonymy.

Species of the genus *Xiphinema*

Type-species: **X. americanum* Cobb, 1913
= *Tylencholaimus americanus* (Cobb, 1913) Micoletzky, 1922

(*) before the species name indicates that this species belongs to the *X. americanum*-group.

Valid species

X. aceri Chizhov, Tiev & Turkina, 1986
X. aequum Roca & Lamberti, 1988
X. algeriense Luc & Kostadinòv, 1982
X. arcum Khan, 1964
X. artemisiae Chizhov, Tiev & Turkina, 1986
X. attorodorum Luc, 1961
    syn. *X. campinense* apud Luc (1958)
X. bacaniboia Orton Williams, 1984
X. bajaji Jairajpuri & Lamberti, 1981
    syn. *X. luci* Bajaj & Jairajpuri, 1979, homonym of *X. luci* Lamberti & Bleve-Zacheo, 1979
X. bakeri Williams, 1961
X. barbercheckae Coomans & Heyns, 1985
X. barense Lamberti, Roca, Agostinelli & Bleve-Zacheo, 1986
X. basilgoodeyi Coomans, 1965
X. basiri Siddiqi, 1959
    syn. *X. cobbi* Sharma & Saxena, 1981; *X. hayati* Javed, 1983
X. bergeri Luc, 1973
X. bolandium Coomans & Heyns, 1985
X. bourkei Stocker & Kruger, 1988
X. brasiliense Lordello, 1951
    syn. *X. itanhaense* Carvalho, 1962; *X. mammillocaudatum* Khan, 1982
**X. brevicolle* Lordello & Da Costa, 1961
    syn. *X. americanum* apud Carvalho (1955, 1962); *X. saopaoloense* Khan & Ahmad, 1975
**X. bricolense* Ebsary, Vrain & Graham, 1989
X. brevistylus Jairajpuri, 1982
**X. californicum* Lamberti & Bleve-Zacheo, 1979
X. capense Coomans & Heyns, 1985
X. cavenessi Luc, 1973
X. chambersi Thorne, 1939
**X. citricolum* Lamberti & Bleve-Zacheo, 1979
X. clavatum Heyns, 1965
X. clavicaudatum Huang, Uesugi & Raski, 1987
X. colombiense Hunt, 1982
X. conurum Siddiqi, 1964
X. coomansi Kruger & Heyns, 1986
X. costaricense Lamberti & Tarjan, 1974
X. coxi coxi Tarjan, 1964
X. coxi europaeum Sturhan, 1985
X. dentatum Sturhan, 1978
X. diannae Kruger & Heyns, 1987
**X. diffusum* Lamberti & Bleve-Zacheo, 1979
X. dimidiatum Loof & Sharma, 1979
X. dimorphicaudatum Heyns, 1966
X. dissimile Roca, Pereira & Lamberti, 1988

X. diversicaudatum (Micoletzky, 1927) Thorne, 1939
syn. *X. paraelongatum* Altherr, 1958; *Dorylaimus elongatus* apud Micoletzky, 1923; = (*Dorylaimus* (*Longidorus*) *diversicaudatus* Micoletzky, 1927; = *Longidorus diversicaudatus* (Micoletzky, 1927) Thorne & Swanger, 1936)
nec *X. diversicaudatum* apud Luc (1958) (= *X. seredouense*); *X. diversicaudatum* apud Cohn (1969) (= *X. israeliae*)
X. diversum Roca, Lamberti, Santos & Abrantes, 1989
X. dolosum Bos & Loof, 1985
X. douceti Luc, 1973
X. ebriense Luc, 1958
X. elitum Khan, Chawla & Saha, 1978
X. elongatum Schuurmans Stekhoven & Teunissen, 1938
syn. *X. campinense* Lordello, 1951; *X. hydrabadense* Quraishi & Das, 1984; *X. nagarjunense* Khan, 1982; *X. pratense* Loos, 1949; *X. uasi* Edward & Sharma, 1982
X. ensiculiferum (Cobb, 1893) Thorne, 1937 (= *Tylencholaimus ensiculiferus* Cobb, 1893)
Syn. *X.ensiculiferoides* Cohn & Sher, 1972
nec *X. ensiculiferum* apud Loos (1949) and Williams (1959) (= *X. krugi*); *X. ensiculiferum* apud Luc (1961) (= *X. hygrophilum*); *X. ensiculiferum* apud Carvalho (1955) (= *X. surinamense*)
X. erriae Hutsebaut, Heyns & Coomans, 1988
X. exile Roca, Lamberti, Santos & Abrantes, 1989
X. fatikae Bos & Loof, 1985
X. filicaudatum Loof & Maas, 1972
X. flagellicaudatum Luc, 1961
**X. floridae* Lamberti & Bleve-Zacheo, 1979
X. fluminense Huang, Uesugi & Raski, 1987
**X. fortuitum* Roca, Lamberti & Agostinelli, 1988
**X. georgianum* Lamberti & Bleve-Zacheo, 1979
X. globosum Sturhan, 1978
X. guirani Luc & Williams, 1978
nec **X. guirani* apud Lamberti & BleveZacheo (1979)
X. hallei Luc, 1958
nec *X. hallei* apud Heyns (1962, 1971) (= *X. mluci*)
X. hardingi Joubert, Kruger & Heyns, 1988
X. heynsi Siddiqi, 1979
X. hygrophilum Southey & Luc, 1974
syn. *X. ensiculiferum* apud Luc (1961)
X. ifacolum Luc, 1961
X. imambaksi Loof & Maas, 1972
X. imitator Heyns, 1965
**X. inaequale* Khan & Ahmad, 1977
syn. *X. neoamericanum* Khan & Ahmad, 1975, homonym of *X. neoamericanum* Saxena, Chabbra & Joshi, 1971
**X. incertum* Lamberti, Choleva & Agostinelli, 1983
**X. incognitum* Lamberti & Bleve-Zacheo, 1979
X. index Thorne & Allen, 1950
X. ingens Luc & Dalmasso, 1964
X. insigne Loos, 1949

syn. *X. indicum* Siddiqi, 1959; *X. neodimorphicaudatum* Khan, 1982; *X. tugewai* Darekar & Khan, 1983

**X. intermedium* Lamberti & Bleve-Zacheo, 1979

X. israeliae Luc, Brown & Cohn, 1982 (= *X. diversicaudatum* apud Cohn (1969))

X. italiae Meyl, 1953

syn. *X. arenarium* Luc & Dalmasso, 1964; *X. bulgariense* Stoyanov, 1964

nec *X. italiae* apud Chavez & Geraert (1977) (= *X. savanicola*)

X. jomercium Joubert, Kruger & Heyns, 1988

**X. kosaigudense* Quraishi & Das, 1984

X. krugi Lordello, 1955

syn. *X. denoudeni* Loof & Maas, 1972; *X. loosi* Southey & Luc, 1974; *X. ensiculiferum* apud Loos (1949) and Williams (1959)

X. lacrimaspinae Hutsebaut, Heyns & Coomans, 1988

**X. laevistriatum* Lamberti & Bleve-Zacheo, 1979

X. lafoense Roca, Pereira & Lamberti, 1988

**X. lambertii* Bajaj & Jairajpuri, 1977

X. limbeense Brown, Luc & Saka, 1983

X. limpopoense Heyns, 1977

X. longicaudatum Luc, 1961

X. longidoroides Luc, 1961

X. loteni Heyns, 1986

X. louisi Heyns, 1979

**X. luci* Lamberti & Bleve-Zacheo, 1979

X. lusitanicum Sturhan, 1983

X. machoni Hunt, 1980

X. macrostylum Esser, 1966

X. magaliesmontanum Kruger & Heyns, 1986

X. majus Bos & Loof, 1985

X. malagasi Luc, 1973

X. malawiense Brown, Luc & Saka, 1983

X. malutiense Heyns, 1976

syn. *X. vanderlindei* Heyns, 1962 *partim*

X. mammatum Siddiqi, 1979

X. mammillatum Schuurmans Stekhoven & Teunissen, 1938

X. mampara Heyns, 1979

X. manubriatum Luc, 1975

X. marsupilami Luc, 1973

X. melitense Lamberti, Bleve-Zacheo & Arias, 1982

X. meridianum Heyns, 1971

X. michelluci Siddiqi, 1979

X. mluci Heyns, 1976

syn. *X. hallei* apud Heyns (1962) and (1971)

X. monohysterum Brown, 1968

X. natalense Heyns & Vermeulen, 1982

X. neobasiri Siddiqi, 1979

X. neovuittenezi Dalmasso, 1969

X. nigeriense Luc, 1961

**X. occiduum* Ebsary, Potter & Allen, 1984
**X. opisthohysterum* Siddiqi, 1961
X. orbum Siddiqi, 1964
X. ornativulvatum Kruger & Heyns, 1987
X. orthotenum Cohn & Sher, 1972
X. oryzae Bos & Loof, 1985
**X. oxycaudatum* Lamberti & Bleve-Zacheo, 1979
**X. pachtaicum* (Tulaganov, 1938) Kirjanova, 1951 (= *Longidorus pachtaicus* Tulaganov, 1938)
syn. *X. mediterraneum* Martelli & Lamberti, 1967; *X. neoelongatum* Bajaj & Jairajpuri, 1977
X. pachydermum Sturhan, 1983
**X. pacificum* Ebsary, Vrain & Graham, 1989
X. papuanum Heyns & Coomans, 1983
**X. paramonovi* Romanenko, 1981
syn. *X. paramericanum* Romanenko, 1973 *nomen nudum*
X. paritaliae Loof & Sharma, 1979
X. parvistilus Heyns, 1971
X. paulistanum Carvalho, 1965
**X. peruvianum* Lamberti & Bleve-Zacheo, 1979
X. phoenicis Loof, 1983
X. pini Heyns, 1965
X. pinoides Joubert, Kruger & Heyns, 1988
X. porosum Roca & Agostinelli, 1986
X. pseudocoxi Sturhan, 1985
X. pyrenaicum Dalmasso, 1969
X. radicicola Goodey, 1936
syn. *X. australiae* McLeod & Khair, 1971; *X. pararadicicola* Phukan & Sanwal, 1982
X. rarum Heyns, 1979
X. riocaquetae Hunt, 1982
X. ripogranum Hutsebaut, Heyns & Coomans, 1988
**X. rivesi* Dalmasso, 1969
X. rotundatum Schuurmans Stekhoven & Teunissen, 1938
X. sahelense Dalmasso, 1969
syn. *X. amarantum* Macara, 1970
X. savanicola Luc & Southey, 1980
syn. *X. italiae* apud Chavez & Geraert (1977)
X. seredouense Luc, 1975 (= *X. diversicaudatum* apud Luc (1958))
X. setariae Luc, 1958
syn. *X. vulgare* Tarjan, 1964
**X. sheri* Lamberti & Bleve-Zacheo, 1979
**X. silvaticum* Luc & Williams, 1978
**X. simile* Lamberti, Choleva & Agostinelli, 1983
X. simillimum Loof & Yassin, 1971
X. smoliki Luc & Coomans, 1988
X. spaulli Heyns & Vermeulen, 1982
X. spinuterus Luc, 1973
X. stenocephalum Luc & Baujard, 1983
X. stockeri Kruger & Heyns, 1985

X. surinamense Loof & Maas, 1972
syn. *X. ensiculiferum* apud Carvalho (1955)
X. swarti Stocker & Kruger, 1988
**X. tarjanense* Lamberti & Bleve-Zacheo, 1979
X. tarjani Luc, 1975
X. tenue Joubert, Kruger & Heyns, 1988
**X. tenuicutis* Lamberti & Bleve-Zacheo, 1979
X. theresiae Stocker & Kruger, 1988
X. thorneanum Luc, Loof & Coomans, 1986
syn. *X. vuittenezi* apud Thorne (1974)
**X. thornei* Lamberti & Golden, 1986
X. transkeiense Joubert, Kruger & Heyns, 1988
X. tropicale Zullini, 1973
X. turcicum Luc & Dalmasso, 1964
X. umobae Heyns & Spaull, 1979
**X. utahense* Lamberti & Bleve-Zacheo, 1979
X. vanderlindei Heyns, 1962
X. variabile Heyns, 1966
X. vitis Heyns, 1974
X. vuittenezi Luc, Lima, Weischer & Flegg, 1964
nec *X. vuittenezi* apud Thorne (1974) (= *X. thorneanum*)
X. xenovariabile Kruger & Heyns, 1985
X. yapoense Luc, 1958
X. zulu Heyns, 1965

Species inquirendae vel dubiae

X. chappuisi (W. Schneider, 1935) n. comb.
syn. *Dorylaimus* (*Longidorus*) *chapuisi* W. Schneider, 1935; *Longidorella chappuisi* (W. Schneider, 1935) Thorne, 1939
X. cubense Razzhivin in Razzhivin, O'Relly & Milian, 1973
X. cylindricaudatum Schuurmans Stekhoven & Teunissen, 1938
X. digiticaudatum Schuurmans Stekhoven, 1951
X. dolichodorum (de Man, 1907) Thorne & Swanger, 1936
syn. *Dorylaimus dolichodorus* de Man, 1907
syn. *Dorylaimus makrodorus* Vanha, 1893, homonym of *Dorylaimus macrodorus* de Man, 1880
syn. *Xiphinema makrodorum* (Vanha, 1893) Thorne, 1939
X. effilatum Schuurmans Stekhoven, 1951
X. grande (Steiner, 1914) Steiner, 1914
syn. *Tylencholaimus grandis* Steiner, 1914
X. lineum (Grube, 1849) Thorne, 1937
syn. *Anguillula linea* Grube, 1849 nec Oken, 1815
syn. *Dorylaimus lineus* (Grube, 1849) Oerley, 1880
**X. neoamericanum* Saxena, Chabbra & Joshi, 1973.
X. obtusum Thorne, 1939
X. parasetariae Luc, 1958

X. sharmai Luc, Loof & Brown, 1985
nom. nov. pro X. indicum Sharma & Saxena, 1981, homonym of *X. indicum* Siddiqi, 1959
X. truncatum Thorne, 1939

Notes upon some species

X. chappuisi
Description and illustrations clearly indicate that *Dorylaimus* (*Longidorus*) *chappuisi* Schneider, 1935 belongs to the genus *Xiphinema*, to which it is herewith transferred. It appears very close to, if not identical with, *X. hygrophilum* by L, V, shape of head end and tail, and by the anterior female genital branch being reduced in length. Both species were found in Ivory Coast, in wet areas. Stylet length is 227–260 μm in *hygrophilum*, 108–128 μm in *chappuisi*, but the latter values most probably refer to the odontostyle only, since Schneider referred the species to the (then) subgenus *Longidorus* and moreover he wrote: "Auf der ganzen Länge beträgt die Dicke gleichmässig 2 μm". Odontostyle length in *hygrophilum* is 136–164 μm. The type-specimens of *chappuisi* are no longer present in Schneider's nematode collection (Schiemer, *in litt.*) so that collection and examination of topotypes is necessary to decide whether or not these two species are identical.

X. cubense
According to the original description this species differs from all *Xiphinema* species in that the posterior female genital branch is reduced. However, Stegarescu (*in litt.*) says that it is not certain whether the reduced branch is really the posterior one. Repeated requests for loan of type-specimens have remained unanswered. We therefore place *X. cubense* in *species inquirendae*. *X. cubense* may also represent abnormal specimens belonging to a didelphic species, as Luc (1981b) described two females lacking the posterior genital branch in a population of the didelphic species *X. yapoense*.

Synonymised species

X. amarantum Macara, 1970 syn. of *X. sahelense*.
X. arenarium Luc & Dalmasso, 1964 syn. of *X. italiae*.
X. australiae McLeod & Khair, 1971 syn. of *X. radicicola*.
X. bulgariense Stoianov, 1964 syn. of *X. italiae*.
X. campinense Lordello, 1951 syn. of *X. elongatum*.
X. cobbi Sharma & Saxena, 1981 syn. of *X. basiri*.
X. denoudeni Loof & Maas, 1972 syn. of *X. krugi*.
X. ensiculiferoides Cohn & Sher, 1972 syn. of *X. ensiculiferum*.
X. hayati Javed, 1983 syn. of *X. basiri*.
X. hydrabadense Quraishi & Das, 1984 syn. of *X. elongatum*.
X. indicum Siddiqi, 1959 syn. of *X. insigne*.
X. itanhaense Carvalho, 1962 syn. of *X. brasiliense*.
X. loosi Southey & Luc, 1974 syn. of *X. krugi*.
X. mammillocaudatum Khan, 1982 syn. of *X. brasiliense*.
X. mediterraneum Lamberti & Martelli, 1967 syn. of *X. pachtaicum*.
X. nagarjunense Khan, 1982 syn. of *X. elongatum*.
X. neodimorphicaudatum Khan, 1982 syn. of *X. insigne*.
X. neoelongatum Bajaj & Jairajpuri, 1977 syn. of *X. pachtaicum*.

X. paraelongatum Altherr, 1958 syn. of *X. diversicaudatum*.
X. pararadicicola Phukan & Sanwal, 1982 syn. of *X. radicicola*.
X. pratense Loos, 1949 syn. of *X. elongatum*.
X. saopaoloense Khan & Ahmad, 1975 syn. of *X. brevicolle*.
X. tugewai Darekar & Khan, 1983 syn. of *X. insigne*.
X. uasi Edward & Sharma, 1982 syn. of *X. elongatum*.
X. vulgare Tarjan, 1964 syn. of *X. setariae*.

Species renamed because of homonymy

X. indicum Sharma & Saxena, 1981, homonym of *X. indicum* Siddiqi, 1959
Valid name: *X. sharmai* Luc, Loof & Brown, 1985
X. luci Bajaj & Jairajpuri, 1979, homonym of *X. luci* Lamberti & Bleve-Zacheo, 1979
Valid name: *X. bajaji* Jairajpuri & Lamberti, 1981
X. neoamericanum Khan & Ahmad, 1975, homonym of *X. neoamericanum* Saxena, Chabbra & Joshi, 1973
Valid name: *X. inaequale* Khan & Ahmad, 1977
Dorylaimus makrodorus Vanha, 1893, homonym of *D. macrodorus* de Man, 1880
Valid name: *X. dolichodorum* (de Man, 1907) Thorne & Swanger, 1936

Species transferred to other genera

X. brevicaudatum Schuurmans Stekhoven, 1951. Transferred to *Longidorus* by Siddiqi (1959).
X. citri Siddiqi, 1959. Transferred to *Longidorus* by Siddiqi (1962); to *Paralongidorus* by Siddiqi, Hooper & Khan (1963).
X. sandellum Heyns, 1966. Transferred to *Longidorus* by Khan, Chawla & Saha (1978); Stegarescu (1980) suggested it could belong to *Brevinema*.

Notes on the characters used for the code to the polytomous key

The code is essentially the same as in the first version, but slight modifications and additions were necessary. The most important modification is a change in the sequence of the characters, which might make the key easier to work with. Since tail shape is directly observable, whereas V has to be calculated, the sequence of columns C, D and E is now:
vulva position, formerly C, is now E
tail shape, formerly D, is now C;
index c′, formerly E, is now D.

Code A
The term "type of female genital tractus" refers to the comparative development and structure of the two female genital branches.
Code A1. This refers to species in which the anterior branch is clearly completely lacking; the ovejector is generally symmetrical (Fig. 1B) but may also be somewhat asymmetrical anteriorly, the vagina being directed slightly backward (*X. brasiliense*, Fig. 1A). This situation is correlated with an anterior position of the vulva ($\acute{V} = c.\ 30$).
Code A2. The anterior uterus may be as long as the posterior one (*X. surinamense*, *X. filicaudatum* (Fig.

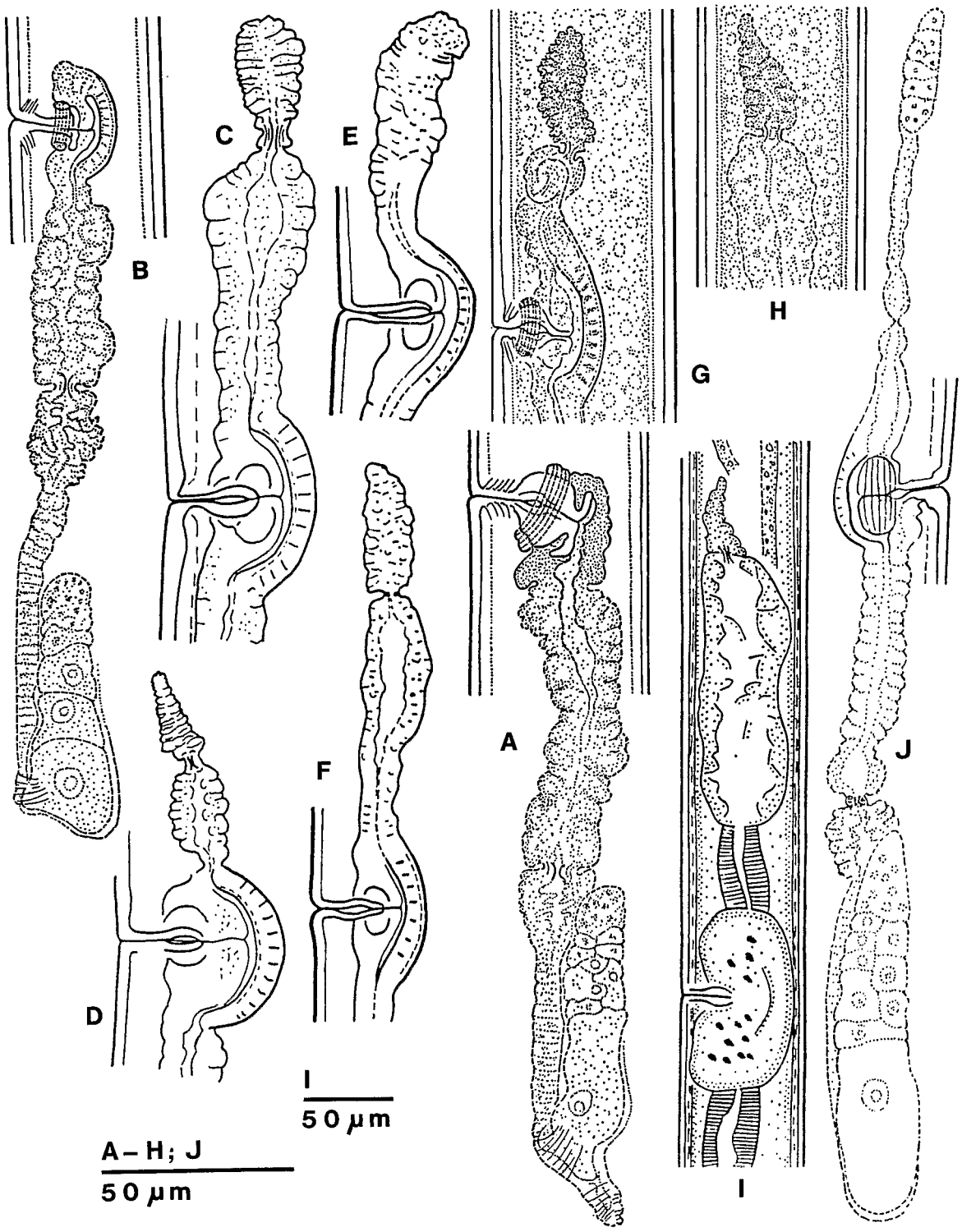

Fig. 1, Reduction of the anterior female genital branch (Code A). A,B Code A1 (A: *X. brasiliense*; B: *X. radicicola*); *C–I Code A2* (*C,D*: *X. longicaudatum*; E,F: *X. krugi*; G,H: *X. costaricense*; I: *X. filicaudatum*); J Code A3 (*X. hygrophilum*). (A,B,G,H from Luc, 1981; C–F from Luc & Hunt, 1978; I from Loof & Maas, 1972; J from Southey & Luc, 1974).

1I), *X. dimidiatum*) but usually it is reduced in length and width. The sphincter separating the uterus from the oviduct is often clearly recognizable, but it may also be difficult to discern (Fig. 1C–H); the oviduct is greatly reduced to a mass of cells in which generally no lumen or structure can be recognised. The ovary is lacking.

Code A3. All the components of the anterior branch are present, but greatly reduced in comparison to those of the posterior branch (Fig. 1J).

The codes A1, A2 and A3 correspond to the three types of reduction of the anterior female genital branch as described by Luc (1981).

Code A4. This is for two fully, equally developed genital branches.

Code B. Uterine differentiation.

Many species in the genus show uterine differentiations. These may be classified into three categories:

The Z-organ. This organ lies at the junction of the *pars dilatata uteri* and the distal, more or less straight, part of the uterus (Fig. 2A,B). It is characterised by being rather well separated from these sections, possessing a heavy wall composed of strong circular muscles, a conspicuous refringent lining of the lumen, this lining being regularly longitudinally folded; and a relatively low number (3–5) of yellowish, often angular, apophyses protruding into the lumen. This structure has been observed in 13 species.

The pseudo-Z-organ. This is found in the same place as the Z-organ, but it is less well characterised. The wall is less thick, the muscles are weaker or almost absent; the lining is thin, its longitudinal folding often difficult to observe. The apophyses are rarely angular (*X. pini*, fig. 2C) and show a great variability in shape: composite bodies with a clear central globular part surrounded by small, less translucent globules (e.g. *X. diversicaudatum*, Fig. 2D); simple globular bodies (*X. marsupilami*, Fig. 2H; *X. basiri*, Fig. 2F) of variable diameter. The pseudo-Z-organ has been recorded for 36 species (in 7 together with uterine spines).

The uterine spines. These are present either all over the length of the tubular part of the uterus (*X. spinuterus*) or only in the part close to the uterine pouch (*X. xenovariabile*). They are of variable length and density, but are always directed away from the vagina. In some species both spines and pseudo-Z-organ are present (e.g. *X. malagasi*, Fig. 2I). These spines have been recorded in 16 species, but it is possible that careful re-examination will lead to the discovery of their presence in more species.

A detailed study of the uterine differentiations was given by Kruger (1988).

Note that: (1) uterine differentiation appears linked to the presence of two complete female genital branches, the only exception being *X. dimidiatum* in which the anterior branch is reduced and the posterior one contains uterine spines; and (2) the presence of a Z- or pseudo-Z-organ is more frequent among species having numerous males. Luc (1973) wrote: "intermediate types exist, and this distinction between Z-organ and pseudo-Z-organ is given, prudently, essentially to establish the two extremities of the chain of various structures that may present this uterine differentiation." Since that time, many species have been described which have more or less intermediate Z-differentiation, and one may question whether both terms need be kept. However, ultrastructural studies on a "true" Z-organ (in *X. ifacolum*) by Bleve-Zacheo *et al.* (1985) and on a "true" pseudo-Z-organ (in *X. diversicaudatum*) by Bleve-Zacheo *et al.* (1984) revealed that: (1) the origin and nature of apophyses (Z-organ) and of globules (pseudo-Z-organ) appear identical; and (2) the muscular cells, however, appear rather different in number, shape and disposition. These studies indicate that the differences between the two Z differentiations are more related to the structure of the wall than to the formations filling the lumen. These authors did not conclude that only one term is appropriate. Consequently we keep both terms in the polytomous key, placing in group 4 the species presenting an obvious, "true" Z-organ, whereas species with pseudo-Z-organ and more or less intermediate differentiation have been placed in group 5. The drawings (Fig. 2) will help to place any species in the correct group.

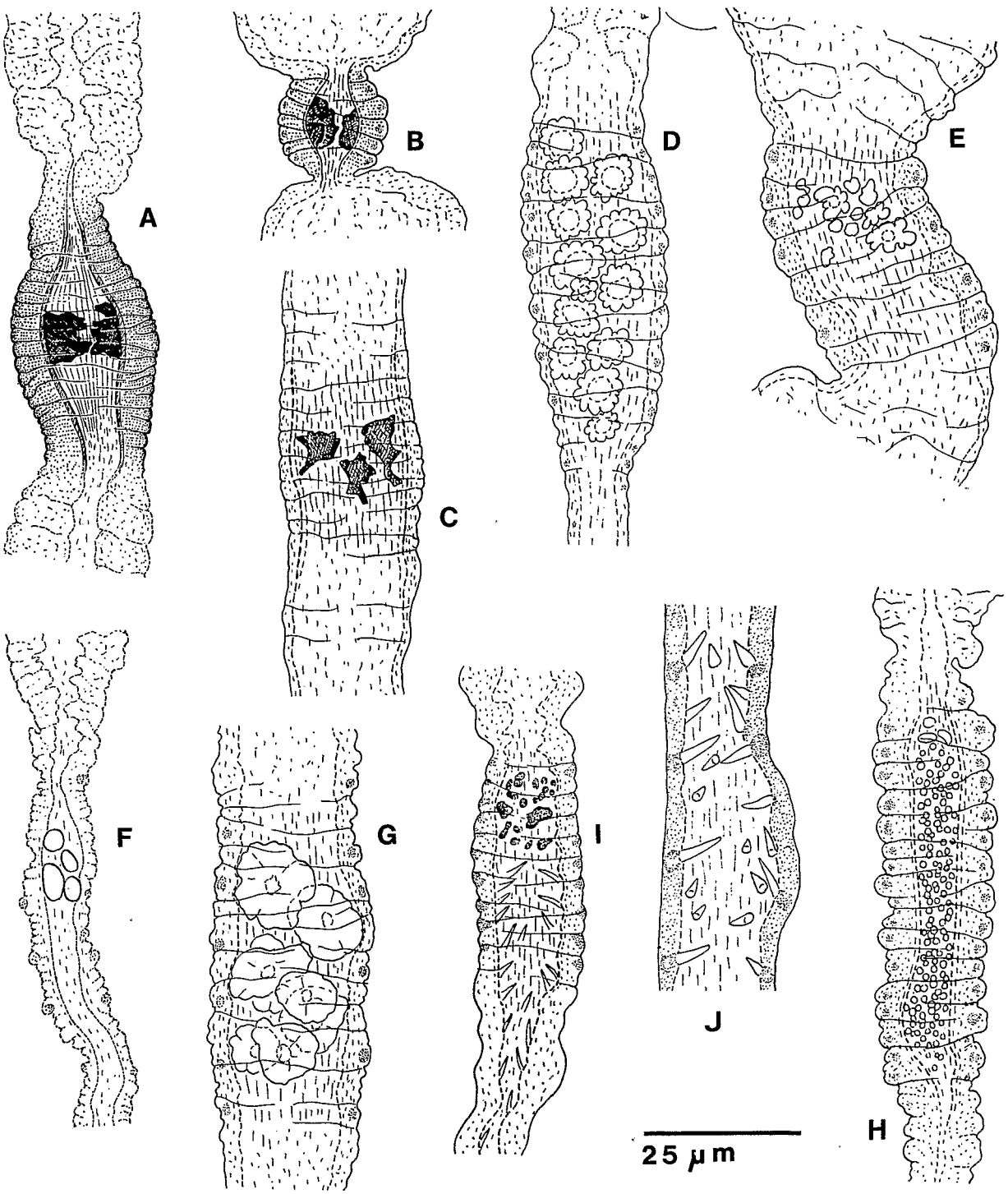

Fig. 2. Uterine differentiation (Code B). A,B Code B1 (A: *X. ifacolum*; B: *X. ebriense*); C–H Code B2 (C: *X. pini*; D: *X. diversicaudatum*; E: *X. turcicum*; F: *X. basiri*; G: *X. ingens*; H: *X. marsupilami*); I: Code B2 + 3 (*X. malagasi*); J: Code B3 (*X. spinuterus*). (From Luc & Dalmasso, 1975b.)

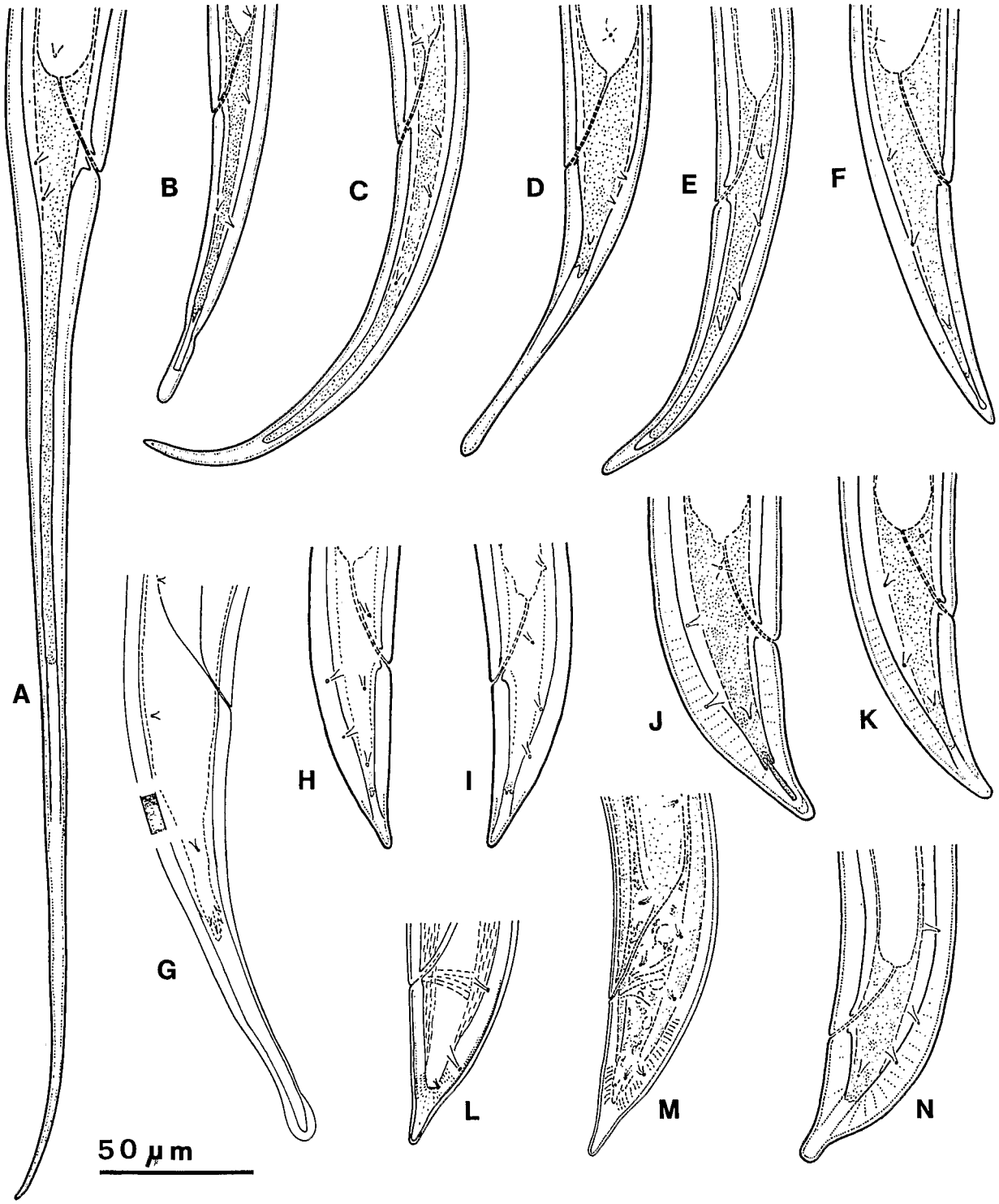

Fig. 3. Tail shape (Code C). A Code C1 (*X. spinuterus*); B–G Code C2 (B: *X. bergeri*; C: *X. douceti*; D: *X. nigeriense*; E: *X. insigne*; F: *X. attorodorum*; G: *X. clavicaudatum*); H,I Code C 2/3 (*X. elongatum*); J,K Code C3 (J: *X. ifacolum*; K: *X. longidoroides*); L,M Code C3/4 (L: *X. coxi coxi*; M: *X. setariae*); N Code 4 (*X. basiri*). (A–C from Luc, 1973; D from Luc, 1961; E,F,J,K,N from Luc & Dalmasso, 1975b; G from Huang, Uesugi & Raski, 1987; H,I from Luc & Southey 1980; L from Sturhan, 1985; M from Tarjan, 1964).

Code C. Tail shape

Female tail shape is one of the most variable characters in the genus. Roughly the various tail shapes can be grouped under two headings:

Long filiform to conical shape (C1 to C4), see Fig. 3; the shortest tails (C4) may be somewhat digitate (Fig. 3N);

Short, more or less rounded to perfectly hemispherical (C5 to C8), see Fig. 4; sometimes provided with a short peg (C5), Fig. 4C or a long one (C8) (Fig. 4J).

Of course some species with a variable tail shape, e.g. *X. krugi*, may correspond to two or more of these divisions, but generally it is a very reliable character.

Code D (coefficient c'), *Code E* (coefficient V), *Code F* (body length) and *Code G* (stylet length) do not require comments.

Code H. Outline of fore part of body.

In this new key there are only three divisions. *Code H1* refers to an absolutely continuous outline (Fig. 5A–B), *Code H3* to a very conspicuously constricted or expanded one (Fig. 5I–J). Intermediate shapes are attributed to *H2* (Fig. 5C–H). For proper application of this code it is essential that the specimens lie in perfect lateral position, otherwise the amphidial slits may be confused with a constriction (cf. Figs. 5E,F).

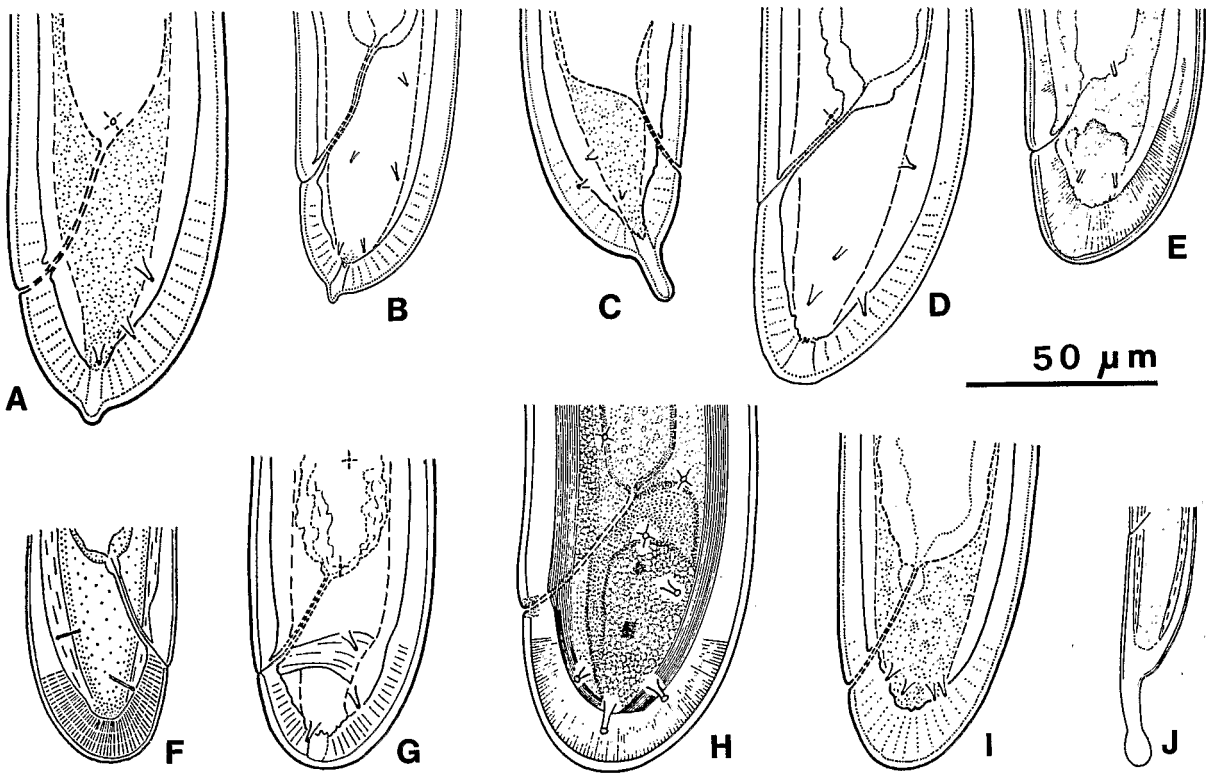

Fig. 4. Tail shape (Code C). A–C Code C5 (A: *X. mammillatum*; B: *X. thorneanum*; C: *X. brasiliense*); D Code C6A (*X. melitense*); E,F Code C6B (E: *X. bacaniboia*; F: *X. surinamense*); G code C7A (*X. guirani*); H,I Code C7B (H: *X. porosum*; I: *X. hygrophilum*); J Code C8 (*X. rotundatum*, J-1). (A from Luc & Tarjan, 1963; B,D from Luc, Loof & Coomans, 1986; C from Luc & Dalmasso, 1975b; E from Orton Williams, 1984; F from Loof & Maas, 1972; G from Luc & Williams, 1978; H from Roca & Agostinelli, 1986; I from Southey & Luc, 1974; J from Bos & Loof, 1985).

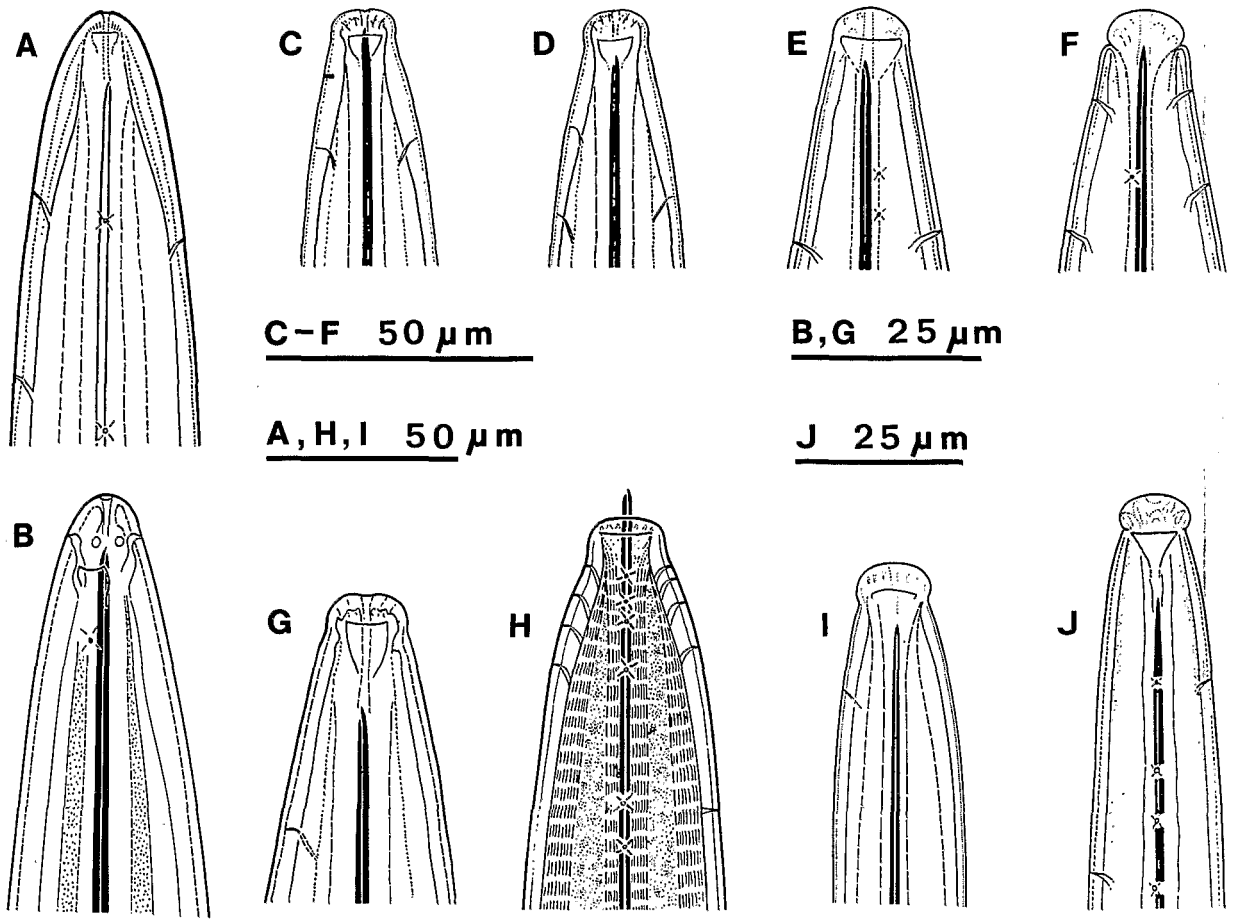

Fig. 5. Outline of anterior part of body (Code H). A,B Code H1 (A: *X. hygrophilum*; B: *X. stenocephalum*); C–H Code H2 (C,D: *X. elongatum*; E,F: *X. coxi europaeum*, lateral & dorsoventral; G: *X. insigne*; *H*: *X. ingens*); I,J Code H3 (I: *X. conurum*; J: *X. pachydermum*). (A from Southey & Luc, 1974; B from Luc & Baujard, 1983; C,D,G from Luc & Southey, 1980; E,F from Sturhan, 1985; I from Luc & Aubert, 1985; J from Sturhan, 1984).

Code I (female body posture when killed) is self-explanatory; *Code J* (tail of J-4) and *Code K* (tail of J-1) do not require further comment.

Code L.

Presence or absence of males. This is correlated with presence or absence of sperm in the female genital tract. It is a good character provided that the number of specimens examined is adequate to allow a reasonable decision.

The new code

A. Type of female genital apparatus.
   1. No anterior genital branch (Fig. 1A–B).
   2. Anterior genital branch reduced and incomplete: ovary absent, oviduct drastically reduced to a

mass in which any structure is frequently difficult to recognize; sphincter and uterus usually recognizable but reduced (Fig. 1C–I).

3. Anterior branch strongly reduced in length and width, but complete (ovary, oviduct and uterus) (Fig. 1J).
4. Two complete genital branches, having the same length or nearly so.

B. Uterine differentiation.

1. Z-organ present (Fig. 2A,B).
2. Z-pseudo-organ present (Fig. 2C–H).

2 + 3. Z-pseudo-organ plus spines present (Fig. 2-I).

3. Uterine spines present (Fig. 2J).
4. No uterine differentiation.

C. Tail shape.

1. Tail long, attenuated or filiform (c′ over 7.5); (Fig. 3A).
2. Tail long (c′ between 2.5 and 7.5), conical or with clavate terminus (Fig. 3B–G).
3. Tail regularly short conical (c′ at most 2.5), i.e. tapering uniformly to narrowly rounded or acute terminus; or slightly subdigitate (Fig. 3H–K, cf L,M).
4. Tail short conical (c′ at most 2.5), distinctly digitate (Fig. 3N, cf. L,M).
5. Tail conical to hemispherical with a terminal peg, mucro or bulge (Fig. 4A–C). In all species with a distinct mucro which we have examined (except *manubriatum*), a blind terminal canal is present, though sometimes very vague (*phoenicis*, *dimidiatum*, some specimens of *index*). We have given these the code 5a. In some species where the terminus is merely bulging, this canal appears to be absent; these species are coded 5b. In a few species presence/absence of a blind canal could not be inferred from description or illustrations and no specimens were available; these have been coded C5 without further qualification.

   In species like *index* (typically C5a) specimens occur without a peg, the terminus being smoothly rounded; in such specimens the terminal canal is absent. Hence the combination 5a7b for such species.
6. Tail broadly convex-conoid, i.e. tapering to broadly rounded terminus with main curvature on dorsal contour, the ventral one being almost straight (Fig. 4D-F).
7. Tail regularly hemispherical, i.e. ventral and dorsal curvatures equal (Fig. 4G–I).
8. Tail conical rounded, with very long clavate peg (Fig. 4J).

Note: Codes C6 and C7 are subdivided in the same way as 5:

a: terminal blind canal in the cuticle present.
b: terminal blind canal absent.

D. Ratio tail length to anal body diameter (c′).

1. >7.5.
2. 5.1–7.5.
3. 2.6–5.0.
4. 1.6–2.5.
5. 1.1–1.5.
6. <1.0.

E. Vulva position.

1. <30.
2. 30–34.

3. 35–39.
4. 40–44.
5. 45–49.
6. >50.

F. Body length.
1. <1.5 mm.
2. 1.5–2.4 mm.
3. 2.5–3.4 mm.
4. 3.5–4.4 mm.
5. >4.5 mm.

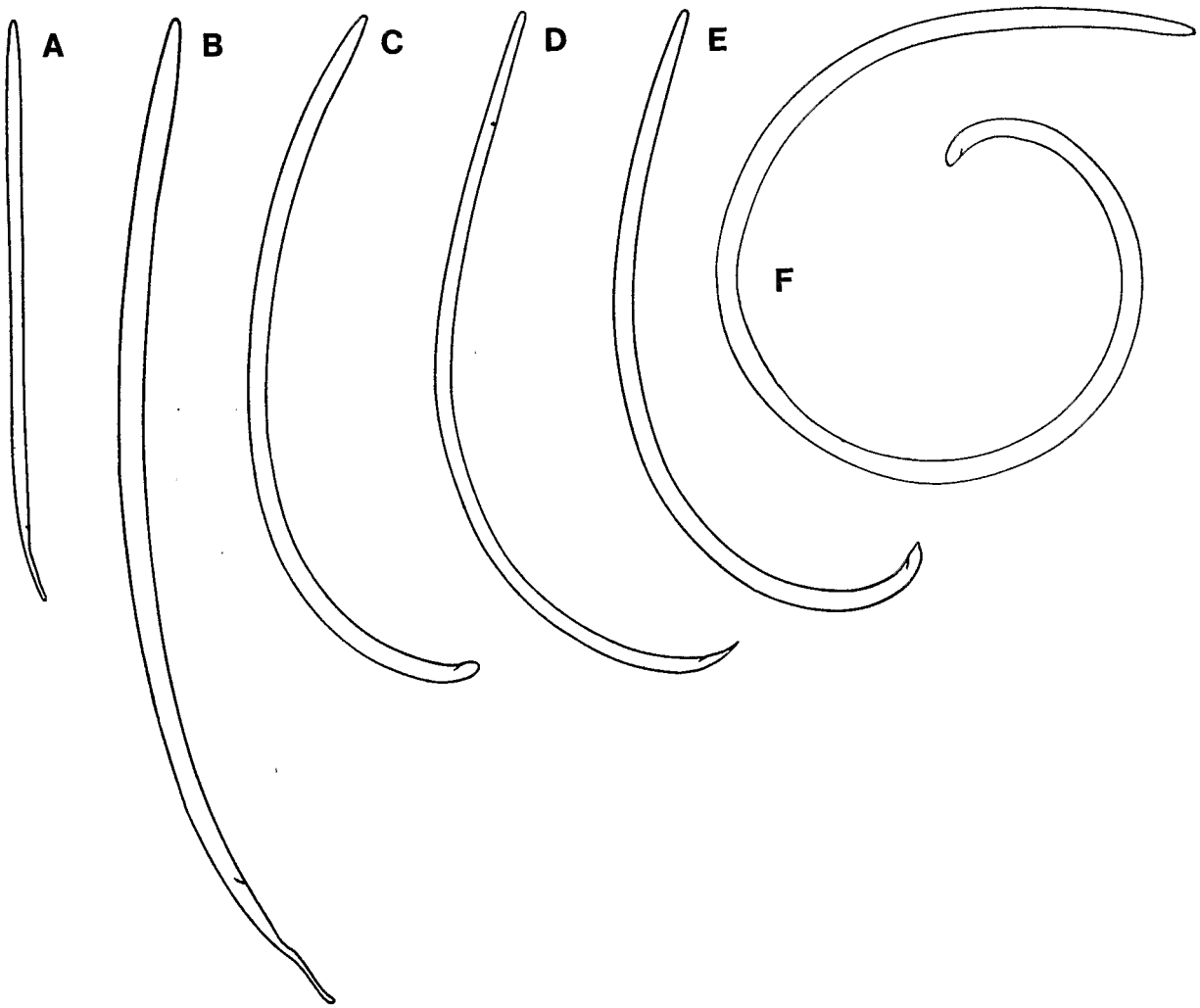

Fig. 6. Body posture of the adult female when killed (Code I) A Code I 1 (*X. orthotenum*); B Code I 1/2 (*X. filicaudatum*); C,D Code I 2 (C: *X. surinamense*; D: *X. italiae*); E Code I3 (*X. index*); F Code I4 (*X. fluminense*). (A-E from Luc & Dalmasso, 1975b; F from Huang, Uesugi & Raski, 1987).

G. Total spear length (odontostyle + odontophore).
1. <150 μm.
2. 150–199 μm.
3. 200–249 μm.
4. >250 μm.

H. Outline of fore-part of body.
1. Lip region perfectly continuous with the rest of the body (Fig. 5A–B).
2. Lip region separated by a weak depression or shallow constriction (Fig. 5C–H).
3. Lip region separated by conspicuous constriction or depression (Fig. 5I–J).

I. Habitus.
1. Body straight or nearly so (Fig. 6A,B).
2. Body weakly curved (Fig. 6B–D).
3. Body hook-shaped, or in C- or J-shape (Fig. 6E).
4. Body spiral-shaped (Fig. 6F).

J. Tail shape of fourth-stage juvenile.
Same divisions as for adult female; see C.

K. Tail shape of first-stage juvenile.
Same divisions as for adult female; see C.

L. Males.
1. Unknown or very rare (female generally devoid of sperm).
2. Abundant (female generally provided with sperm).

How to use the polytomous key

The procedure is similar to that outlined in the previous polytomous key (Luc & Dalmasso, 1975a,b).

The characteristics corresponding to each letter of the code are observed, measured or calculated; each of them is allocated the corresponding figure according to the preceding paragraph (the 'new code'). These figures are put on a strip of paper, so that each corresponds to the column of each letter. For example, one finds the following combination:

A	B	C	D	E	F	G	H	I	J	K	L
4	2	4	5	5/6	3	2/3	1/2	3	4	–	2

The figures under letters A and B give the group to which the species pertains (see below, section 7); in this case group 5. On the list under group 5, the strip of paper is moved from the top of the lattice until a horizontal line is found in which the figures correspond exactly to those on the strip, in this case *X. natalense*. Nevertheless, it is necessary to continue to the last line, in case of double correspondence. In this case, see the notes following the lattice where supplementary differential characters are given. For each column, only one identical figure is needed; in the example chosen, for character G (stylet length) the figures are 2/3 because of an overlap on two divisions (stylet length being 197–204 μm). For this character the species of the group coded G2 or G3, not only those with G2/3, are in correspondence.

On the other hand, species coded G1/2 or G3/4 are to be discarded except in case of perfect identity of figures for all other letters.

If no identity for all the letters is observed in any horizontal line, the specimens being identified are theoretically representative of an undescribed species, but it is more prudent to test, by gradual approach, the species appearing most close to them.

The *X. americanum*-group

The species belonging to this group (marked by an asterisk in the species list) share the following characters, which render them easy to differentiate from species outside this group:

- body small (L at most 2.2 mm), in open or more or less close spiral;
- stylet robust, its length rarely exceeding 150 μm;
- thick cuticular lining of the pharynx;
- V generally 50 or more;
- female genital branches equally developed, generally short; uterus without Z-differentiation or spines, often very short;
- oocytes usually with associated bacteria;
- tail short, conoid-rounded to slightly digitate, c′ under 2.5;
- males very rare or unknown, females devoid of sperm;
- male with 5 or more supplements, the posteriormost of the midventral ones lying close to the paired precloacal papillae.

The taxonomic situation within this group is not clear, due to:

- the high number of species defined in it (about 30 at present);
- the weak differences reported between many species;
- the lack of data on intraspecific variability for the majority of the species;
- the insufficient illustrations for many species.

It is symptomatic that no key for the *americanum*-group has yet been published, not even by the most prolific creators in the group; only Ebsary *et al.* (1989) gave a key to 17 species. We are of the opinion that a thorough revision of the group is necessary before any statements can be made about number and validity of the species pertaining to it. Consequently we think it legitimate to exclude this group from the polytomous key; all species would share the following code: A4 – B4 – C3 (rarely 6b) – D4/6 – E5/6 – F1/2 – G1/2 – H2/3 (rarely 1) – I3/4 – J3/4 – K3/4 – L1. We strongly advise against proposing new species in this group until such a revision has been made.

X. pachydermum shows several characters of the *americanum*-group: habitus, body length, tail shape, lip region shape, arrangement of supplements. On the other hand, the uteri are long, there are no bacteria in the oocytes, and males are numerous. We have therefore included it in the key.

X. guirani. Under this name Lamberti & Bleve-Zacheo (1979) described a population from the type locality, which belongs in the *americanum*-group and is different from the real *guirani*: the body is shorter (1.6–2.0 mm vs 2.0–2.9 mm), vulva more posterior (52–58 vs 49–54), odontophore shorter (52–56 μm vs 61–68 μm), GR shorter (73–90 μm vs 90–103 μm), the tail has a different shape and does not possess a terminal blind canal. The real *guirani* does not belong in the *americanum*-group: the uteri are long and the male has only one ventromedian supplement.

The following species belonging to group 8 might be mistaken by the code characters for members of the *americanum*-group:
X. elitum: distinguished by peculiar tail structure and by tail length of about 50 μm which is much longer than in the *americanum*-group.
X. elongatum: code E is usually 2–4, exceptionally 5. Moreover tail length is 46–77 μm which is much longer than in the *americanum*-group.
X. louisi: body length over 2.3 mm; h = 15–22 μm, distinctly longer than in the *americanum*-group.[1]
X. mampara: body length mostly greater than in the *americanum*-group (2.1–4.2 mm); h = 25–48 μm; males are common.
X. variabile: males are common; body generally more slender (a = 61–115) than in the *americanum*-group.

All these species differ from the *americanum*-group also by absence of bacteria in the female genital tract.

The groups in the polytomous key

The two first characters used in the key, A and B (see under 4), refer to the structure of the female genital tractus: regression *vs* normal development of the anterior branch (A), and presence *vs* absence of particular uterine differentiations (B). These characters are perhaps not in every case the easiest ones to observe, but they have been chosen as "prime characters" because of their constancy within species; they permit clear distinctions between groups of species.

The next characters refer to the tail, viz. shape (C) and coefficient c′ (D). Due to the great variability within the genus, these data allow easy separation of species into groups.

Thus the new polytomous key is presented with eight subdivisions. The eight groups so defined have no taxonomic value, the species involved having been assembled only to facilitate identification, not to demonstrate phylogenetic relationships. The contents of these groups may be deducted from the coding A and B as follows:
Group 1: no anterior genital branch (code A1).
Group 2: no anterior ovary (code A2).
Group 3: anterior genital branch complete but strongly reduced (code A3).
Group 4: both female genital branches equal; presence of a Z-organ (code A4–B1).
Group 5: both female genital branches equal; presence of a pseudo-Z-organ (code A4–B2), or of pseudo-Z-organ plus uterine spines (code A4–B2 + 3).
Group 6: both female genital branches equal; no Z-organ or pseudo-Z-organ, but uterine spines present (code A4–B3).
Group 7: both female genital branches equal, without uterine differentiation; tail elongate to conical (code A4–B4–C1–4).
Group 8: both female genital branches equal, without uterine differentiation; tail short, rounded (code A4–B4–C5–7).

[1]h = length of the hyaline terminal part of the tail.

Group 1

	A	B	C	D	E	F	G	H	I	J	K	L
orthotenum	1	4	1	1	1	2	23	1	1	(2)	(2)	1
chambersi[1]	1	4	2	3	1	2	2	2	3	(2)	(2)	1
monohysterum[1]	1	4	2	3	12	23	2	2	2	–	–	1
radicicola	1	4	4	4	1	23	23	2	3	–	2	1
brasiliense	1	4	5*a*	(4)5	123	2	23	2	3	5	–	1
ensiculiferum	1	4	7*b*	6	12	2	3	2	2	7	2	1

Note 1. X. chambersi and *X. monohysterum*. In addition to the habitus, these species may easily be separated by tail shape (strongly ventrally curved in *chambersi*, only slightly so in *monohysterum*) and mainly by the length of the hyaline terminal part of the tail (about 35 μm in *chambersi*, about 15 μm in *monohysterum*).

Group 2

	A	B	C	D	E	F	G	H	I	J	K	L
longicaudatum	2	4	12	12	23	3	3	2	3	(2)	2	1
clavicaudatum	2	4	2	3	234	34	34	12	3	–	–	1
filicaudatum[2]	2	4	2	1	45	45	44	1	2	2	2	12
krugi	2	4	46	456	123	2	2(3)	2	3	34	2	1
dimidiatum[3]	2	3	5*a*	45	34	2	2	2	3	4	2	1
costaricense[4]	2	4	7*b*	6	3	2	3	2	2	7*b*	2	1
surinamense[4]	2	4	7*b*	6	34	234	234	2	2	7*b*	23	2

Note 2. X. filicaudatum. Loof & Maas (1972) found two populations: one with 7 males to 28 females, the other with no males to 28 females.

Note 3. Reexamination of type material of *X. dimidiatum* showed that this species possesses spine-like structures in the uterus. However, it is not sure whether these are real spines, attached to the uterine wall, or mere crystalline structures (Kruger, 1988).

Note 4. X. costaricense and *X. surinamense*. In the former species the anterior uterus is much reduced in size, in the latter the two uteri are of equal size and structure. In addition, the tail shape of J-2 differs: conical with clavate tip in *costaricense*, subcylindrical with rather broadly rounded terminus in *surinamense*. A very faint terminal blind canal seems to be present in some females of *X. surinamense*.

Group 3

	A	B	C	D	E	F	G	H	I	J	K	L
simillimum[5]	3	4	2	3	2	2	2	2	3	–	–	1
orbum	3	4	23	34	1	3	1	2	34	23	(2)	1
arcum	3	4	7*b*	56	2	23	2	2	2	–	–	1
hygrophilum	3	4	7*b*	6	34	(1)2	34	1	2	7*b*	–	1

Note 5. X. simillimum. Luc (1981a) showed that the anterior female genital branch bears an ovary.

Group 4

	A	B	C	D	E	F	G	H	I	J	K	L
oryzae	4	1	2	12	3	3	2	2	3	2	2	1
hallei	4	1	2	2	5	34	23	2	3	–	–	2
fatikae	4	1	2(3)	3(4)	56	23	2	2	3	2	2	1
dolosum	4	1	23	34	34	3	2	2	3	2	1	1
limpopoense	4	1	23	34	5	23	12	2	23	2	–	2
algeriense	4	1	3	4	5	45	2	3	3	3	–	2
ifacolum[6]	4	1	3	4	56	34	2	2	34	3	–	1
machoni	4	1	4	5	4	3	2	2	3	–	–	2
ebriense	4	1	45*a*	5	4	2	2	2	3	–	–	2
manubriatum	4	1	45*b*	45	6	2	23	1	3	–	–	1
phoenicis	4	1	5*a*	45	56	45	3(4)	2	3	4	–	2
rotundatum	4	1	6*b*7*b*	56	56	(2)34	23	2	3	7	8	1
tropicale[6a]	4	1	5*a*7*b*	46	3	23	2	2	2	–	–	1

Note 6. X. ifacolum can always be recognized by its peculiar terminal canal in the tail (Fig. 3J) which is present already from the J-2 onwards.
Note 6a. codes C and D of *X. tropicale* from examination of paratypes.

Group 5

	A	B	C	D	E	F	G	H	I	J	K	L
paritaliae	4	2	2	3	34	34	23	2	3	2	–	1
marsupilami	4	2	2	1	45	4	4	2	1	–	–	2
meridianum[7]	4	2	3	45	456	34	2	2	3	3	–	1
tenue	4	2	3*a*	5	6	34	1	2	23	3*a*	–	1
dissimile	4	2	3(4)	5	45	5	23	2	3	34	2	2
coxi coxi[7,9]	4	2	34	4	45	34	23	2	3	34	2	1
capense	4	2	34	45	56	4	2(3)	2	2	–	–	1
pseudocoxi[7,9]	4	2	(3)4	45	45	345	2	2	3	234	2	1
coxi europaeum[7]	4	2	34	5	45	45	23	2	3	3	2	1
limbeense[8]	4	2	4	4	4	23	2	2	3	2	–	1
malawiense[8,9]	4	2	4	45	(4)5	23	2	2	3	34	–	1
parvistilus	4	2	4	45	56	(2)3	1	2	3	3	–	1
umobae	4	2	4	45	6	45	23	2	34	3	–	2
basiri	4	2	4	(4)5	56	3	2	2	34	3	–	1
bolandium[10]	4	2	4	5	5	23	2	23	23	–	–	2
natalense[10]	4	2	4	5	56	3	23	12	3	4	–	2
diversicaudatum[11]	4	2	4(5*a*)	5	345	45	3	2	3	5	1	2
imambaksi[9]	4	2	45	5	4	3	23	2	3	–	–	1
transkeiense	4	2	5*a*	45	6	34	1	2	23	5a	–	1
stockeri	4	2	5*a*	(4)5	5	34	2	2	23	5	–	2
erriae	4	2	5*a*	56	45	3	2	2	2	4	–	1
ripogranum[12]	4	2	5*a*	56	456	3(4)	2	2	2	5	23	2

Group 5 continued

	A	B	C	D	E	F	G	H	I	J	K	L
artemisiae[11]	4	2	5	56	45	45	3	2	3	5	–	2
lusitanicum	4	2	5*a*	56	6	4(5)	4	2	3	4	2	1
hardingi[12]	4	2	5*a*	6	5	4	23	2	23	6*a*	–	1
jomercium[12]	4	2	5*a*	(5)6	5	34	2	2	23	5*a*	–	1
pini[12]	4	2	5*b*	6	56	3(4)	2	2	34	5	–	2
pinoides[12]	4	2	5*b*6	(5)6	4(5)	4	2	2	2	4*a*	–	2
majus[13]	4	2	5*a*6*a*	6	56	45	34	2	3	56*a*	2	1
imitator	4	2	6*b*	6	456	23	12	2	3	–	–	1
melitense	4	2	6	6	6	45	34	2	34	6	3	1
dentatum	4	2	6*b*7*b*	6	45	34	4	2	3	7*b*	2	1
globosum	4	2	7*b*	6	34	34	3	2	3	7*b*	1	2
turcicum	4	2	7*b*	6	56	45	34	2	3	7*b*	2	1
heynsi	4	2	7*b*	6	5	3	2	1	2	7*b*	2	2
zulu[14]	4	2+3	2	3	56	34	23	1	4	(2)	–	2
theresiae	4	2+3	2	23	56	4	3	2	3	2	–	2
malagasi	4	2+3	2	3	45	3	2	2	3	–	–	1
rarum[15]	4	2+3	23	34	56	3	12	2	34	23	–	2
ornativulvatum[15]	4	2+3	3	34	5	3	2	2	3	3	–	2
diversum	4	2+3	4	4	456	3	2	2	2	4	2	1
thorneanum[16]	4	2+3	5*a*	56	45	34	2	2	3	5	–	2
loteni[16]	4	2+3	5*a*	56	56	3	23	2	3	5	2	2
smoliki	4	2+3	5*b*7*b*	5(6)	4(5)	45	2	2	2	–	–	1
ingens	4	2+3	5*a*7*a*	6	56	5	(3)4	2	3	5*a*	3	2

Note 7. X. coxi, *X. pseudocoxi*, *X. dissimile* and *X. meridianum* are not well separated in the key. In addition, within *X. coxi* two subspecies were distinguished. The five taxa can be separated as follows:

1 Lip region width 13–16 μm; total spear length over 180 μm 2
– Lip region width 11–13 μm; total spear length under 180 μm 4
2 Body length 3.1–4.0 mm; blind terminal canal indistinct ..... *coxi coxi*
– Body length 3.7–5.8 mm; blind terminal canal distinct 3
3 Dorsal cervical pores 7 or more; $a = 90–118$; $c = 97–135$; J-1 $c = 24–26$, $c' = 2.9–3.8$, replacement odontostyle = 73–83 μm, GR = 51–55 μm; uteri with sperm, males numerous ..... *dissimile*
– Dorsal cervical pores 2–4; a = 64–91; c = 61–92; J-1 c=15–17, c′ = 3.5–4.8, replacement odontostyle = 65–72 μm, GR = 42–50 μm; uteri without sperm, males rare ..... *coxi europaeum*
3 Pseudo-Z-organ with 4–5 sclerotised bodies of granular structure; tail digitate to conoid, 31–50 μm long ..... *meridianum*
– Pseudo-Z-organ with 8–15 sclerotised bodies, each consisting of a roundish hyaline central part surrounded by irregular, often granular bodies; tail digitate, 43–50 μm long ..... *pseudocoxi*

Note 8. X. malawiense and *X. limbeense*. These species are very similar. They differ mainly by tail shape, the terminal peg being more clearly demarcated in *limbeense*, and longer than in *malawiense* (about 22 μm against 12 μm). The pseudo-Z-organ of *limbeense* contains fewer and smaller composite bodies than that of *malawiense*.

Note 9. X. imambaksi. The structure called a Z-organ in the original description should really be considered as a pseudo-Z-organ. In the key this species is not clearly separated from *malawiense*, *coxi* and *pseudocoxi*. However, it differs from these three species by the tail peg being sharply offset, ventrally directed, and 18–20 μm long, whereas in the three other species it is only slightly offset, directed posteriad, and notably shorter in *coxi* and *pseudocoxi*.

Note 10. X. natalense and *X. bolandium* cannot be separated clearly by key characters. The lip region is offset by a shallow constriction in *bolandium*, and by a slight depression to almost continuous in *natalense*. Odontostyle length is 92–101 μm in *bolandium*, 111–123 μm in *natalense*; odontophore length 63–72 μm in *bolandium*, 82–92 μm in *natalense*; total spear length: *bolandium* 155–169 μm, *natalense* 197–204 μm. Furthermore *h* is 9–12 μm in *bolandium*, 15–20 μm in *natalense*. Spicule length is 50–61 μm in *bolandium*, 70–84 μm in *natalense*.

Note 11. X. artemisiae and *X. diversicaudatum* have identical codes. It is claimed that the pseudo-Z-organ is more compact in *artemisiae* than in *diversicaudatum*, but the CIH illustration of *diversicaudatum* (Siddiqi, 1974) shows hardly any difference from *artemisiae*. A strongly offset terminal tail peg such as was described as diagnostic for *artemisiae*, occurs occasionally in *diversicaudatum* as well. These species might be synonymous.

Note 12. X. jomercium is not clearly separated by key characters from *X. hardingi*, *X. pini*, *X. pinoides* and *X. ripogranum*. From *X. hardingi* it differs by the structure of the pseudo-Z-organ: four multilobate bodies in *jomercium*, numerous small simple granules in *hardingi*. In *pini* and *pinoides* the pseudo-Z-organ contains four rather peculiar stellate inclusions (see Joubert *et al.*, 1988). From *ripogranum* it can be distinguished by the very short and inconspicuous tail peg.

Note 13. X. majus. Re-examination of paratypes showed that this species possesses a very weakly developed pseudo-Z-organ. *X. majus* is very similar to *X. melitense*: there are only slight differences in tail length (*majus* 30–36 μm, *melitense* 38–45 μm) and V (*majus* 47–51, *melitense* 50–53). The best difference is found in the J-1: c′ = 4.5–4.9 in *majus*, 1.6–1.9 in *melitense*.

Note 14. Hutsebaut, Heyns & Coomans (1988) showed that the uterus of *X.zulu* contains a pseudo-Z-organ as well as spines. These structures were already illustrated by Heyns (1979, Figs 19 and 20).

Note 15. X. rarum and *X. ornativulvatum* have identical codes, but *ornativulvatum* can be recognised immediately by the ventral cuticular wrinkles near the vulva. In addition, the spear is longer in *ornativulvatum* (174–185 μm) than in *rarum* (146–156 μm), and there are differences in the uterine differentiation: in *ornativulvatum* there are few spines and the pseudo-Z-organ consists of 6–8 globular structures; in *rarum* there are numerous spines throughout the uterus and the pseudo-Z-organ has 25–40 globular bodies.

Note 16. The codes of *X.thorneanum* and *X. loteni* are almost identical. The species can be differentiated by the following characters:

thorneanum: tail length = 27–36 μm, c = 92–134; odotostyle = 89–105 μm, odontophore = 61–69 μm, total spear length = 153–171 μm; GR = 73–90 μm; V = 44–48.

loteni: tail length = 36–51 μm, c = 68–80; odontostyle = 108–131 μm, odontophore = 78–98 μm, total spear length = 187–227 μm; GR = 92–113 μm; V = 48–52.

Group 6

	A	B	C	D	E	F	G	H	I	J	K	L
spinuterus	4	3	1	1	4	3	3	2	12	–	–	2
mluci[17]	4	3	2	123	45	(3)45	23	2	34	2	–	1
xenovariabile	4	3	23	34	56	23	1	2	3(4)	2	–	2

Group 6 continued

	A	B	C	D	E	F	G	H	I	J	K	L
diannae[18]	4	3	3	4	45	3	12	2	23	3	–	2
coomansi[18]	4	3	3	45	456	3	2	2	3	3	–	2
lacrimaspinae	4	3	4	4	4	3	2	2	3	34	2	1
barbercheckae	4	3	4	5	56	3	2	2	23	3	–	1
mammatum	4	3	5*a*	4	4	3	2	2	3	5	2	2
aequum	4	3	5*a*	5	5	45	3	2	3	5	2	2
aceri	4	3	6*a*	56	5	4	23	3	3	6	–	1

Note 17. Re-examination of *X. mluci* type specimens by Stocker & Kruger (1988) showed that "numerous spiniform structures are evenly distributed all through the uterus".

Note 18. X. diannae and *X. coomansi* cannot clearly be separated by key characters. They may be distinguished as follows:

diannae: c′ = 1.8–2.1; tail length = 50–62 μm; odontostyle = 87–94 μm, odontophore = 63–69 μm, total spear length = 148–156 μm; GR = 69–78 μm.

coomansi: c′ = 1.2–1.6; tail length = 41–51 μm; odontostyle = 94–116 μm, odontophore = 69–77 μm, total spear length = 163–184 μm; GR = 81–96 μm.

Group 7

	A	B	C	D	E	F	G	H	I	J	K	L
flagellicaudatum[19]	4	4	1	1	4	23	23	12	1	(1)	(1)	1
stenocephalum[19]	4	4	1	12	34	23	3	1	1	2	2	1
spaulli	4	4	2	12	45	34(5)	2	2	12	(2)	(2)	1
vanderlindei[20]	4	4	2	12	456	3(4)	1(2)	3	12	–	–	1
cavenessi	4	4	1	12	56	2(3)	(1)2	1	12	–	–	1
dimorphicaudatum	4	4	2	12(3)	56	45	(1)2	2	3	2	–	2
douceti	4	4	2	(1)2	5	23	2	2	3	2	2	1
bergeri[21]	4	4	2	23	123	23	12	2	3	2	2	1
insigne[21]	4	4	2	23	123	23	12	2	3	2	2	1
savanicola[21]	4	4	2	23	34	23	1	2	3	2	–	1
swarti	4	4	2	23	5	4	2	2	3	2	–	1
nigeriense[23]	4	4	12	23	6	2	2	2	1	2	–	1
malutiense	4	4	2	23	6	3	1	2	23	–	–	1
attorodorum[22]	4	4	2	3	4	23	2	2	2	–	–	1
bourkei	4	4	2	3	5	4	2	2	3	2	–	2
italiae	4	4	2	3(4)	45	23	12	3	3	2	2	1
conurum	4	4	2(3)	3(4)	56	4	2	3	3	–	–	1
elongatum[22]	4	4	23	34	2345	23	12	2	3	2	2	1
mampara	4	4	23	34	56	234	23	2	4	2	–	2
variabile	4	4	23	34	(5)6	23	1	3	34	2	–	2
exile	4	4	3	34	6	23	1	3	3	3	2	2
vitis	4	4	3	4	45	3	2	2	3	2	–	1
elitum[22]	4	4	3	4	5	2	2	2	3	–	–	1

Group 7 continued

	A	B	C	D	E	F	G	H	I	J	K	L
bajaji	4	4	3	4	56	3	1	3	23	3	–	1
longidoroides	4	4	3	4	6	34	23	12	3	–	–	1
louisi	4	4	3	45	56	(2)3	2	2	4	3	–	2
pachydermum	4	4	3	45	6	2	1	3	34	–	–	2
magaliesmontanum	4	4	3	5	34	2	2	2	3	3	–	1
paulistanum	4	4	3	5	4	2	2	1	–	–	–	2
setariae[24]	4	4	34	4	34	23	2	2	3	34	–	1
michelluci[25]	4	4	34	45	5	34	3	2	3	3	2	1
israeliae[25]	4	4	34	5	56	34	23	2	3	34	2	2
barense	4	4	34	5	6	34	23	3	3	5	5	2
neobasiri	4	4	4	4	6	34	2	3	3	23	2	1
bakeri	4	4	4	45	12	4	3	2	3	–	–	1
brevistilus	4	4	4	5	4	2	1	2	3	3	–	1
sahelense	4	4	4	45	5	45	23	3	2	34	–	2
seredouense	4	4	4	45	(5)6	34	3	1	34	–	–	1

Note 19. X. stenocephalum and *X. flagellicaudatum* can be separated by the shape of the fore part: in *stenocephalum* the lip region is narrow and perfectly continuous with the neck and the amphid aperture is narrow (30% of corresponding diameter); in *flagellicaudatum* the lip area is separated from the neck by a shallow but conspicuous groove and the amphid aperture is large (75% of corresponding diameter). Moreover, the 10 labial and cephalic papillae are very prominent in *stenocephalum*.

Note 20. X. vanderlindei. In the original description this species was mixed with *X. malutiense*. Data based upon Heyns (1976).

Note 21. X. bergeri and *X. insigne* can be separated by tail structure: in *bergeri* the terminal part is offset, subclavate, with a conspicuous blind canal; in *insigne* the terminal part is continuous and the blind canal inconspicuous.

Note 22. The four species *X. attorodorum*, *X. elitum*, *X. elongatum* and *X. savanicola* cannot be separated clearly by the characters used in the key. They may be differentiated as follows:

1 Tail terminus with blind canal thin, but expanded terminally 2
– Tail with plain blind canal, not expanded terminally 3
2 V = 40–42; c′ = 2.8–3.3 ..... *attorodorum*
– V = 47–50; c′ = 1.6–2.7 ..... *elitum*
3 c′ = 1.9–3.3; total spear length = 134–178 μm ..... *elongatum*
– c′ = 3.2–5.0; total spear length=114–137 μm ..... *savanicola*

Note 23. The code for *X. nigeriense* is based upon the original description only. Bos & Loof (1985) described a second population, which differs in some respects from the type population, and there is some doubt whether it is conspecific with it.

Note 24. The status of the two species *X. setariae* and *X. vulgare* has been controversial for twenty years. Tarjan (1964) differentiated them mainly on six tail measurements or ratios: ABW (anal body diameter), c′, tail length, WTP (tail diameter at anterior level of hyaline terminal portion), LNT (length of hyaline terminal part of tail) and tail/LNT. In 1974 he again stressed that of the six characters five were clearly

different, and he rejected the opinion of Cohn & Sher (1972) that the two species should be synonymised. Luc & Dalmasso (1975b) also considered *X. vulgare* distinct from *X. setariae*: in the latter species the tail is longer (55 μm or more *vs* 53 μm or less) and also the length of the hyaline part is greater (23–29 μm *vs* 13–20 μm).

From the descriptions and illustrations by Tarjan (1964, Florida), Cohn & Sher (1972, Nigeria and Ivory Coast), Loof & Maas (1972, Surinam), Williams & Luc (1977, Mauritius) and Loof & Sharma (1979, Brazil) we computed:

	X. setariae	*X. vulgare*
WTP	9–15 μm	9–15 μm
LNT	16–29 μm	11–24 μm
tail/LNT	2.1–3.0	2.2–4.0
ABW	23–31 μm	25–30 μm
c′	1.9–2.3	1.4–2.0
tail length	47–63 μm	40–61 μm

Thus there are no differences in these measurements or ratios except in some instances in c′, and this overlaps. Consequently we propose to consider *X. vulgare* a junior synonym of *X. setariae*, in accordance with Cohn & Sher (1972).

Note 25. X. israeliae and *X. michelluci*. The codes of these species differ little except in L. They may be distinguished as follows: *israeliae* has a rounded lip region, no blind canal in the tail, c = 71–109; *michelluci* has a peculiar, angular lip region, a blind canal in the tail, c = 53–65.

Group 8

	A	B	C	D	E	F	G	H	I	J	K	L
mammillatum	4	4	5*a*	6	34	(2)3	23	2	3	–	–	1
papuanum[26]	4	4	5*a*	6	4	3	2	2	–	5	3	1
basilgoodeyi[26]	4	4	5*a*	56	45	3	23	2	3	5	2	1
tarjani	4	4	5*a*	5	56	2	2	1	23	4	–	1
index	4	4	5*a*(6)	56	34	3	23	2	3	4	–	1
vuittenezi[27]	4	4	5(7*b*)	56	56	34	23	2	3	45	2	1
neovuittenezi[27]	4	4	56*b*	6	5	3	23	2	23	5	3	2
pyrenaicum	4	4	6*a*	6	56	345	3	2	3	6*a*	2	1
fluminense	4	4	6	6	5	3	1	23	4	6	–	2
lafoense	4	4	6*b*	5	6	34	1	3	2	3	23	2
bacaniboia	4	4	6*b*	6	6	23	4	2	34	6*b*	3	1
guirani	4	4	7*a*	6	56	23	2	2	3	7*a*	–	1
yapoense	4	4	7*b*	6	34	23	23	2	3	6*b*	–	1
macrostylum	4	4	7*b*	6	345	2	4	1	23	–	–	1
colombiense	4	4	7*b*	6	56	34	23	1	3	–	–	1
clavatum	4	4	7*b*	56	56	3	23	2	3	5*a*7*b*	–	2
riocaquetae	4	4	7*b*	6	6	3	4	2	1	–	–	1
porosum	4	4	7*b*	6	6	5	4	2	3	7	–	1

Note 26. X. basilgoodeyi and *X. papuanum*. The only clear-cut difference in the key is the shape of the J-1 tail: short, straight in *papuanum*, curved ventrad in *basilgoodeyi*. Adults can be distinguished as follows:

basilgoodeyi: c = 57–93; tail length = 29–51 μm; peg located on ventral side of the tail; the dorsal curvature of the tail is stronger than the ventral one.

papuanum: c = 105–137; tail length = 21–27 μm; peg located axially; dorsal and ventral curvatures of tail equal.

Note 27. X. vuittenezi and *X. neovuittenezi* are very similar. Apart from code L, the only difference is in the tail of the J-1: short, straight in *neovuittenezi*, somewhat more slender and slightly curved ventrad in *vuittenezi*.

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Notes added in proof

1. Since the submission of the manuscript two new species have been described by Hutsebaut, Heyns & Coomans:

   X. capriviense. This species is peculiar in possessing various-shaped inclusions in the uteri. Since these, when viewed under a certain angle, resemble spines and will probably be considered as such by the user, the species can best be included in Group 6. The code is: A4–B3–C34–D45–E34–F34–G23–H3–I3–J3– K3–L1.

   X. simplex. Belongs in Group 7 and codes as follows: A4–B4–C3–D45–E56–F23–G2–H2–I3–J3–K3–L1. Both codes are clearly different from those of the other species in the respective groups.

Reference:

Hutsebaut, M., Heyns, J. & Coomans, A. (1989) The genus *Xiphinema* in Southern Africa. XIX: Descriptions of two new and one known species (Nematoda: Dorylaimida). *Phytophylactica*, **21**, 1–11.

2. Coomans, Rashid & Luc (1990) distinguish two subspecies of *X. fatikae*, viz. *X. fatikae fatikae* Bos & Loof, 1985 and *X. fatikae eburnense* n. subsp. The latter is distinguished from the nominate subspecies by: (i) longer uterus; (ii) Z–organ containing three roundish sclerotizations *vs* four squarish ones; (iii) cylindrical terminal part of tail more strongly curved ventrally; (iv) three pairs of caudal pores *vs* two; (v) smaller number of body pores in the neck region.

Reference

Coomans, A., Rashid, F. & Luc, M. (1990) Observations on *Xiphinema vitis* Heyns, 1974, *X. elongatum* Schuurmans Stekhoven & Teunissen, 1938 and *X. fatikae fatikae* Bos & Loof, 1985, and description of *X. fatikae eburnense* subsp. n. (Nemata: Longidoridae) from Africa. *Revue de Nématologie*, **13**, 239–248.

3. Hutsebaut, Heyns & Coomans (1989) described three forms within *X. mampara*, viz. f. *bisexualis* (*bisexuale* emend.), f. *major* and f. *minor*. The two last mentioned are monosexual; they differ in body length, cuticle thickness in mid-body (*major* 4.0–5.5 μm, *minor* 2.5–3.5 μm) and spear length (*major* 194–241 μm, *minor* 151–181 μm). The codes are:

mampara bisexualis: A4–B4–C23–D34–E56–F34–G23–H2–I4–J2–L2.

mampara major: A4–B4–C23–D34–E56–F34–G23–H2–I4–J2–L1.

mampara minor: A4–B4–C23–D345–E56–F23–G2–H2–I4–J2–L1.

Furthermore these authors described a new species *X. ornatizulu*. Code: A4–B2 + 3–C23–D34–E56–F(3)4–G(2)3–H2–I34–L2. The code is not clearly different from that of:

X. zulu, from which it differs in its lower and broader lip region, its tail which is curved ventrally throughout its length (distal part straight in *zulu*), its slightly smaller values of h and h%T, and its shorter ovejector and uteri.

X. ornativulvatum, from which it differs by its greater body length (3.1–4.7 mm *vs* 2.8–3.4 mm), longer odontostyle (111–143 μm *vs* 101–109 μm), longer tail (84–150 μm *vs* 69–92 μm), direction of uterine spines (all directions *vs* towards pars dilatate uteri) and absence of distinct granules in the pseudo-Z-organ.

X. theresiae, from which it differs by its shorter tail (89–138 μm *vs* 163–235 μm, c = 28–41 *vs* 17–22) and direction of spines (all directions *vs* towards pars dilatata uteri).

X. rarum, from which it differs by its greater length (3.1–4.2 mm *vs* 2.6–3.1 mm), longer tail (89–138 μm *vs* 64–83 μm) and longer stylet (odontostyle 111–143 μm *vs* 85–95 μm, odontophore 82–97 μm *vs* 57–66 μm, total spear 195–237 μm *vs* 146–156 μm).

In addition, it differs from these species (except *ornativulvatum*) by the presence of 2–4 ventral transverse cuticular grooves on either side of the vulva.

Reference:

Hutsebaut, M., Heyns, J. & Coomans, A. (1989) The genus *Xiphinema* in southern Africa. XVIII. A study of the *X. zulu* and *X. mampara* species complex (Nematoda: Dorylaimida). *Nematologica*, **34**, 373–400.

4. The same authors (1989) described two new species:

X. judex, code: A4–B4–C1–D1–E45–F3–G2–H2–I3–L2. It belongs in group 7, the code being clearly distinct from those of the other species in this group.

X. dracomontanum, code: A4–B2–C12–D123–E56–F34–G2–H2–I3–J1–L2. It belongs in group 5, the code being clearly distinct from those of the other species in this group.

Reference:

Hutsebaut, M., Heyns, J. & Coomans, A. (1989) The genus *Xiphinema* in southern Africa. XX. Two species related to *X. flagellicaudatum* Luc, 1961 (Nematoda: Dorylaimida). *Phytophylactica*, **21**, 113–120.