

A Contribution to the Taxonomy of the Genus *Xiphinema* Cobb, 1913

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Abstract: In a comparative study of different populations of *Xiphinema*, the significance of the female gonad structure in species determination is stressed, and monodelphic, pseudomonodelphic, and didelphic forms in the genus are defined. *X. chambersi* is redescribed and illustrated, *X. ensiculiferum* and *X. krugi* are redefined, and *X. ensiculiferoides* n.sp. and *X. orthotenum* n.sp. are described. Proposed new synonymies are: *X. itanhaense* = *X. brasiliense*; *X. bulgariensis* and *X. conurum* = *X. italiae*; *X. ifacolum* = *X. basiri*; *X. macrostylum* = *X. ensiculiferum*; *X. truncatum* = *X. elongatum*; and *X. vulgare* = *X. setariae*. *X. yapoense* is considered *species inquirenda* and *X. obtusum* a *nomen dubium*. The following eight subgenera of the genus *Xiphinema* are proposed: *Radiphinema* n. subg., *Krugiphinema* n. subg., *Xiphinema* n. subg., *Elongiphinema* n. subg., *Halliphinema* n. subg., *Basiphinema* n. subg., *Rotundiphinema* n. subg., and *Diversiphinema* n. subg. A key to the subgenera of *Xiphinema* is presented, plus a list of 50 species in the genus, their synonyms, and 10 *species inquirendae*.

Because of their economic importance as plant pathogens and as vectors of virus diseases of plants, *Xiphinema* species have received increased attention during the last decade. In 1963, Luc and Tarjan listed 29 valid species and 9 *species inquirendae* (28). Since then, 28 other species have been described or resurrected, while another three have been designated as *species inquirendae* and one has been synonymized.

The purpose of the present work was primarily to study the variations and interrelationships of some of the species described to date; descriptions of new species were kept to a minimum. The basis for this study was the nematode collection of the University of California at Riverside (UCR) which contained more than 3000 mounted specimens of *Xiphinema* representing several hundred populations from all continents, and additional specimens in mass collections. Use also was made of the nematode collection at UC, Davis. Type material of 25 described species was assembled and used for comparative studies.

DIAGNOSTIC CHARACTERS FOR SEPARATION OF SPECIES: The major characters used for separating species of *Xiphinema* are summarized below. They consist primarily of female features and are essentially

similar to those suggested by Luc and Tarjan (28), and by Stegarescu, translated by Weischer (44), with some alterations:

1. General morphology and body measurements: body length (L); "a" ratio; stylet length; shape of lip region.
2. Reproductive system: position of vulva (V); single or double genital tract and state of regression of anterior gonad; presence or absence of Z organ.
3. Tail structure: c ratio; tail length/anal body diameter (c'); tail shape.

Many descriptions of existing species contain various morphological and biometrical details in addition to the major characters listed above (e.g., depth of vulva, number of body pores, thickness of cuticle, position of fixed guiding ring, width of amphid opening, etc.). Some of these characters cannot be used because they have been studied on only a few specimens and information on their consistency is lacking; others, once considered valid, like the number of caudal pores, are now known to be variable. We therefore consider such characters to be of minor diagnostic value, and valid only as supplementary to existing major characters.

The structure of the female gonad is of the utmost importance in the taxonomy of the genus. Luc (26) observed and described three different types of anterior gonads in a state of regression:

- X. insigne* (*X. indicum*): oviduct normal, ovary reduced and not functional.
- X. longicaudatum*: oviduct reduced, no ovary.
- X. ensiculiferum*: oviduct and ovary present

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but reduced, and apparently not functional.

It is, however, not possible to determine by observation whether an organ which is present is functional or not; this must be shown experimentally. Our observations have shown that most species of *Xiphinema* with a vulva position of 35% or less bear an anterior gonad which is smaller than the posterior gonad. These species differ, however, in whether they possess all or some of the basic components of the gonad, viz., uterus, oviduct and ovary. The absence or presence of these organs appears to be constant in populations and constitutes a good character for separating species.

The terminology of the gonad components needs some clarification. Luc (26) considered the oviduct as that portion of the gonad between the distal end of the ovary and the muscular-walled structure adjacent to the vagina, which he termed uterus. Hence, he described most of the variation in the gonad structure of different *Xiphinema* species—including the presence of the Z organ—as occurring in the oviduct. Coomans (8), regards the sphincter muscle (called by some authors “sphincter Z”) as the junction between the oviduct and the uterus; accordingly, it is then the uterus which contains the Z organ and is often highly differentiated. The terminology of Coomans is employed in this paper.

Recently, McLeod and Khair (30) reported the presence of a small “prevulval sac” in the monodelphic species. From our studies it appears that there is some extension of the single posterior gonad beyond the vulva. However, this prevulval extension is not a separate organ, differentiated from the adjoining postvulval section, but part of one and the same organ—the ovijector (Fig. 1)—which in the didelphic species is formed by the convergence of the uteri, and extends to both sides of the vagina. The ovijector is a single organ, and can be considered a distinct, well-defined morphological entity in all *Xiphinema* species, mono- and didelphic. It is a dilated pouch with a large lumen, extending deep into the body dorsally, and is bordered by a thick wall. The junction of the ovijector and the proximal part of the uterus is usually distinct and in some cases, as reported by Luc (26) is characterized by “une structure a muscles circulaires.” Species of *Xiphinema*

differ in whether or not they possess parts of the anterior gonad adjoining the ovijector (Fig. 1 and 2). For these reasons we distinguish between ovijector and uterus, and the latter term is used in the present context to describe that portion of the gonad between the sphincter muscle and the ovijector. Consequently, we differentiate between three types of anterior gonads in the genus:

1. Uterus, oviduct and ovary absent in anterior gonad—truly monodelphic forms (Fig. 1, A).
2. Uterus and possibly oviduct, or parts of them, present in anterior gonad, but ovary absent (Fig. 1, B). We term these pseudomonodelphic forms.
3. All components of the anterior gonad—uterus, oviduct and ovary—present but may be reduced in size as compared with the posterior gonad (Fig. 1, C). These are the didelphic forms.

These three types constitute recognizable stages in the evolutionary regression of the anterior gonad in *Xiphinema*.

LIST OF VALID SPECIES OF *XIPHINEMA* COBB, 1913

Type species: *X. americanum* Cobb, 1913

Other nominal species and their synonyms:

- X. arcum* Khan, 1964
- X. attorodorum* Luc, 1961
- X. australiae* McLeod & Khair, 1971
- X. bakeri* Williams, 1961
- X. basilgoodeyi* Coomans, 1964
- X. basiri* Siddiqi, 1959
- = *X. ifacolum* Luc, 1961, new synonymy
- X. brasiliense* Lordello, 1951
- = *X. itanhaense* Carvalho, 1962, new synonymy
- X. brevicolle* Lordello & Da Costa, 1961
- X. chambersi* Thorne, 1939
- X. clavatum* Heyns, 1965
- X. coxi* Tarjan, 1964
- X. dimorphicaudatum* Heyns, 1966
- X. diversicaudatum* (Micoletzky, 1927) Thorne, 1939
- = *X. paraelongatum* Altherr, 1958
- X. ebriense* Luc, 1958
- X. elongatum* Schuurmans Stekhoven & Teunissen, 1938
- = *X. campinense* Lordello, 1951
- = *X. pratense* Loos, 1949

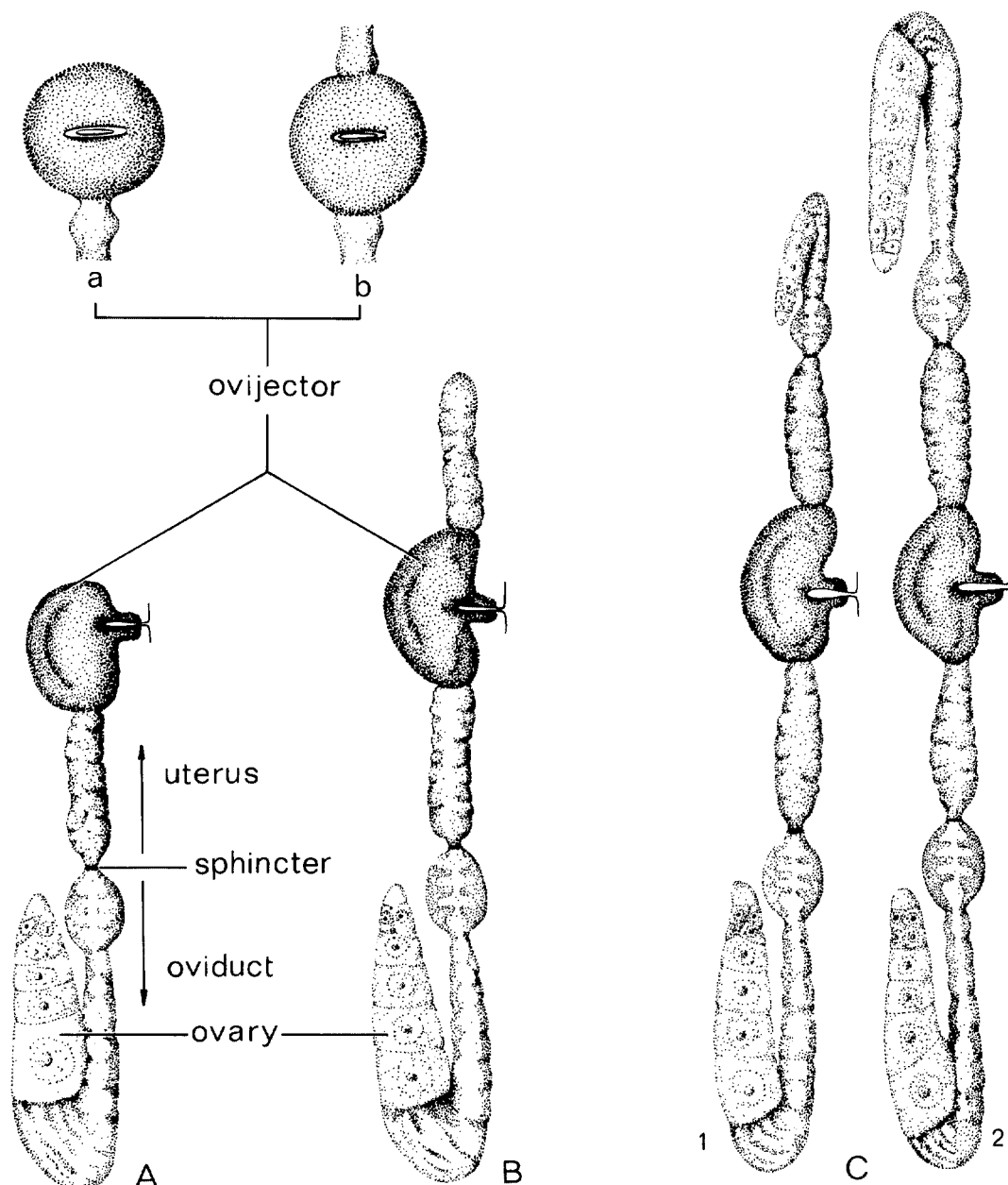


FIG. 1. Types of female gonads in *Xiphinema*. A. Monodelphic form; B. Pseudomonodelphic form; C. Didelphic forms; 1 - reduced anterior gonad; 2 - full-sized anterior gonad. a,b - ventral view of ovijector and uteri in monodelphic and pseudomonodelphic forms.

= *X. truncatum* Thorne, 1939, new synonymy
X. ensiculiferoides n. sp.
X. ensiculiferum (Cobb, 1893) Thorne, 1937
 = *X. macrostylum* Esser, 1966, new synonymy
X. flagellicaudatum Luc, 1961

X. hallei Luc, 1958
X. imitator Heyns, 1965
X. index Thorne & Allen, 1950
X. ingens Luc & Dalmasso, 1963
X. insigne Loos, 1949
 = *X. indicum* Siddiqi, 1959
X. italiae Meyl, 1953
 = *X. arenarium* Luc & Dalmasso, 1963



FIG. 2. Lateral view of vulval and prevulval region of: A. paratype of *X. monohysterum* (monodelphic); B. specimen of *X. krugi* from Hawaii (pseudomonodelphic).

= *X. bulgariense* Stoyanov, 1964, new synonymy
 = *X. conurum* Siddiqi, 1964, new synonymy
X. krugi Lordello, 1955
X. longicaudatum Luc, 1961
X. longidoroides Luc, 1961
X. mammillatum Schuurmans Stekhoven & Teunissen, 1938
X. mediterraneum Martelli & Lamberti, 1967
X. monohysterum Brown, 1968
X. neovuittenezi Dalmaso, 1969 (9)
X. nigeriense Luc, 1961
X. opisthohysterum Siddiqi, 1961
X. orbum Siddiqi, 1963
X. orthotenum n. sp.
X. paulistanum Carvalho, 1965
X. pini Heyns, 1965
X. pyrenaicum Dalmaso, 1969
X. radicola Goodey, 1936
X. rivesi Dalmaso, 1969
X. rotundatum Schuurmans Stekhoven & Teunissen, 1938
X. sahelense Dalmaso, 1969
X. sandellum Heyns, 1966
X. setariae Luc, 1958
 = *X. vulgare* Tarjan, 1964, new synonymy
X. simillimum Loof & Yassin, 1970
X. turcicum Luc & Dalmaso, 1963

X. vanderlinde Heyns, 1962
X. vuittenezi Luc, Lima, Weischer & Flegg, 1964
X. zulu Heyns, 1965

Species inquirendae:

X. brevicaudatum Schuurmans Stekhoven, 1951
X. digiticaudatum Schuurmans Stekhoven, 1951
X. effilatum Schuurmans Stekhoven, 1951
X. grande Steiner, 1914
X. lineum (Grube, 1849) Thorne, 1939
X. makrodorum (Vaňha, 1893) Thorne, 1939
X. obtusum Thorne, 1939
X. pachtaicum (Tulganov, 1938) Kirjanova, 1951
X. parasetariae Luc, 1958
X. yapoense Luc, 1958, new designation

SYSTEMATICS

A. MONODELPHIC SPECIES

The separation of the monodelphic *Xiphinema* species has proven difficult for two reasons. Firstly, the descriptions of all except *X. monohysterum* (2) and *X. australiae* (30) are brief, based on few specimens and, therefore, lack information on the variability of biometrical characters. Secondly, all described

species in this group are relatively short ($L = 1.5-2.8$ mm); and possess an anteriorly situated vulva ($V = 23-31\%$), and a simple undifferentiated posterior uterus, lacking a Z organ. Since these important characters are of little diagnostic value in this group, species differentiation is based primarily on shape and size of the tail. Our conclusions regarding their specific validity are reviewed below.

X. brasiliense Lordello, 1951

(Fig. 4, A-D)

= *X. itanhaense* Carvalho, 1962, new synonymy

As already pointed out by Sturhan (39) a number of discrepancies exist between some measurements given by Lordello (21) and these values as calculated from his illustrations. Thus the a and c ratios are given as 34.1 and 24.55 respectively, whereas these values are about 48 and 54 respectively when calculated from Fig. 1 in the original description. The true c ratio is of the utmost importance in determining the specific status of this animal. We were unable to obtain type specimens of *X. brasiliense*; however, according to Tarjan (*in litt.*), the c ratios of two syntypes examined by him were 51 and 54. We may, therefore, conclude that the illustration in Lordello's description is more reliable than the measurements he gave.

Since the description of *X. brasiliense* includes a single set of measurements, no information on the variability of the species is

available. We examined three small populations — from Guatemala, Ceylon, and Nigeria — with characters similar to *X. brasiliense*, and which we consider to be conspecific with it. Biometrical characters of these populations are compared with those of the type of *X. brasiliense* in Table 1; their tail shapes appear in Fig. 4.

In describing *X. itanhaense*, Carvalho (4) recognized its resemblance to *X. brasiliense*, but considered it different because of its smaller size, the shorter 'peg' or extension of the tail, the more posterior position of the vulva, and the absence of eggs in the ovary. We failed to obtain type specimens of *X. itanhaense*, but A. C. Tarjan kindly supplied us with his measurements of three syntypes. In comparing these and the measurements in the original description with those of the different populations of *X. brasiliense* (Table 1), it is clear that the differences in the L , c , c' and V values are insignificant; naturally, presence or absence of eggs in the ovary is of no diagnostic significance. We therefore consider *X. itanhaense* a synonym of *X. brasiliense*.

Emended diagnosis of X. brasiliense: Comes closest to *X. radicolica* Goodey, 1936 (12) from which it can be separated primarily by its distinct peg-shaped tail (Fig. 4), and lower c' value (0.9-1.5:1.7-2.8). It usually has a higher c value and slightly more posterior vulva position, although some overlapping in these characters does occur.

TABLE 1. Biometrical characters of different populations of *Xiphinema brasiliense*^a

| Locality and host | n | L(mm) | a | b | c | V | total stylet length (μ) | c' |
|--|---|-----------|-----------------|-----------|-----------------|---------|-------------------------------|------------------|
| Potato, Sapecado, Brazil (Type) ^c | 1 | 2.1 | 48 ^b | 5.1 | 54 ^b | 28 | 204 | 1.2 ^b |
| Jungle soil, Rio Montaguilla | 4 | 1.7 | 34 | 4.4 | 37 | 31 | 214 | 1.4 |
| Guatemala | | (1.6-1.8) | (30-38) | (4.3-4.4) | (35-40) | (30-33) | (212-219) | (1.1-1.5) |
| Jungle soil, Balangoda, Ceylon | 4 | 2.1 | 48 | 5.7 | 54 | 27 | 187 | 1.4 |
| | | (2.0-2.2) | (47-50) | (5.6-6.1) | (47-64) | (26-28) | (181-196) | (1.3-1.6) |
| Forest, Port Harcourt Prov. Nigeria | 8 | 1.7 | 30 | 4.4 | 47 | 33 | 224 | 1.2 |
| | | (1.6-1.7) | (29-30) | (4.2-4.6) | (43-51) | (32-34) | (219-228) | (1.1-1.2) |
| Banana, Itanhaem, Brazil (<i>X. itanhaense</i>) ^d | 5 | (1.5-1.7) | (23-30) | (4.4-5.2) | (36-41) | (31-32) | (182-193) | 1.4 ^b |
| As above ^e | 3 | 1.5 | 34 | 4.6 | 39 | 30 | 190 | 1.1 |
| | | (1.4-1.5) | (27-42) | (4.1-5.0) | (35-42) | (29-32) | (186-193) | (0.9-1.3) |

^aFor tail shapes, see Fig. 4

^bCalculated from illustration

^cFrom Lordello (22)

^dFrom Carvalho (4)

^eSupplied by A. C. Tarjan

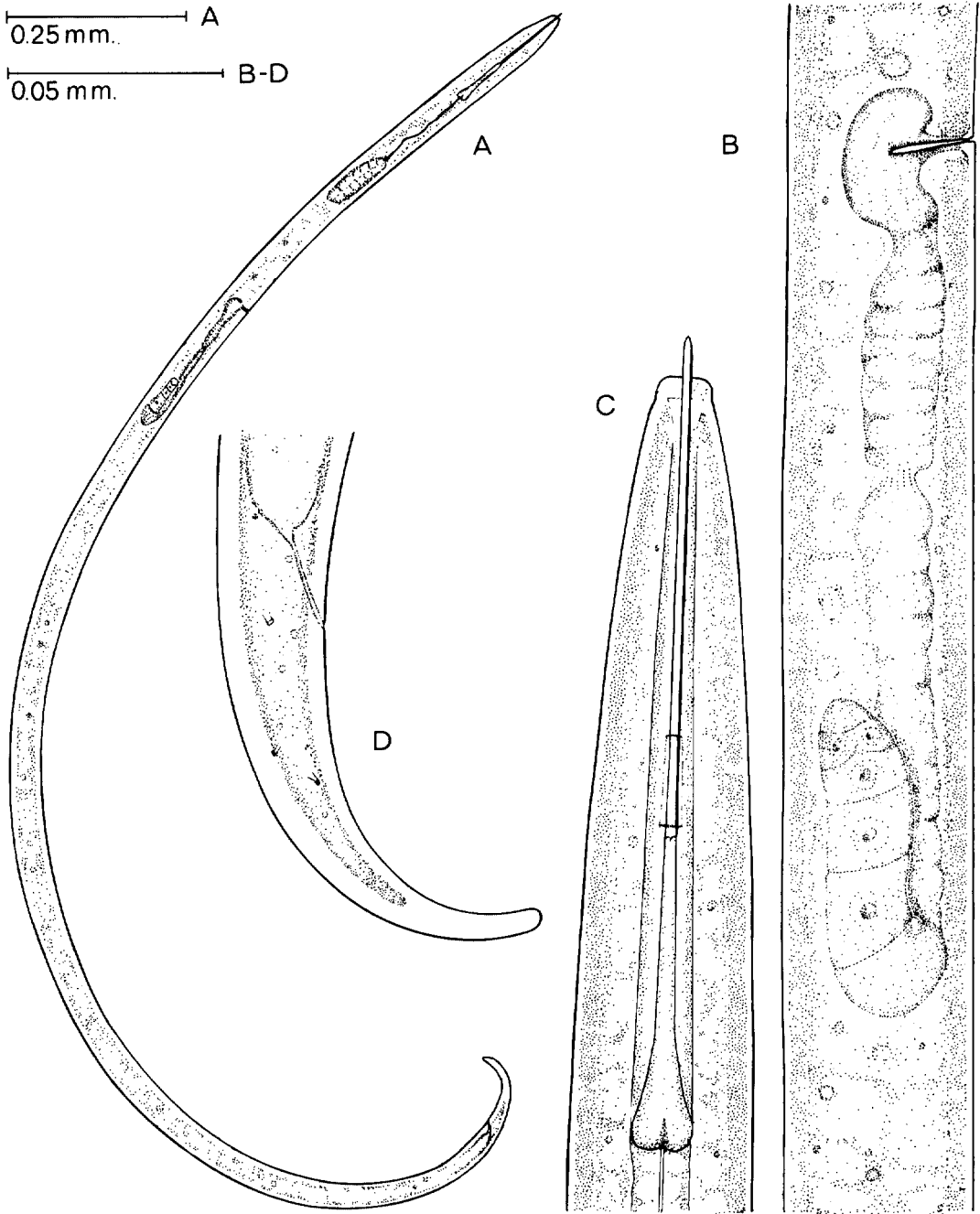


FIG. 3. *Xiphinema chambersi* Thorne, 1939. A. Adult female. B. Female reproductive system. C. Anterior end of female. D. Posterior end of female.

Xiphinema chambersi Thorne, 1939
(Fig. 3)

As indicated by Loof and Yassin (19), Thorne's description gives the length of odontostyle as 125 μ and the basal portion as

75 μ , whereas his illustration shows approximately 110 μ and 70 μ , respectively. Brown (2) quotes a total stylet length of 169 μ in the original description. Furthermore, a single set of all measurements is given, and no

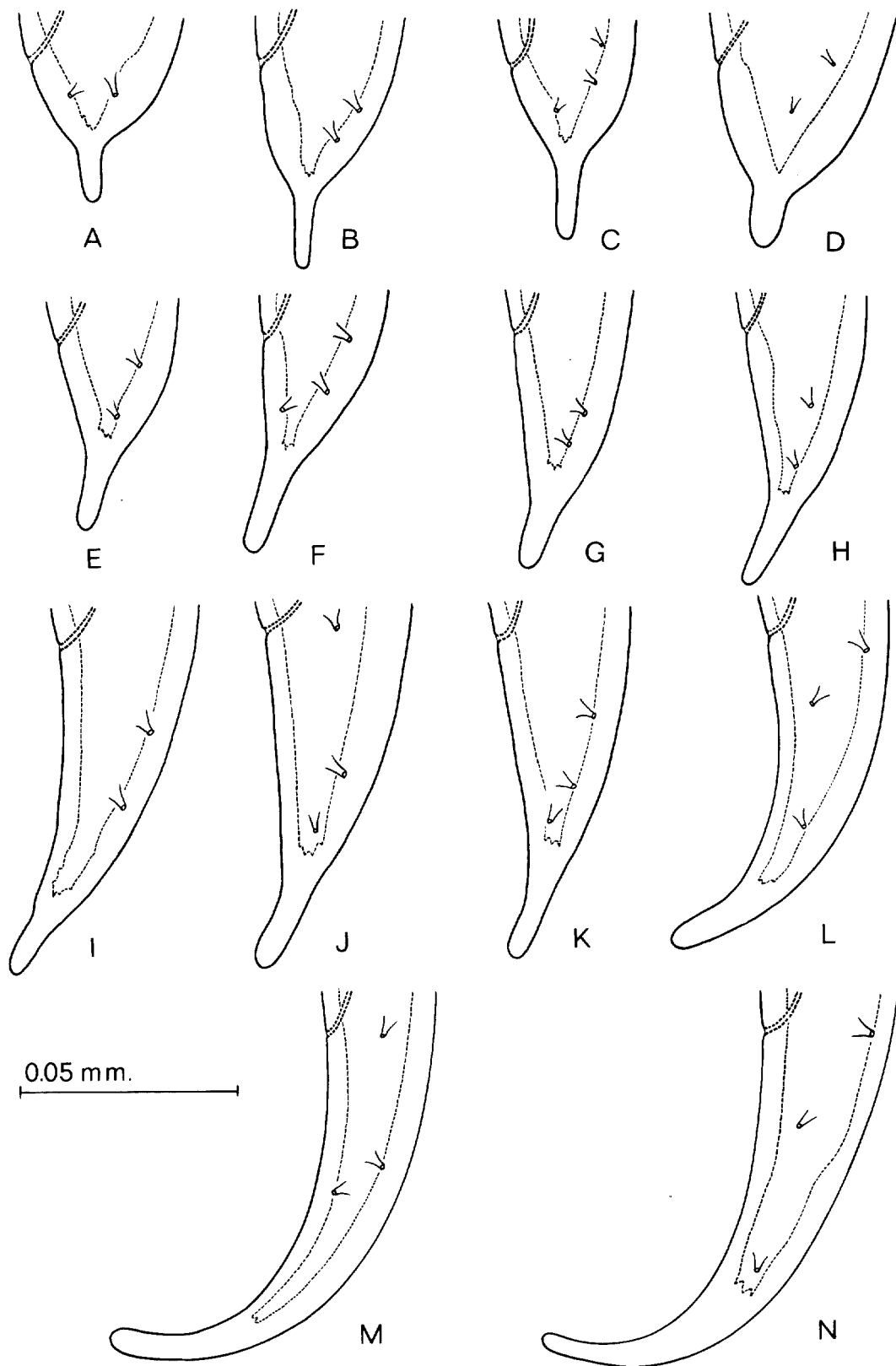


TABLE 2. Main characters of *Xiphinema australiae*, *X. chambersi*, *X. monohysterum*, *X. radicola* and closely related populations from different localities and hosts.^a

| Character | Related populations | | | | | | | | | | Related populations | | | | <i>X. chambersi</i> Arlington Farm, Virginia Pine Woods ^c | | | |
|-------------------------|----------------------|--------------|-----------------------|------------------|------------------------------|------------------|-----------------------|------------------|-----------------------------------|------------------|---------------------|---------------------|----------------------------|------------------|--|------------------------------|----------------------|------------------|
| | <i>X. australiae</i> | | Katmale, Ceylon Grass | | Thailand Citrus ^b | | Nahunta, Georgia Soil | | W. Palm Beach, Florida Slash Pine | | <i>X. radicola</i> | | <i>X. monohysterum</i> | | | | | |
| | Victoria, Australia | Nigeria Soil | | | | | | | | | Bangla, Indonesia | Pepper ^c | Balldale, N.S.W. Australia | Graped | | Silver Spring Park, Maryland | Pee Dee, S. Carolina | Nettle |
| n | 7 | 1 | 8 | 8 | 29 | 2.6 | 2.6 | 2.6 | 10 | 2.6 | 3 | 2.2 | 2.2 | 2.7 | 2.2 | 12 | 14 | 6 |
| L(mm) | 2.7 (2.6-2.8) | 1.9 | 2.1 (2.0-2.2) | | (1.5-2.8) | (2.4-2.8) | | (2.3-3.0) | | | (2.1-2.3) | | (2.4-2.8) | | (1.9-2.4) | | 2.3 (2.1-2.5) | 2.4 (2.2-2.5) |
| V | 27 (27-38) | 29 | 25 (24-26) | 25 (23-25) | 27 (20-30) | 24 (23-25) | 24 (23-25) | 23 (23-24) | 204 (177-210) | 209 (206-212) | 28 (27-29) | 28 (27-29) | 30 (28-32) | 30 (28-32) | 23 (22-25) | 23 (22-25) | 24 (23-25) | 24 (23-25) |
| Total stylet length (μ) | 198 (183-207) | 188 | 166 (161-171) | 166 (161-171) | 170 (151-189) | 170 (151-189) | 209 (206-212) | 204 (177-210) | 204 (177-210) | 143 (136-148) | 143 (136-148) | 143 (136-148) | 169 (162-177) | 169 (162-177) | 176 (164-184) | 176 (164-184) | 197 (193-205) | 192 (187-198) |
| c | 46 (40-58) | 36 | 39 (36-41) | 39 (36-41) | 39 (37-53) | 34 (31-38) | 34 (31-38) | 33 (31-36) | 33 (31-36) | 38 (34-41) | 38 (34-41) | 38 (34-41) | 31 (25-34) | 31 (25-34) | 28 (24-37) | 28 (24-37) | 20 (18-23) | 22 (21-22) |
| c' | 1.9 (1.6-2.2) | 2.0 | 2.0 (1.9-2.1) | 2.0 (1.9-2.1) | 2.1 (1.7-2.8) | 2.1 (1.7-2.8) | 2.3 (2.2-2.4) | 2.5 (2.3-2.6) | 2.5 (2.3-2.6) | 2.3 (2.1-2.5) | 2.3 (2.1-2.5) | 2.3 (2.1-2.5) | 3.1 (2.6-3.5) | 3.1 (2.6-3.5) | 3.3 (2.6-3.9) | 3.3 (2.6-3.9) | 4.4 (3.7-4.9) | 4.4 (4.3-4.7) |

^aFor corresponding tail shapes see Fig. 4

^bComposite measurements of three populations with minor differences

^cSyntypes

^dFrom Brown (2)

FIG. 4. Tail shapes of some monodelphic species and closely related populations of *Xiphinema*. A. *X. brasiliense*, Nigeria; B. *X. brasiliense*, Guatemala; C. *X. brasiliense*, Ceylon; D. *X. brasiliense*, type (after Lordello); E. Unidentified, Thailand; F. Unidentified, Ceylon; G. *X. australiae*, paratype; H. *X. radicola*, syntype; I. *X. monohysterum*, paratype; J. Unidentified, Georgia, USA; K. Unidentified, Florida, USA; L. Unidentified, Maryland, USA; M. *X. chambersi*, lectotype; N. Unidentified, S. Carolina, USA.

indication of the variability range is available; also, no type specimens were designated. In comparing *X. simillimum* with *X. chambersi* (material from Ames, Iowa), the authors (19) illustrate and refer to a tail with the "distal part offset, somewhat clavate" in *X. chambersi*; this does not wholly agree with Thorne's illustration and description of a tail "uniformly elongate-conoid or with sub-cylindroid terminus" in *X. chambersi* (43). As stated earlier, the tail shape is of cardinal importance in this group.

For the aforementioned reasons, we feel that a redescription of *X. chambersi* is necessary. A. M. Golden kindly sent us six syntypes from the USDA collection at Beltsville, Maryland. A brief redescription follows:

Measurements: 6 ♀♀ (syntypes); L = 2.4 mm (2.2-2.5); a = 54 (52-60); b = 5.8 (5.1-6.4); c = 22 (21-22); V = 24 (23-25); odontostyle = 118 μ (115-123); spear extension = 74 μ (72-75); total stylet length = 192 μ (187-198); c' = 4.4 (4.3-4.7).

Lectotype: L = 2.5 mm; a = 57; b = 6.3; c = 22; V = 24; odontostyle = 122 μ ; spear extension = 74 μ ; total stylet length = 196 μ ; c' = 4.6. Body ventrally curved as an open "C" when relaxed (Fig. 3, A). Lip region amalgamated, slightly set off from rest of body by a faint depression. Cuticle with fine transverse striations, particularly conspicuous in the caudal region, 3 μ wide in the head region, 2 μ near the vulva and 5-6 μ in the tail region. Amphid aperture about two-thirds of width of lip region. Spear flanges 16 μ wide. Fixed ring of spear guiding apparatus 109 μ from anterior end. Hemizonid 6 μ behind base of spear extension; nerve ring faint, just less than one body width from base of spear extension. Basal oesophageal bulb 93 μ \times 22 μ , occupying just over one-third of oesophagus. Small oesophago-intestinal valve present. Gonad single, extending posteriorly, 275 μ long with simple, barely differentiated uterus. Vagina directed slightly posteriorly, occupying about one-half of body width; ovary reflexed. Intestine opaque, prerectum obscure, rectum 36 μ long. Tail 113 μ long, arcuate, elongate-conoid, terminating in a cylindroid nonprotoplasmic tip, measuring 35 μ long. Two caudal pores visible.

Males: Thorne (43) described and illustrated a male; no male, however, was seen on the slide with the syntypes, and no males were encountered in any other population studied.

Juveniles: Resemble adults in general appearance and tail shape.

Type locality and habitat: Pine soil, Arlington Farm, Virginia, USA.

Type material: Lectotype and paralectotypes (6 females and 4 juveniles) with U. S. Department of Agriculture, Beltsville, Md., USA.

Relationship to allied species: *X. chambersi* resembles three other described species — *X. radiculicola* Goodey, 1936 (12), *X. monohysterum* Brown, 1968 (2), and *X. australiae* McLeod and Khair, 1971 (30).

D. J. Hooper, Rothamsted Experimental Station, supplied us with three syntypes of *X. radiculicola*. These showed differences in two major characters from the original description — an a value of 50 (48-53) as opposed to 62-66 and a total stylet length of 143 (136-148) as opposed to 170-178 in the original description. Two other syntypes of *X. radiculicola* have a total stylet length of 174 μ and 180 μ (Hooper, *in litt.*); it thus appears that stylet length is extremely variable in this species, as reported by McLeod and Khair (30). A redescription of *X. radiculicola* and selection of a lectotype is currently underway (Hooper, *in litt.*). The only other population of *X. radiculicola* described is that from Ceylon by Loos (20) with nematodes "slightly smaller and somewhat more robust" than the type specimens, and a total stylet length of 160-170 μ . The specimens used by Loos are now deposited in the UCR collection and the measurements of Loos have been confirmed.

X. monohysterum and *X. australiae* are considered adequately described from abundant material. The type populations of the four species — *X. australiae*, *X. chambersi*, *X. monohysterum* and *X. radiculicola* — can be separated by differences in body length, vulva position, stylet length, c and c' and tail shape. There are, however, many similarities between them, and McLeod and Khair (30) in their key to these species have resorted to such doubtful characters as number of caudal pores and size of eggs. Several populations were encountered with intermediate characters (Fig. 4 and Table 2). For clarity, only the aforementioned five characters are given in Table 2 for all populations; no consistent differences were seen in other morphological or biometrical characters.

Some of these populations are clearly identical species—the South Carolina specimens tally with *X. chambersi*, the Georgia and

Florida populations appear the same, and the Ceylon and Thailand populations obviously represent a single species, probably conspecific with *X. radiculicola*. However, the continuous gradation and overlapping in all the major characters make it extremely difficult to separate these populations into the four existing specific categories. We do not propose any taxonomic change in this group at this stage, but believe that with the accumulation of additional morphological and biological information it might be necessary to review the validity of these taxa.

Xiphinema orthotenum n. sp.

(Fig. 5)

= *Xiphinema* sp. B in Sher, 1968 (33)

Measurements: 17 ♀♀ (paratypes): L = 1.9 mm (1.7-2.1); a = 41 (35-49); b = 5.7 (4.9-6.7); c = 11.6 (10.1-13.3); V = 27 (25-28); odontostyle = 119 μ (110-127); spear extension = 73 μ (66-82); total stylet length = 192 μ (176-209); c' = 8.3 (7.0-10.5).

Holotype: L = 1.9 mm; a = 43; b = 4.8; c = 11.2; V = 28; odontostyle = 124 μ ; spear extension = 74 μ ; total stylet length = 198 μ ; c' = 8.0. Body straight when relaxed (Fig. 5, A). Anterior end tapering strongly at about 45 μ from head forming a narrow lip region, 12 μ wide at level of amphid apertures, not set off (Fig. 5, B). Amphid aperture width about two-thirds of lip diameter. Cuticle 2-3 μ in width throughout body, maximum thickness in caudal region, 6 μ . Spear flanges 15 μ wide. Fixed ring of spear guiding apparatus 116 μ from anterior end. Hemizonid 10 μ posterior to base of spear. Nerve ring about one body width from base of spear. Mucro, 3 μ long, situated near level of nerve ring, 40 μ behind spear base. Basal oesophageal bulb 19 \times 80 μ . Oesophago-intestinal valve present. Gonad single, extending posteriorly (Fig. 5, D), 222 μ long, lacking Z organ. Prerectum 230 μ long, rectum 25 μ long. Tail 167 μ long, attenuated, terminating in a nonprotoplasmic tip which constitutes just more than one-half of tail length, slightly curved at distal end (Fig. 5, C); 3 caudal pores.

Paratype females: Distance of fixed ring of spear apparatus from anterior end variable — 98-122 μ . Basal oesophageal bulb larger in most specimens than in holotype, averaging 26 \times 105 μ . Gonad length 220-280 μ , single uterine egg, 50 \times 243 μ . Tail length 136-197 μ , fine cuticular tip of tail fragile, broken in some

specimens. 2-3 caudal pores, position variable.

Males: Unknown.

Juveniles: Resemble adults in general appearance and tail shape.

Diagnosis: *X. orthotenum* is unique among the monodelphic species in the genus because of its long attenuated tail and, consequently, its low c and high c' values.

Type habitat and locality: Collected by the junior author in heavy clay soil around roots of lichee tree (*Litchi chinensis* Sonn.) in Thonburi, Thailand, May 2, 1968.

Type material: Holotype and paratypes (11 ♀♀ and 7 juveniles) in UCR nematode collection; 4 paratypes (3 ♀♀ and 1 juvenile) with Division of Nematology, The Volcani Institute of Agricultural Research, Bet Dagan, Israel; 3 paratypes (2 ♀♀ and 1 juvenile) with Nematology Department, Rothamsted Experimental Station, Harpenden, England.

Xiphinema ensiculiferum (Cobb, 1893)

Thorne, 1937 (42)

Considerable confusion exists concerning the true identity of this species. The description of *Tylencholaimus ensiculiferus* Cobb 1893 (6) from Fiji does not contain details on the structure of the gonad although the measurements given (V = 34) and the indistinct illustration of the "immature female" (6, Plate XLII, Fig. 1) suggest the existence of a single posterior gonad. However, Cobb's figure shows a short, truly hemispherical tail for the female. Thorne in 1939 reported that the species had a single ovary and an hemispheroid tail (43); in his description of *X. obtusum*, which also has an hemispheroid tail, Thorne (43) separates his new species from *X. ensiculiferum* by "its much smaller size and double ovaries." The term "ovary" has been misused by most authors to refer to the entire gonad, rather than part of it; it appears, therefore, that *X. ensiculiferum* probably has a single gonad, but certainly has a single posterior ovary.

The species described by Loos in 1949 as *X. ensiculiferum* from Ceylon (20) differs from the type population description in having a slightly longer and more conical, rather than a truly hemispherical tail in the female. Moreover, the juveniles in the Ceylon population possess a distinctly sub-digitate tail. The female has an "ovary usually paired, but the anterior ovary, when present, is invariably short and rudimentary...; posterior ovary well developed..." Loos' illustration, however, shows

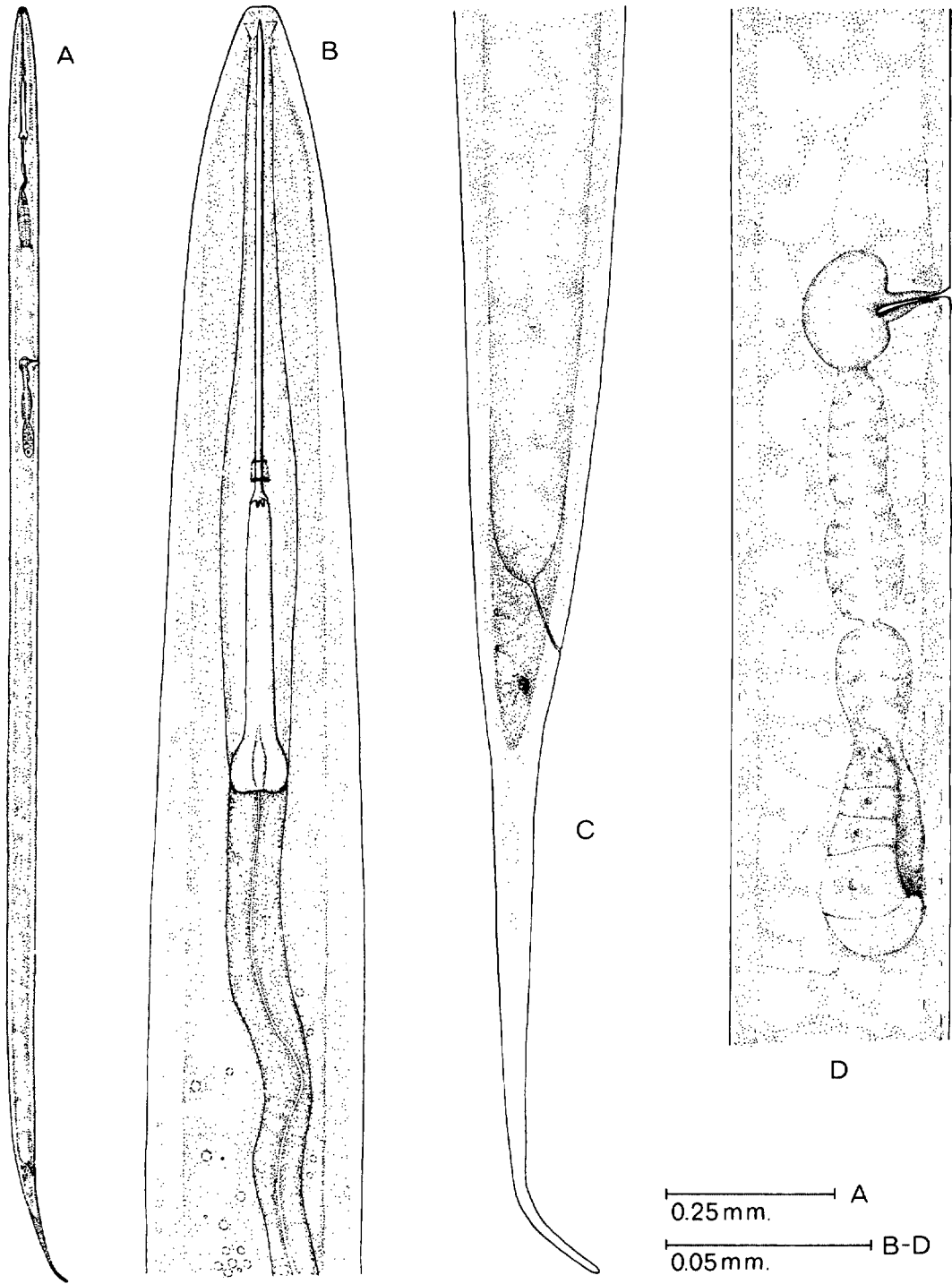


FIG. 5. *Xiphinema orthotenum* n. sp. A. Adult female. B. Anterior end of female. C. Posterior end of female. D. Female reproductive system.

no anterior ovary at all, but rather a uterine sac; clearly Loos was misusing the term "ovary" for "gonad," and his specimens had a gonad structure corresponding to our designated "B" type (Fig. 1). We have been able to confirm this by examining the material used by Loos.

Carvalho, in reporting *X. ensiculiferum* from Brazil in 1955 (3), describes "ovário duplo, mas o anterior é quase sempre curte e rudimentar..." From his illustration, it is not clear whether or not the anterior gonad has an ovary. However, his population differs from the type population in having a more posteriorly situated vulva (38-43% compared with 34% in the type), suggesting the possible existence of an anterior ovary. In this character and in a longer spear and more rounded tail, his population differs from the Ceylon specimens.

Williams neither illustrated nor described the gonad structure of *X. ensiculiferum* from Mauritius (45), but gave a vulva position of 32%; in this and in the tail shape of the female which is slightly longer and less rounded than that of the type, his specimens resemble the Ceylon population.

In his diagnosis of *X. krugi*, Lordello in 1955 (23) acknowledges the similarity of his species with *X. ensiculiferum*, "...especially the population studied by Loos (1949)." However, in justifying the erection of his new species, he reports "...differences in the shape of the tail (subconoid in *X. krugi* and rounded in *X. ensiculiferum*) and in the organization of the reproductive apparatus (*X. krugi* has two ovaries and *X. ensiculiferum* only one)..." From the description and the illustration, it is clear that Lordello, too, has misused "ovary" for "gonad" when he described *X. krugi* as having two ovaries, "...the posterior one being normal and well developed, and the anterior one being much reduced and very obscure ... not a functional ovary, but rather in process of disappearance." His illustration shows a uterine sac as an anterior gonad and clearly fits our "B" type. Furthermore, the tail shape in the female and larvae of *X. krugi* are almost identical to that of the Ceylon population, being longer and more conical than the type of *X. ensiculiferum*. The great similarity of *X. krugi* to Loos' material from Ceylon was recognized by Andrassy in 1960 (1).

In 1961, Luc redescribed *X. ensiculiferum* and erected a neotype from a population from the Ivory Coast (25). His specimens, however, have two gonads complete with ovaries (type

"C" - see Fig. 1), the anterior gonad being shorter than the posterior one (172-232 μ : 292-660 μ). Moreover, the vulva position is somewhat more posterior (V = 34% in the type, 36-39% in Luc's specimens), but the hemispherical shape and size of the tail fit the original description. In these characters, and in the longer spear length, the West African population comes close to the population described by Carvalho from Brazil. In discussing the discrepancy between his population and the original type, Luc maintains that Cobb's figure is that of an immature female, in which case the structure and even the existence of an anterior gonad could well have been overlooked. It seems to us highly unlikely that either Cobb, or Thorne in his amended description could have overlooked an anterior gonad with a visible ovary, simply because it is smaller in size than the posterior gonad. Indeed, on the same page in his publication, Thorne (43) presents a description of *X. truncatum* with an "anterior female sexual branch shorter than posterior." Luc's neotype, therefore, can be considered invalid since it does not fulfill two important conditions of the International Code of Zoological Nomenclature (16): his material is not "consistent with what is known of the original type-material, from its description and from other sources" (Article 75c4) and does not "come as nearly as practicable from the original type-locality..." (Article 75c5).

From the material studied by us, it is clear that *X. ensiculiferum sensu lato* contains three separate species, differing primarily in their gonad structure (types "A", "B" and "C"), but also in tail shape and spear length. All three species occur in countries with a tropical or semitropical climate and the differences are consistent. One population, which was collected in Hawaii, is the most consistent with what is known about the type material of *X. ensiculiferum* (single gonad [type "A"]; hemispherical tail), and comes from a location near to the type locality (it is known that there has been considerable interchange of plant material, including banana - the type host - between Fiji and Hawaii). We cannot, however, be certain since the slide supposedly with type material, supplied to us by A. M. Golden from the USDA collection at Beltsville, Md. did not contain any specimens of *X. ensiculiferum*; the type material, therefore, is considered lost. Thus, in the interests of nomenclatural stability, and in view of the fact that an

TABLE 3. Biometrical characters of populations of *Xiphinema ensiculiferoides* n. sp., *X. krugi* and *X. ensiculiferum* from various localities and hosts.^a

| Character | <i>X. ensiculiferoides</i> n. sp. | | | <i>X. krugi</i> | | | | <i>X. ensiculiferum</i> | | | | | |
|-------------------------|--|---------------------------|--|--------------------------------|---------------------------------|----------------------------|----------------------|---|---------------------------------------|----------------------------------|---|--|------------------------------------|
| | Warm Springs, Hawaii Screw Pine ^b | Albay, Philippines Orchid | Piracicaba, Brazil Forest ^c | St. Coombs, Ceylon Easter Lily | Bel Etang, Mauritius Sugar Cane | Belle Glade, Florida Ramie | Oahu, Hawaii Cypress | Sassandra, Ivory Coast <i>Musa acuminata</i> ^e | São Paulo Brazil Unknown ^f | Uvira, Congo Forest ^g | Victoria Falls, Northern Rhodesia Rain Forest | Guayaquil, Ecuador Banana ^h | Ein Gedi, Israel Fern ⁱ |
| n | 14 | 6 | ? | 10 | 2 | 10 | 5 | 7 | 2 | 2 | 10 | 1 | 10 |
| L(mm) | 1.8 (1.6-2.1) | 1.7 (1.5-1.9) | (2.1-2.2) | 1.9 (1.7-2.2) | 2.0 | 1.9 (1.7-2.1) | 1.7 (1.6-1.8) | (1.8-2.4) | (2.1-2.2) | (1.3-1.8) | 1.8 (1.5-2.1) | 2.4 | 1.9 (1.7-2.1) |
| a | 27 (23-31) | 31 (30-34) | (38-44) | 41 (32-51) | 39 | 40 (35-46) | 34 (30-37) | (30-35) | (41-48) | (28-32) | 27 (24-30) | 24 | 32 (28-37) |
| b | 5.0 (4.6-5.8) | 4.3 (3.9-4.6) | (5.2-5.6) | 5.1 (4.5-5.9) | 4.5 | 5.0 (4.2-5.4) | 5.6 (4.9-6.2) | (3.6-6.2) | (4.6-5.1) | (3.4-4.3) | 4.1 (3.6-4.6) | 4.3 | 4.7 (4.2-5.3) |
| c | 93 (85-110) | 79 (67-100) | (66-70) | 74 (65-88) | 60 | 64 (57-82) | 61 (52-63) | (82-113) | 64 | (62-80) | 89 (65-130) | 79 | 79 (67-87) |
| V | 31 (29-32) | 30 (28-32) | (33-34) | 33 (31-35) | 32 | 33 (32-34) | 33 (32-33) | (36-39) | (38-43) | (39-45) | 37 (35-38) | 40 | 36 (34-38) |
| odontostyle (μ) | 140 (115-152) | 140 (136-146) | (116-120) | 117 (111-121) | 113j | 118 (113-128) | 115 (113-118) | (146-168) | | (142-150) | 153 (140-161) | 167 | 148 (130-160) |
| spear extension (μ) | 75 (71-80) | 74 (73-77) | (68-72) | 70 (63-73) | 77j | 73 (68-77) | 66 (57-71) | (81-92) | | (79-82) | 88 (83-93) | 91 | 84 (78-89) |
| total stylet length (μ) | 215 (188-232) | 214 (209-223) | (184-192) | 187 (184-193) | 190j | 191 (185-205) | 181 (170-189) | (227-260) | 215 | (221-232) | 241 (226-248) | 258 | 232 (219-241) |
| c' | 0.5 (0.4-0.6) | 0.6 (0.5-0.7) | 0.9j | 0.8 (0.7-0.9) | 0.9j | 0.9 (0.8-1.0) | 0.9 (0.8-0.9) | (0.5-0.6) | 0.6j | 0.6j | 0.5 (0.4-0.6) | 0.5 | 0.6 (0.5-0.7) |

^aFor tall shapes, see Fig. 7^bType^cType, from Lordello, (23)^dFrom Williams, (45)^eNeotype, from Luc, (25)^fFrom Carvalho, (3)^gFrom Andrassy, (1)^hParatype of *X. macrostylum* (= *X. ensiculiferum*)ⁱThis population contained first-stage juveniles with a long cylindroid process on the tail; since first-stage juveniles were not seen in other populations, it is uncertain whether this is a specific character.^jCalculated from illustration

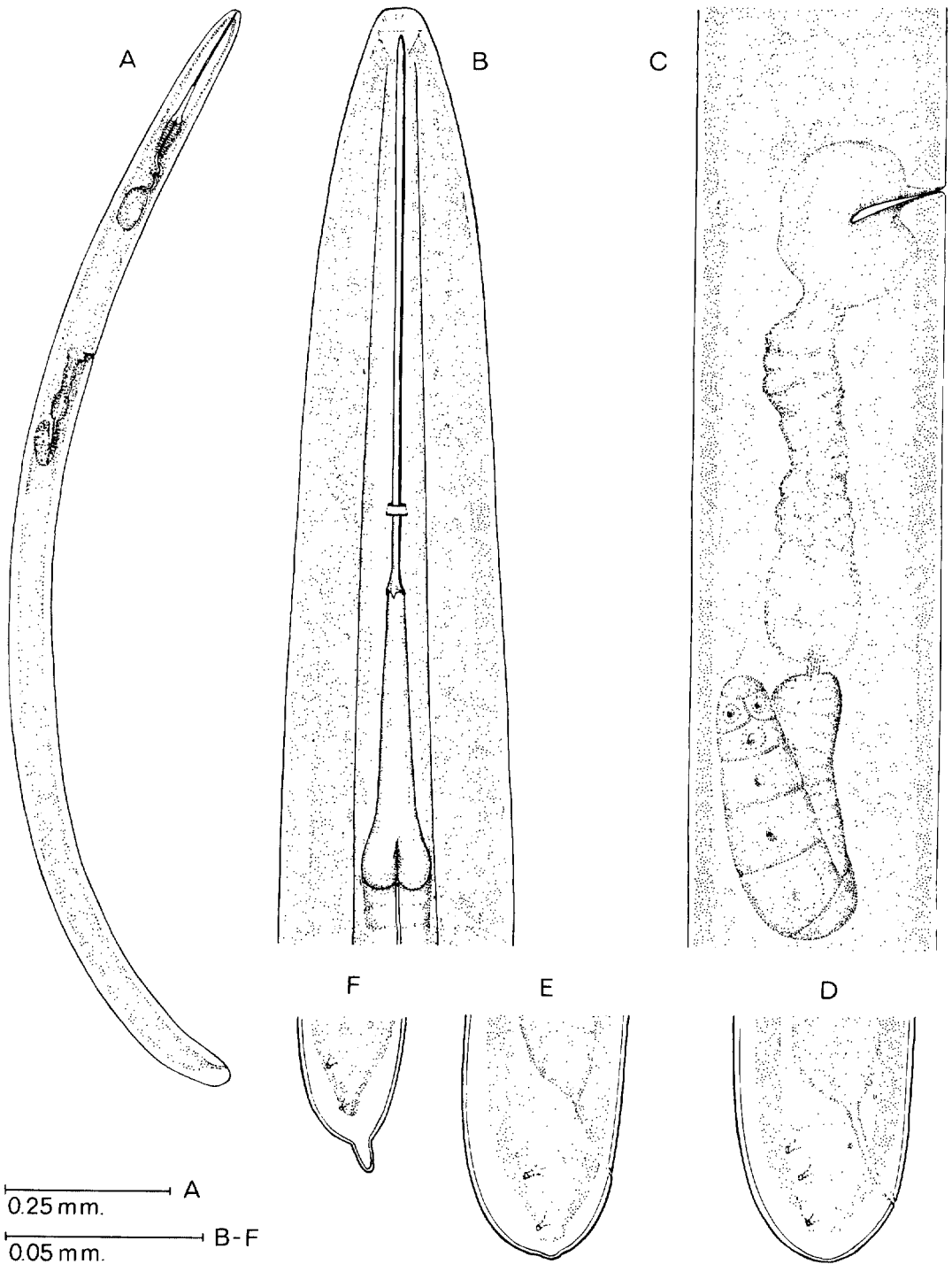


FIG. 6. *Xiphinema ensiculiferoides* n. sp. A. Adult female. B. Anterior end of female. C. Female reproductive system. D. Posterior end of female. E. Posterior end of female from Guinobatan, The Philippines. F. First-stage juvenile.

alternative neotype from the type locality is not available, we propose to retain Luc's neotype of *X. ensiculiferum* despite its inadequacy. *X. ensiculiferum* is defined and discussed in a later section dealing with the didelphic forms. The population from Hawaii with a type "A" gonad is described below as *X. ensiculiferoides* n. sp., and the species with a type "B" gonad and more conoid tail — *X. krugi* — is discussed in the section on the pseudomonodelphic forms. Biometrical characters of several populations of all three species are given in Table 3 and tail shapes of adults and fourth-stage juveniles are compared in Fig. 7.

Xiphinema ensiculiferoides n. sp.
(Fig. 6; 7, A-C)

Measurements: See Table 3.

Holotype: L = 2.0 mm; a = 27; b = 5.3; c = 104; V = 31; odontostyle = 151 μ ; spear extension = 78 μ ; total stylet length = 229 μ ; c' = 0.5. Body only slightly arcuate when relaxed (Fig. 6, A), lip region 15 μ wide, almost confluent with body (Fig. 6, B). Amphid aperture width three-quarters of lip diameter. Cuticle 2-3 μ thick in middle of body, maximum thickness of 6 μ near lip region and 9 μ in caudal region. Spear flanges 20 μ wide. Fixed ring of spear guiding apparatus 140 μ from anterior end. Nerve ring and hemizonid barely visible, situated less than one up to two body widths behind base of spear. Mucro 3 μ long, 245 μ from anterior end. Basal oesophageal bulb short, 87 μ long and 30 μ wide. Oesophago-intestinal valve present. Gonad single, extending posteriorly (Fig. 6, C), 355 μ long. Vagina directed slightly posteriorly, occupying just more than one-third of body width. Uterus simple, nondifferentiated. Rectum 24 μ long, prerectum indistinct. Tail hemispherical, 19 μ long, with three caudal pores (Fig. 6, D).

Paratype females: Some specimens have a larger ovary in relation to other gonad components. Four uterine eggs observed with average measurements of 172 \times 58 μ . Caudal pores 2-3, position variable.

Males: Unknown.

Juveniles: Only seven juveniles occurred in the population, most of them fourth-stage. All except the smallest specimen resembled the adult in general appearance and tail shape. This single specimen, a first or second-stage juvenile (odontostyle = 90 μ ; reserve odontostyle = 115

μ), had a tail with a distinct peg (Fig. 6, F).

Diagnosis: *X. ensiculiferoides* n. sp. is distinct among the monodelphic species of the genus by its hemispherical tail.

Type habitat and locality: Collected by the junior author from soil around roots of screw pine (*Pandanus* sp.), Warm Springs, Hawaii, March, 1953.

Other populations: An additional population, consisting of six females from orchid roots, Guinobatan, Albay, Philippines, was examined. These females differed from the Hawaiian population only in that five of the specimens had a slight protuberance at the tail terminus (Fig. 6, E). The major biometrical characters of this population are given in Table 3. A second population from Hawaii (2 ♀♀, 2 juveniles from soil around sugar cane, Hawi) was identical to the types.

Type material: Holotype and 16 paratypes (8 ♀♀, 8 juveniles) deposited in UCR nematode collection; 8 paratypes (5 ♀♀, 3 juveniles) with Division of Nematology, The Volcani Institute of Agricultural Research, Bet Dagan, Israel; 4 paratypes (2 ♀♀, 2 juveniles) with Nematology Department, Rothamsted Experimental Station, Harpenden, England.

B. PSEUDOMONODELPHIC SPECIES

Xiphinema krugi Lordello, 1955
(Fig. 7, D-F)

= *X. ensiculiferum* in Loos (20)

= ?*X. ensiculiferum* in Williams (45)

The species was adequately described from Brazil (23) and is undoubtedly one of the more common species of *Xiphinema* in the tropical regions of the world. Loos (20) described the only male ever seen so far; this specimen is now deposited in the UCR collection.

Emended diagnosis: *X. krugi* is closest to *X. ensiculiferum* (25) and *X. ensiculiferoides* n. sp., from which it can be separated primarily by the presence of a partial atrophied anterior gonad without an ovary (type "B"). It also differs from these two species in having a slightly longer, less rounded and more conical tail (larger c' value) and a shorter spear (cf. Table 3, Fig. 7).

X. krugi is one of three known pseudomonodelphic species, all of which occur in tropical regions. The other two, both of which have elongated tails and are closely related, are:

1. *X. longicaudatum*: Described from the Ivory

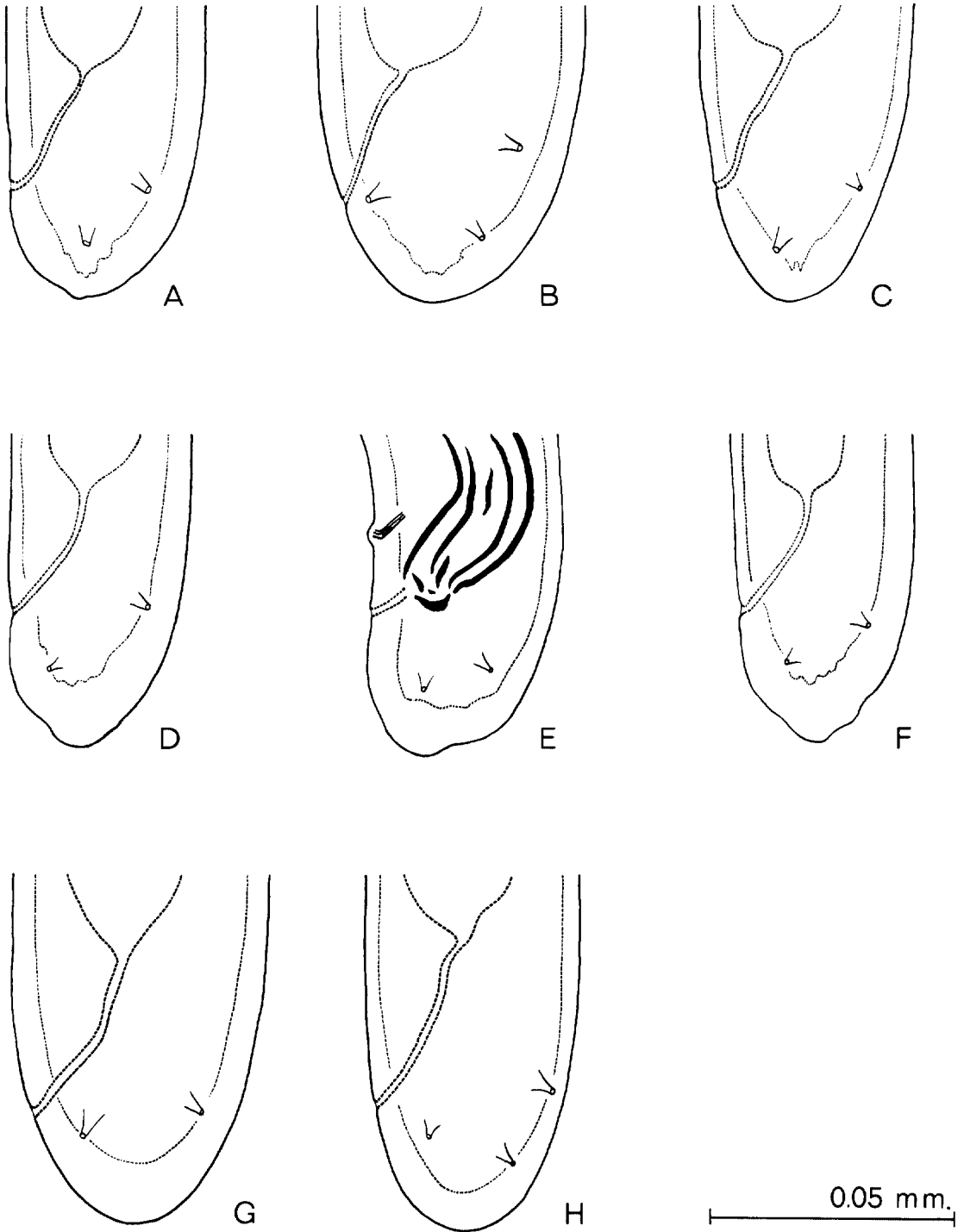


FIG. 7. Tail shapes of *X. ensiculiferoides* n. sp. A. Female, The Philippines. B. Female, paratype. C. Fourth-stage juvenile, paratype. *X. krugi*, Ceylon. D. Female. E. Male. F. Fourth-stage juvenile. *X. ensiculiferum*, Southern Rhodesia. G. Female. H. Fourth-stage juvenile.

Coast (25) and observed by us in samples from several locations in Nigeria and a single population from Ceylon.

2. *X. simillimum*: Described from the Sudan and reported to occur also in the Congo (19).

C. DIDELPHIC SPECIES

Within this group there are four described species: *X. arcum* (17); *X. ensiculiferum* (25); *X. insigne* (20); *X. orbum* (36). They possess a fully formed anterior gonad, which is generally shorter than the posterior gonad; accordingly the vulva position in these species is relatively anterior—30–45%.

Xiphinema ensiculiferum (Cobb, 1893)
Thorne, 1937

(Fig. 7, G-H)

= *X. ensiculiferum* in Luc (25, 26)

= ?*X. ensiculiferum* in Carvalho (3)

= *X. obtusum* in Andr ssy (1)

= *X. macrostylum* Esser, 1966 (10), new synonymy

nec *X. ensiculiferum* in Loos (20)

nec *X. ensiculiferum* in Williams (45)

The description of the neotype population, locality and habitat (*Musa acuminata*, Ivory Coast) can be found in Luc (25). Unfortunately, we could not obtain material from Carvalho for study. His report contains details of two females. From his data, particularly the vulva position and tail shape, these females probably belong to *X. ensiculiferum*, but this can only be determined conclusively, after studying the gonad structure.

The population identified by Andr ssy from the Congo (1) as *X. obtusum*, fits the general description of *X. ensiculiferum* although one of his specimens has a V value of 45. However, from the general morphology, the fully formed anterior gonad, tail shape and spear length, there seems little doubt that we are dealing with the same species.

X. macrostylum, which was found in Ecuador also around roots of a banana variety (10) has a somewhat higher V value than the neotype population of *X. ensiculiferum* (average 43 compared with 36–39) and higher spear length range (257–294 μ :227–260 μ). However, there is slight overlapping in both characters. Moreover, the variability of *X. macrostylum* is naturally greater since its description was based on more than twice the

number of specimens than the neotype of *X. ensiculiferum*. The average c value given for *X. macrostylum* — 48 — is smaller than the range of *X. ensiculiferum*, but Esser's illustration shows a c value of over 70. The single paratype of *X. macrostylum* which we examined, supplied to us by R. P. Esser, had a V value of 40, c value of 79, a total stylet length of 258 μ and could not be separated from other populations of *X. ensiculiferum* (cf. Table 3). Furthermore, the general morphology of the specimen, including the reduced size but morphologically complete anterior gonad (anterior gonad 342 μ , posterior gonad 473 μ), was similar to specimens from other populations examined. We believe that there are no valid differences between the two species and consider *X. macrostylum* a synonym of *X. ensiculiferum*.

Emended diagnosis: *X. ensiculiferum* can be separated from *X. ensiculiferoides* n. sp. and *X. krugi* by the presence of an anterior gonad, complete with ovary. It differs from *X. ensiculiferoides* n. sp. also by having a more posteriorly situated vulva, and from *X. krugi*, by its more rounded tail (smaller c' value) and longer spear length.

Xiphinema italiae Meyl, 1953

(Fig. 8)

= *X. arenarium* Luc & Dalmasso, 1963 (29)

= *X. bulgariense* Stoyanov, 1964, new synonymy

= *X. conurum* Siddiqi, 1964, new synonymy

X. italiae (31) was placed in *species inquirendae* by Luc and Tarjan in 1963 (28) since its description was based partially on juvenile stages, and the type material was lost. The species was resurrected in 1966 by Martelli, Cohn, and Dalmasso (29) who set up a neotype from the original type locality (Ischia, Italy) and described several populations of *X. italiae* from Italy, Israel and southern France.

X. bulgariense was erected before *X. italiae* was redescribed, so that it was ostensibly a valid species when described by Stoyanov (38). The similarity between *X. bulgariense* and *X. italiae* is clear from the published descriptions, which show an overlapping in all major biometrical characters. A single paratype of *X. bulgariense*, kindly supplied to us by A. C. Tarjan, was examined for comparison with *X. italiae*, especially with regard to the morphology of the

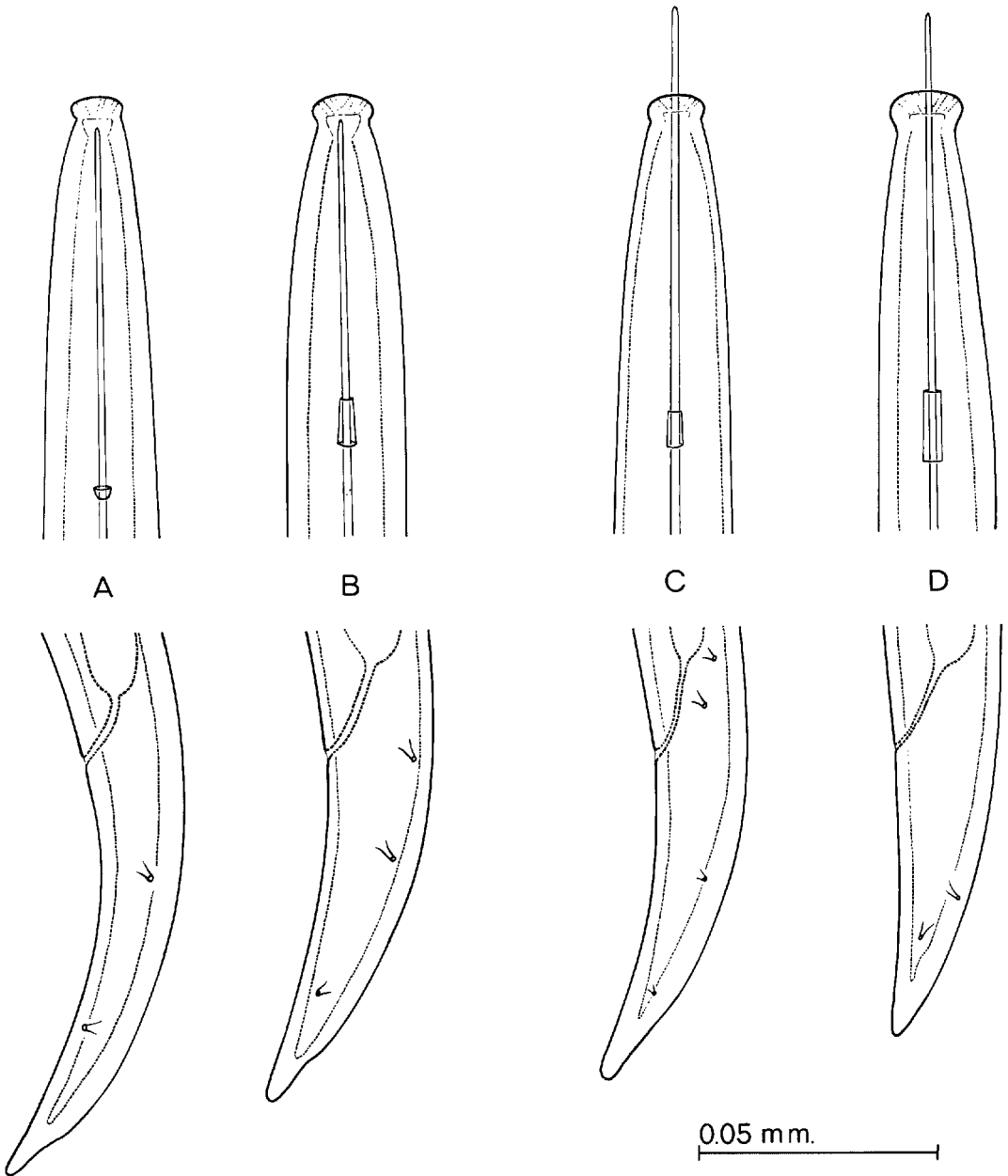


FIG. 8. Anterior and posterior ends of different specimens of females of *X. italiae*. A. *X. bulgariense*, paratype (= *X. italiae*). B. Neotype, Italy [after Martelli *et al.* (29)]. C. France [after Martelli *et al.* (29)]. D. *X. conurum* (= *X. italiae*) [after Siddiqi (37)].

head region and tail shape. These parts of the specimen — the typical knob-like head and the long, almost sub-digitate tail (Fig. 8) — are very reminiscent of some of the Italian populations of *X. italiae* (29), and indeed, of the neotype population of the species. The measurements of this specimen were as follows: L = 2.9 mm; a = 87; b = 7.7; c = 30; V = 43; odontostyle = 93 μ ;

spear extension = 56 μ ; total stylet length = 149; c' = 4.7. All these values — except c', which is only slightly higher — fall within the range of the *X. italiae* populations described from other Mediterranean countries. It is also of interest that *X. bulgariense* was found around virus-diseased grapevine roots in Bulgaria. *X. italiae* is a common parasite of

grapevines in Italy and France (27, 29) and has recently been shown to transmit grapevine fanleaf virus in Israel (7). There seems no doubt that the two species are conspecific, and *X. bulgariense* is considered a junior synonym of *X. italiae*.

X. conurum was described from a single specimen collected around almond roots in Tunisia (37), and its similarity to *X. arenarium* – a synonym of *X. italiae* (29) was admitted by the author himself in a footnote in his paper (37). Martelli, Cohn and Dalmasso concluded that the only differences between *X. conurum* and *X. italiae* are in body length and in the a and c ratios, and regarded *X. conurum* as *species inquirenda* (29). Due to its importance as a pest in the Mediterranean region, many additional specimens of *X. italiae*, particularly from Israeli populations, have been examined by us, a number of them with an a value of up to 115 and a c value of up to 65; moreover, the a range for the Bulgarian population reaches 118, which covers the a value of *X. conurum* (a in *X. conurum* = 117, c = 63). A body measurement of 4.2 mm, as described for *X. conurum*, is indeed rather unusually long but we have measured a body length of 3.9 mm on some specimens from around citrus roots in Israel. Furthermore, it has been shown that body length is extremely variable in this species (29). We feel that there is sufficient evidence that the Tunisian specimen and the populations of *X. italiae* from other Mediterranean countries represent a single species and *X. conurum* is considered a subjective synonym of *X. italiae*.

Xiphinema basiri Siddiqi, 1959

(Fig. 9, A-I)

= *X. ifacolum* Luc, 1961, new synonymy

Considerable similarity is evident between these two species as judged by the original descriptions. A slightly offset head region, a conical sub-digitate tail, similar or overlapping values of L, a, b, c, V and stylet length – all occur in both type populations. Furthermore, both species were described from the rhizosphere of citrus. However, the illustration of the tail in *X. ifacolum* (25) is slightly longer than in *X. basiri* (34) ($c' = 1.6-1.9:1.4$) and the former species is reported to possess a Z organ in the uterus. The resemblance is not mentioned by Luc in his diagnosis for *X. ifacolum*.

The diagnostic value of the Z organ in the

taxonomy of the genus was first pointed out by Luc in 1961 (25, 26), prior to the description of *X. basiri*. As already reported by Loof and Yassin (19), paratypes of *X. basiri* were observed also to possess a Z organ in the uterus, thus eliminating an additional apparent difference between the two species.

Populations studied by us were from Ceylon, India, Mexico, Nigeria and Southern Rhodesia; M. R. Siddiqi kindly lent us eight paratypes of *X. basiri*. This material offered a good opportunity for studying the variability in the group, particularly of the tail structure. The major biometrical characters of the different populations – as well as those of populations studied by other workers – are presented in Table 4. Variation of tail size and shape is illustrated in Fig. 9.

These data clearly indicate that the various populations are inseparable and constitute a single taxon. *X. ifacolum* is, therefore, synonymized with *X. basiri*, the older established species.

Relationship to allied species: *X. basiri* is very close to *X. coxi* which, too, was found around roots of citrus (in Florida), and has been shown to reproduce on potted grapefruit seedlings in the greenhouse (40). This close resemblance was overlooked by Tarjan in his diagnosis for *X. coxi*. In their general morphology, head region, tail shape, presence of Z organ, and most biometrical characters, the two species are virtually indistinguishable. *X. coxi* differs from *X. basiri*, however, in having a slightly more anteriorly placed vulva (40-46%), and generally a longer body (average, 3.6), although there is overlapping in this latter character. Fortunately, *X. coxi* was well described from a sizable population (15 females) so that the lower V value does seem to be a fairly constant character in the species. Two paratypes of *X. coxi*, loaned to us by A. C. Tarjan, had V measurements of 41 and 45. We propose, therefore, to retain the species at this stage, although future investigations may show it to be invalid. The major biometrical characters of *X. coxi* are compared with those of *X. basiri* in Table 4, and the similarity in tail shape is shown in Fig. 9.

Another West African species, *X. ebriense* (24), also shows similarity to *X. basiri* but has a smaller body length (L = 1.9-2.0). The type population of *X. ebriense* has a V value of 42-46, but we have encountered several Nigerian populations with V = 50-55 and a

TABLE 4. Major biometrical characters of *Xiphinema basiri* from different localities and hosts, and of the type population of *X. coxi*^a

| Character | <i>X. basiri</i> | | | | | | | | <i>X. coxi</i> |
|----------------------------------|---|---|---|---|---------------------------|--------------------------------|---------------------------|--|---|
| | Jhansi, India Citrus ^b | Gezira, Sudan Citrus & Rose ^c | Foulaya, Guinea Citrus ^d | Ibadan, Nigeria Elephant Grass | Udaipur, India Soil | Lunuwila, Ceylon Coconut | La Paz, Mexico Soil | Sabi Valley, Southern Rhodesia Sugar Cane | Orsino, Florida Citrus ^e |
| n | 35 | 20 | 10 | 12 | 4 | 3 | 5 | 14 | 15 |
| L(mm) | 3.1 (2.7-3.4) | 3.2 (2.8-3.5) | 3.5 (3.1-3.7) | 3.2 (2.9-3.4) | 3.6 (3.5-3.7) | 3.1 (2.9-3.2) | 3.1 (2.9-3.6) | 2.9 (2.3-3.5) | 3.6 (3.1-4.0) |
| a | 62 (57-72) | 68 (57-77) | (50-62) | 50 (46-55) | 58 (53-63) | 52 (49-55) | 64 (59-75) | 56 (43-70) | 75 (66-82) |
| b | 7.6 (6.4-8.0) | 7.7 (7.0-8.4) | (7.3-11.3) | 7.7 (7.0-8.2) | 8.7 (8.0-9.2) | 8.1 (7.2-9.0) | 9.8 (9.0-10.7) | 8.4 (7.8-9.8) | 8.4 (7.5-9.2) |
| c | 69 (62-80) | 71 (59-82) | (45-59) | 56 (49-54) | 84 (80-87) | 58 (54-62) | 67 (62-75) | 60 (53-73) | 66 (59-82) |
| V | 51 (50-53) | 50 (48-51) | (48-53) | 52 (49-54) | 48 (46-48) | 52 (51-52) | 49 (48-51) | 48 (46-52) | 44 (40-46) |
| length of spicules (μ) | 60 | | 53 | 74 | | | | | |
| total stylet length (μ) | 180 (168-188) | 186 (177-195) | (185-197) | 197 (195-203) | 192 (189-196) | 192 (188-198) | 182 (173-188) | 175 (162-201) | 194 (185-210) |
| c' | 1.5 ^f (1.3-2.0) | (1.2-1.6) | (1.6-1.9) | 1.6 (1.4-1.7) | 1.3 (1.2-1.4) | 1.6 (1.5-1.6) | 1.6 (1.5-1.7) | 1.6 (1.4-1.7) | 1.8 (1.5-2.0) |

^aFor corresponding tail shapes, see Fig. 9^bType, from Siddiqi (34)^cFrom Loof & Yassin (19)^dType, *X. ifacolum* (= *X. basiri*), from Luc (25)^eType, from Tarjan (40)^fMeasured on eight paratypes

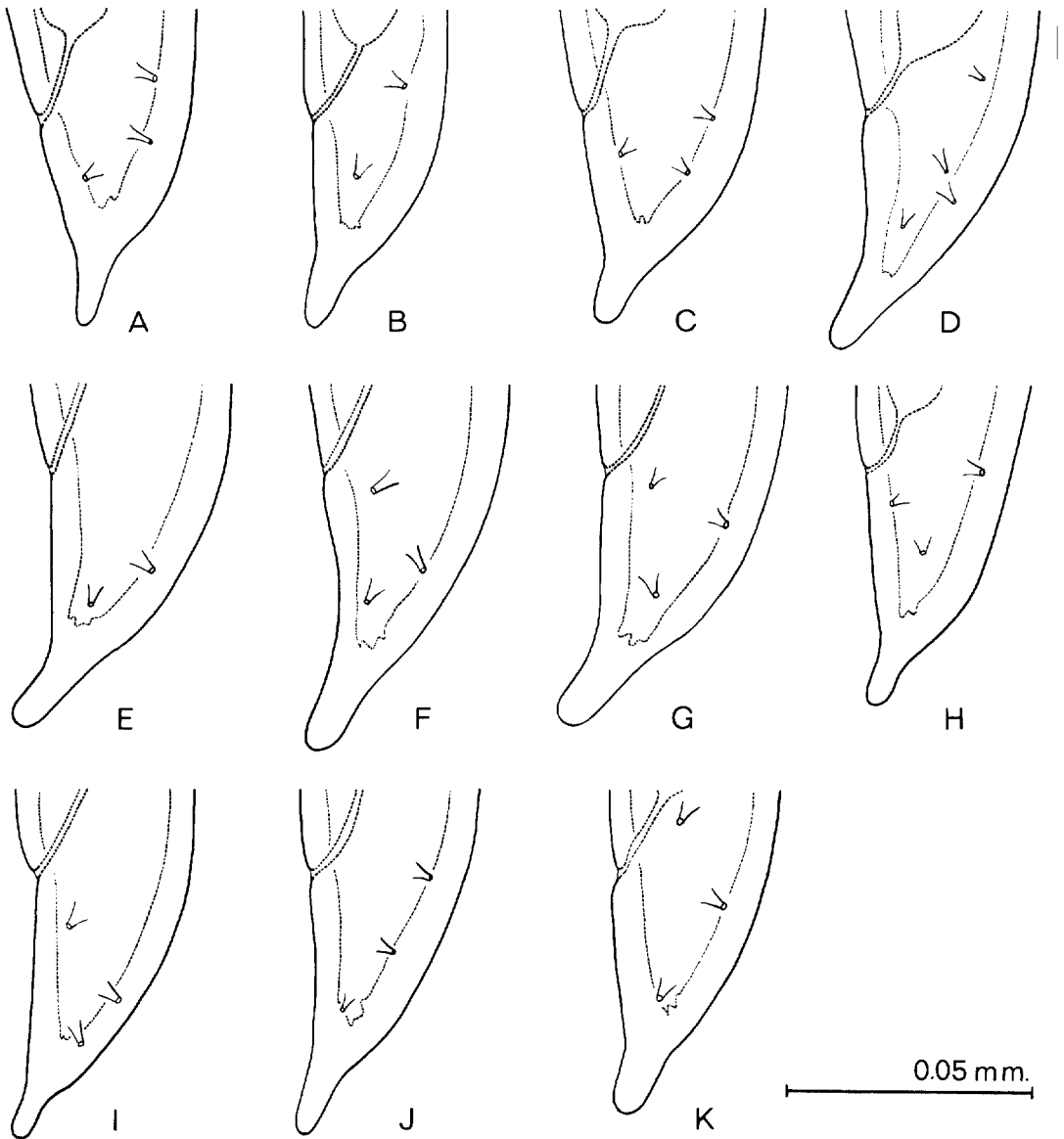


FIG. 9. Tail shapes of *X. basiri* and *X. coxi*. A-L. *X. basiri*: A, B. Paratypes; C. Udaipur, India; D. *X. ifacolum* (= *X. basiri*), Guinea [after Luc (25)]; E, F. Nigeria; G. Ceylon; H. Mexico; I. Southern Rhodesia; J, K. *X. coxi*, paratypes.

slightly longer stylet. The variability within this species and its true relationship to *X. basiri* need closer study.

Xiphinema elongatum Schuurmans
Stekhoven & Teunissen, 1938

(Fig. 10)

= *X. campinense* Lordello, 1951 (22)

= *X. pratense* Loos, 1949 (20)

= *X. truncatum* Thorne, 1939, new
synonymy

X. truncatum was described by Thorne from one male and four females collected "from soil about pineapple roots ... on the Island of Hawaii" (43). The species was considered distinctive primarily because of "the uniform tapering of the neck to the continuous truncate head and the elongate-conoid tail." To the best of our knowledge, *X. truncatum* has been reported only on one other occasion from around roots of sugar cane in Hawaii by

Holtzmann (14). The identification was made by Chitwood, but the specimen is not available and is apparently lost (Holtzmann, *in litt.*).

In a later paper, Holtzmann (15) reported two other species of *Xiphinema* occurring on sugar cane in Hawaii — *X. elongatum* and *X. insigne*. *X. elongatum* (under its synonym, *X. pratense* Loos, 1949) has, in fact, been reported on sugar cane also in Mauritius (45), and is considered to be one of the major nematode parasites of sugar cane in Queensland, Australia (14). This species is morphologically very similar to *X. truncatum*, having also an elongate-conoid tail, as described by Thorne, but lacking the truncate head. Since its description was published in 1938 (32), Thorne did not include it in his review of the Dorylaimoidea in 1939 (43), and was probably not aware of its existence at that time. Moreover, the drawings and description of *X. elongatum* are extremely meagre and inaccurate (32), and the species was redescribed from the holotype by Tarjan and Luc in 1963 (41), who also designated *X. pratense* and *X. campinense* as its junior synonyms.

Through the cooperation of A. M. Golden, the slide containing the type specimens of *X. truncatum* was made available to us for study. However, only the male was present on the slide, and the four original females are apparently lost. Unfortunately the tail tip of the male was broken, but we were able to observe clearly the anterior part of its body (Fig. 10, A). No outstanding differences were observed between *X. elongatum* specimens from Hawaii and Thailand (Fig. 10, B-C) and it is likely that the uniform tapering of the neck, described and illustrated by Thorne, was probably an artifact on a specimen under surface pressure.

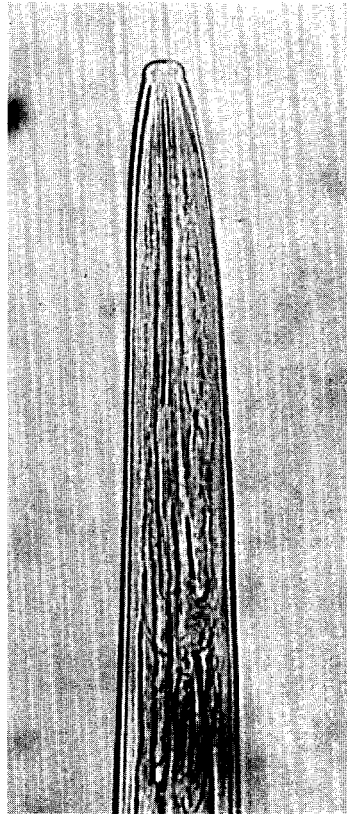
In all major biometric characters, with the exception of V (33 in *X. truncatum*; 40 in *X. elongatum*), there is complete agreement between the two species (Table 5). We, therefore, studied some nematode populations collected on the Island of Hawaii by the junior author and some additional material from three other Hawaiian Islands (Kauai, Maui and Oahu), kindly supplied by O. V. Holtzmann, University of Hawaii. Seven different populations, from all four islands, tallied entirely with *X. elongatum* including tail shape, c' and V (Table 5). One specimen from Lihue, Kauai, with a vulva position of 30%, was definitely *X. insigne*, bearing a long (c' = 4.5) tail, quite unlike that

TABLE 5. Major biometrical characters of *Xiphinema elongatum* from Hawaii and of the holotype.

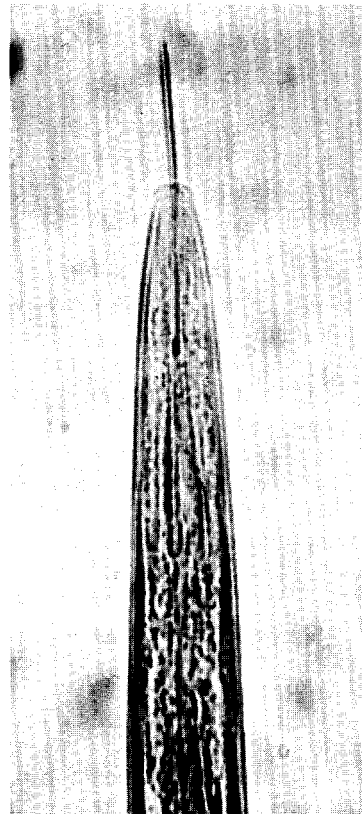
| | L (mm) | a | b | c | V | odontostyle (μ) | spear (μ) | total stylet length (μ) | c' |
|--|------------------|-------------------------------|---|---------------|---------------|-------------------------------------|---|----------------------------|------------------|
| Male, <i>X. truncatum</i> (= <i>X. elongatum</i>) Hawaii (type) ^a | 2.4 | 57 | 5.6 | 56 | | 92 | 64 | 156 | 1.6 |
| Female, <i>X. truncatum</i> (= <i>X. elongatum</i>) Hawaii (type) ^b | 2.5 | 50 | 7.1 | 39 | 33 | 95 | 68 | 164 | 2.9 ^e |
| <i>X. elongatum</i> Hawaii ^c | 2.2 (2.0-2.4) | 53 (40-63) | 6.6 (5.9-7.2) | 36 (33-40) | 38 (37-40) | 95 (90-100) | 59 (56-61) | 154 (150-160) | 2.7 (2.1-2.9) |
| <i>X. elongatum</i> Rutshuru, Congo (holotype) ^d | 2.1 | 49 | 6.1 | 35 | 40 | 94 | 59 | 153 | 2.5 |
| ^a Our measurements | | ^b From Thorne (43) | ^c N=16, from 6 different populations | | | ^d From Tarjan & Luc (41) | ^e Calculated from illustration | | |



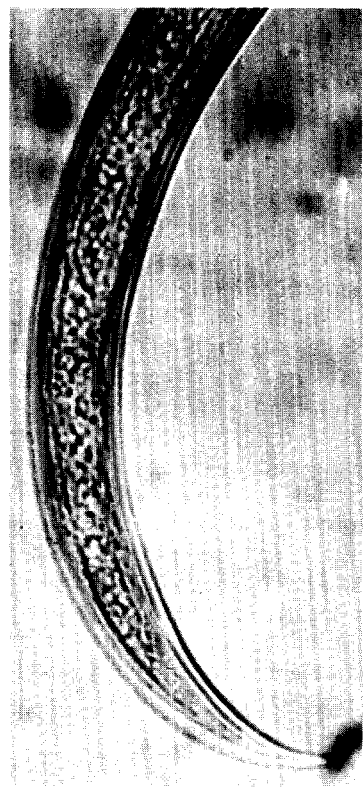
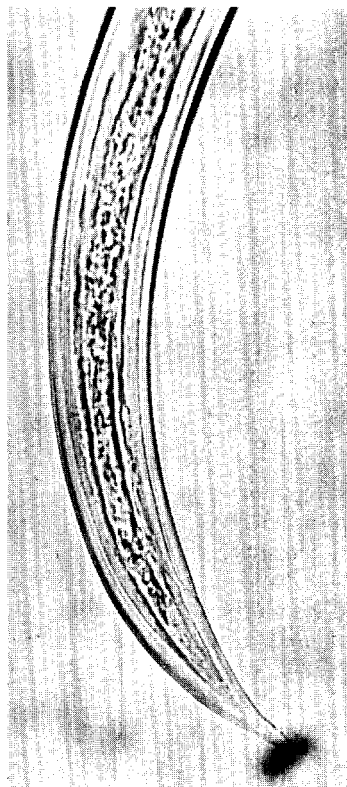
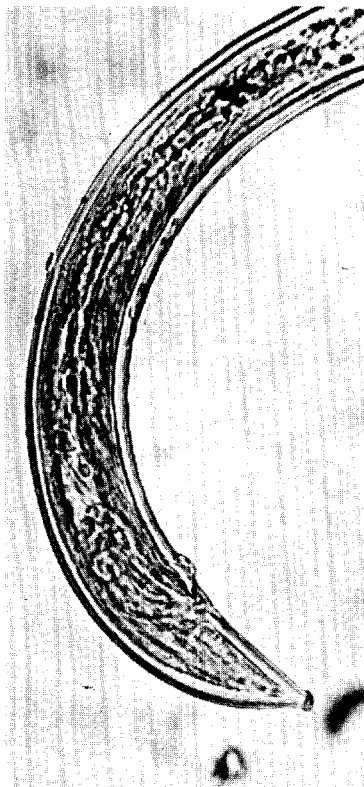
A



B



C



of *X. truncatum*. Since only a single set of measurements for *X. truncatum* was given by Thorne (43), it is possible that the specimen measured with a vulva position of 33% was exceptional, or, more likely, the result of an error in measurement or print. We feel that the foregoing information strongly indicates the conspecificity of *X. truncatum* with *X. elongatum* and regard *X. truncatum* as identical with and a synonym of *X. elongatum*.

Relationship to allied species: *X. elongatum* shows considerable resemblance to *X. insigne* as redescribed by Tarjan and Luc (41). Essentially the two species differ in only two characters: *X. insigne* has a more anteriorly situated vulva (about 30%:40% in *X. elongatum*), and a longer, though fairly similarly shaped tail (c = about 20:35, c' = about 4.5:2.3). The differences in these biometric dimensions between the two species are thus not much greater than the degree of geographical variation sometimes found within a single species [e.g., c' range in *X. italiae*, deduced from populations occurring in five Mediterranean countries is 2.1-4.7 (29)]. Furthermore, the two species often share a common habitat, occurring in similar geographical regions and around roots of the same host type (e.g., grasses in Ceylon, sugar cane in the Philippines and Hawaii, citrus and avocado in Israel), sometimes even in mixed populations. Nevertheless, the differences in the two characters — V and tail length — are consistent and the species seem to be separable on this basis in each environment. We encountered populations of both *X. elongatum* and *X. insigne* from several countries, and present their V, c, and c' values in Table 6. The number of specimens measured in each case (n) is omitted from the table for the sake of clarity, but 3-15 specimens were selected at random from each population.

We, therefore, regard *X. elongatum* and *X. insigne* as possible sibling species, but valid taxa.

Xiphinema setariae Luc, 1958

(Fig. 11)

= *X. vulgare* Tarjan, 1964, new synonymy

Tarjan recognized the close resemblance between *X. vulgare* and *X. setariae* and

consequently did some comparative work on specimens from the type populations of the two species (40). He differentiates *X. vulgare* from *X. setariae* by its shorter, thinner body, shorter odontostyle in relation to the basal portion of the stylet, and less pronounced digitate portion to the tail. However, in his own measurements of the two populations, there is overlapping in both L and a values, and in the odontostyle, spear extension and total stylet lengths (40) (Table 1). If, to these measurements, are added those given by Luc of the type population of *X. setariae* (24), the three populations are totally inseparable on the basis of these characters (Table 7).

The tail length of *X. vulgare* is indeed slightly shorter than that of the type of *X. setariae*, but this difference is so small that it can be considered a geographical variation (a 2 μ margin separates the ranges in Tarjan's measurements of specimens of the two species). Moreover, tail length in itself is not of diagnostic importance, if it is not related to body length and anal body diameter, and the c and c' values of the two species are similar and certainly overlap (Table 7).

From our investigations, it appears that the degree of digitation in the tail is not as constant as Tarjan suggested, but varies as in the populations we studied from Nigeria and Panama (Fig. 11, E-H). Tarjan kindly provided us with four paratypes of *X. vulgare* for comparison (Fig. 11, A-B).

It is our view that there are no consistent and valid differences between the two species and we consider *X. vulgare* a synonym of *X. setariae*.

Xiphinema yapoense Luc, 1958 -
species inquirenda

X. yapoense was described from a single female found around roots of *Dryetes mutikoro* in a forest at Yapo, Ivory Coast (24). The specimen was justifiably considered to constitute a distinctly separate taxon at the time since it was then the only known species in the genus with a hemispherical tail other than *X. obtusum*, which had been reported to be much smaller (0.8 mm:3 mm). To the best of our knowledge it has not been reported elsewhere since its description, but a number of

FIG. 10. Anterior and posterior ends of different specimens of *X. elongatum*. A. Male, *X. truncatum* (= *X. elongatum*), Hawaii. B. Female, Thailand. C. Female, Hawaii.

TABLE 6. Three biometrical characters (V, c, c') of populations of *Xiphinema elongatum* and *X. insigne*, occurring in six different countries.

| Populations | V | | c | | c' | |
|--------------------|-------------------|----------------------|-------------------|----------------------|-------------------|--------------------------|
| | <i>X. insigne</i> | <i>X. elongatum</i> | <i>X. insigne</i> | <i>X. elongatum</i> | <i>X. insigne</i> | <i>X. elongatum</i> |
| Types ^a | 30 | 40 | 20 | 35 | 4.4 ^b | 2.5 ^c |
| Philippines | 32 (31-33) | 37 (36-39) | 20 (20-21) | 36 (35-38) | 5.4 (5.2-5.5) | 2.8 (2.6-2.9) |
| Ceylon | 30 (29-31) | 39 (38-41) | 20 (17-22) | 38 (32-42) | 4.9 (4.2-5.7) | 2.0 (1.8-2.2) |
| Israel | 29 (28-30) | 40 (38-41) | 23 (22-25) | 32 (30-34) | 4.2 (3.7-4.4) | 2.7 (2.6-2.8) |
| Thailand | 31 (28-33) | 39 (37-41) | 22 (21-23) | 35 (32-38) | 4.4 (4.2-4.8) | 2.5 (2.0-2.8) |
| India | 32 (32-33) | (40-44) ^c | 29 (25-33) | (35-46) ^c | 3.8 (3.5-4.4) | (2.0-2.7) ^{b,c} |
| Hawaii | 30 (29-30) | 38 (37-40) | 26 (25-27) | 36 (33-40) | 4.5 (4.3-4.6) | 2.7 (2.1-2.9) |

^aFrom Tarjan & Luc (41)^bCalculated from illustration^cMeasurements of *X. pratense* (= *X. elongatum*) from Siddiqi (35)TABLE 7. Major biometrical characters of *Xiphinema setariae*.

| | Host and Locality | | |
|----------------------------|---|---|---|
| | Citrus, Lake Alfred, Florida ^a | <i>Setaria megaphylla</i> , Adiopodoume, Ivory Coast ^b | <i>Setaria megaphylla</i> , Adiopodoume, Ivory Coast ^c |
| n | 12 | 13 | ? |
| L(mm) | 2.7 (2.4-2.8) | 3.0 (2.8-3.2) | (2.7-2.9) |
| a | 56 (52-61) | 64 (60-67) | (50-55) |
| b | 7.2 (6.7-8.0) | 7.2 (6.6-8.1) | (6.0-6.9) |
| c | 53 (48-58) | 51 (46-54) | (42-47) |
| V (%) | 39 (37-40) | 37 (35-39) | (35-39) |
| odontostyle (μ) | 109 (104-120) | 120 (110-130) | |
| spear extension (μ) | 72 (67-78) | 70 (64-82) | (72-77) |
| total stylet length (μ) | 181 (175-193) | 190 (183-200) | (192-199) |
| c' | 1.8 (1.7-2.0) | 2.1 (1.9-2.3) | 1.9 ^d |

^aType of *X. vulgare* (= *X. setariae*) from Tarjan (40)^bType, from Tarjan (40)^cType, from Luc (24)^dCalculated from illustration

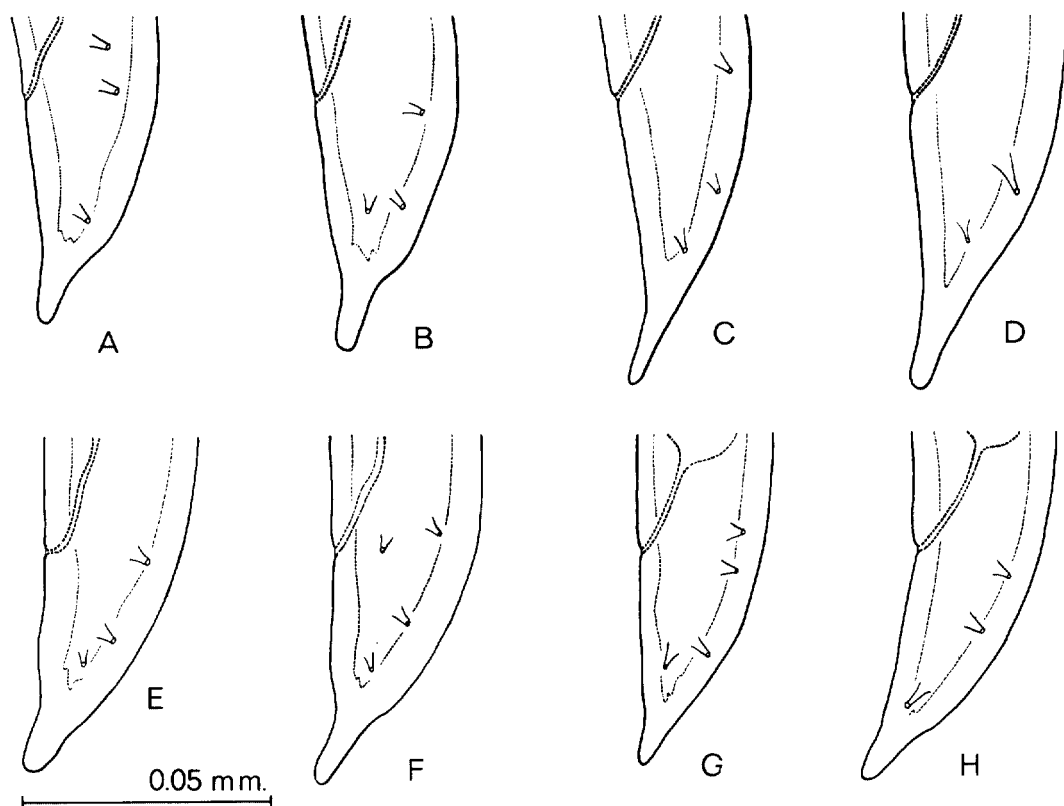


FIG. 11. Tail shapes of *X. setariae*. A, B. *X. vulgare* (= *X. setariae*), paratypes, Florida, USA. C. Paratype (after Tarjan). D. Holotype (after Luc). E, F. Panama. G, H. Nigeria.

closely related species have in the meantime been described or redescribed from other African countries and the Mediterranean region. The relationship of *X. yapoense* to these more recently described species cannot be determined to an adequate degree of confidence due to the lack of information on its variability range. Unfortunately, we were unable to obtain the holotype of *X. yapoense* for observation, but in addition to Luc's published description, we also had access to drawings and measurements of the holotype made by A. C. Tarjan. The lone specimen of *X. yapoense* is similar in many respects to at least seven nominal species of *Xiphinema* (*X. clavatum*, *X. ensiculiferum*, *X. mammillatum*, *X. neovuittenezi*, *X. pini*, *X. rotundatum* and *X. turcicum*). It shows a slight deviation from these species in one or more of the following characters:

(a) The biometrical characters L, V and stylet length. These characters are naturally variable within populations and it is impossible to know whether there is actual overlapping in

range between *X. yapoense* and some of the other species.

(b) Tail shape. The differences in tail shape between all the abovementioned species are very slight. This character, too, cannot be determined accurately for populations on the basis of a single specimen, since we now know that populations of species with tails which typically bear a protuberance, or even a distinct peg, may also contain individuals with fully rounded tails.

(c) Absence of Z organ and males. Both characters cannot be identified with confidence on a single specimen. In this particular case there is additional doubt because a spermatheca with rounded spermatozooids is reported in the gonad of *X. yapoense* (24) and it would be necessary to examine more than one specimen to distinguish such an organ from a Z organ.

For these reasons we think that *X. yapoense* should be considered *species inquirenda* until additional specimens from the type locality are studied and the variability range of the species can be reliably established.

Status of *X. obtusum* Thorne, 1939
(= *X. obtusum* Cobb, unpublished
in Thorne, 1939)

The description of *X. obtusum*, found in soil about roots of lemon trees in Oxnard, California, was based on a single juvenile specimen with a hemispherical tail (43). Nevertheless, Thorne refers to the number of ovaries in the specimen as being "probably two," and in his diagnosis separates the new species from its nearest relative, *X. ensiculiferum*, because of its "much smaller size and double ovaries." Although Andrassy (1) described two specimens from the Congo in 1960 as females of *X. obtusum*, the species was justifiably considered as *species inquirenda* in 1963 by Luc and Tarjan (28) and by Sturhan (39). As mentioned earlier, the characters of Andrassy's specimens from the Congo agree in general with those of *X. ensiculiferum*.

No type material of *X. obtusum* is known to exist (Golden, *in litt.*). Among the fixed specimens of *Xiphinema* originating from soil around lemon roots from Oxnard in the UCR nematode collection, no specimens fitting Thorne's description for *X. obtusum* were found. Additional soil samples were taken from five 40-year-old lemon orchards in Oxnard, all differing in soil texture. The nematode fauna in these samples included many specimens of *X. americanum* Cobb, 1913, identical to the specimens handled by Cobb from lemon trees in Oxnard and considered by Lima (18) to constitute a separate species; we have found this nematode to be the predominant *Xiphinema* species in southern California. However, no adults or juveniles of a *Xiphinema* species with a hemispherical tail, as described by Thorne for *X. obtusum*, were found.

That *X. obtusum* has never been observed, since its description, in a region which has been amply surveyed for plant parasitic nematodes over the years, and because the identity of this species, which could not be determined previously due to insufficient data (28, 39), causes us to consider *X. obtusum* a *nomen dubium*.

DISCUSSION

The growing awareness of the economic importance of nematodes belonging to the genus *Xiphinema* — particularly since the discovery in 1958 of their capacity to transmit viruses in plants (13) — has led to the naming of many new species, differing only slightly from

described forms. As is the case with other nematode genera, the taxonomy of *Xiphinema* is at present based almost entirely on morphological and morphometric criteria. Upon studying the species of *Xiphinema*, one cannot but realize that we are approaching a situation in the genus, where the validity of apparently sound morphological and morphometric characters will be questioned, due to an abundance of characters intermediate to existing extremes, creating an uninteruptable gradation. Consequently, it has become increasingly difficult in recent years to identify and separate populations of *Xiphinema*.

Time and conditions have not permitted us to examine critically the morphological interrelationships of all *Xiphinema* species, and the present paper is by no means a review of the entire genus. Indeed, it is not unlikely that a complete review will reveal additional synonymies among current nominal species omitted from our study. We feel, therefore, that more caution should be exerted when describing and naming forms of *Xiphinema* which show only slight morphological variations from the known forms. On the other hand, there is a dire need to acquire more basic information on aspects other than morphology in this group — biology, ecology, host-parasite and virus-vector relationships, physiology, etc. — in order to attain a better understanding of the interrelationships of the various forms and to lay down a more sound basis for their classification.

For purposes of convenience in identification, it might be advantageous at this stage to arrange the large number of existing species into categories based on gross morphological differences; this would eliminate the need for a single lengthy key. We propose, therefore, the following eight groups, arranged primarily according to gonad structure, body size, and tail shapes, as subgenera of *Xiphinema*. As more information on all aspects of their biology becomes available, the natural relationship between these subgenera, as well as the taxonomic status of the species within each subgenus, could be defined with a greater measure of confidence.

Subgenus RADIPHINEMA n. subg.

Diagnosis: *Xiphinema*. Reproductive system monodelphic, vulva position anterior (V =

22-32), Z organ absent. Body short (L = 1.5-2.8 mm). Tail shape variable.

Type species: *Xiphinema radicolica*

Other species: *X. australiae*
X. brasiliense
X. chambersi
X. ensiculiferoides n. sp.
X. monohysterum
X. orthotenum n. sp.

Subgenus KRUGIPHINEMA n. subg.

Diagnosis: *Xiphinema*. Reproductive system pseudomonodelphic, vulva premedian (V = 30-35), Z organ absent. Body short (L = 1.6-2.9 mm). Tail shape variable.

Type species: *Xiphinema krugi*

Other species: *X. longicaudatum*
X. simillimum

Subgenus XIPHINEMA n. subg.

Diagnosis: *Xiphinema*. Reproductive system didelphic, vulva median to postmedian (V = 48-61), Z organ absent. Body short (L = 1.5-2.3 mm). Tail short, conical (c' = 0.8-2.2).

Type species: *Xiphinema americanum*

Other species: *X. brevicolle*
X. mediterraneum
X. opisthohysterum
X. rivesi

Subgenus ELONGIPHINEMA n. subg.

Diagnosis: *Xiphinema*. Reproductive system didelphic, vulva premedian (V = 28-48), Z organ absent. Body medium (L = 2-3.8 mm). Tail elongated (c' = 2.1-4.5).

Type species: *Xiphinema elongatum*

Other species: *X. attorodorum*
X. insigne
X. italiae
X. orbum

Subgenus HALLIPHINEMA n. subg.

Diagnosis: *Xiphinema*. Reproductive system didelphic, vulva median (V = 44-53), Z organ absent. Body medium to long (L = 1.8-5.2 mm). Tail long and thin (c' = 3.0-11.0).

Type species: *Xiphinema hallei*

Other species: *X. dimorphicaudatum*
X. flagellicaudatum
X. nigeriense
X. vanderlinde
X. zulu

Subgenus BASIPHINEMA n. subg.

Diagnosis: *Xiphinema*. Reproductive system didelphic, vulva premedian to median (V = 34-54), Z organ present in about half the species. Body medium to long (L = 2.0-5.0 mm). Tail short and sub-digitate (c' = 1.1-2.3).

Type species: *Xiphinema basiri*

Other species: *X. bakeri*
X. coxi
X. ebriense
X. sahelense
X. setariae

Subgenus ROTUNDIPHINEMA n. subg.

Diagnosis: *Xiphinema*. Reproductive system didelphic, vulva premedian to median (V = 34-54), Z organ present in about half the species. Body length variable (L = 1.8-5.5). Tail short, rounded or with slight median protuberance (c' < 1).

Type species: *Xiphinema rotundatum*

Other species: *X. arcum*
X. clavatum
X. ensiculiferum
X. imitator
X. ingens
X. neovuittenezi
X. pini
X. pyrenaicum
X. turcicum

Subgenus DIVERSIPHINEMA n. subg.

Diagnosis: *Xiphinema*. Reproductive system didelphic, vulva premedian to median (V = 38-55), Z organ absent.² Body medium to long (L = 2.0-5.0 mm). Tail short with distinct peg (c' = 0.7-1.2).

Type species: *Xiphinema diversicaudatum*

Other species: *X. basilgoodeyi*
X. index
X. mammillatum
*X. paulistanum*³
X. vuittenezi

Unplaced species: *X. sandellum* and *X. longidoroides* have characters intermediate

² Presence of a Z organ was reported in some populations of *X. diversicaudatum* from Kent, England (11); however, since these were not from the type locality, their taxonomic position is uncertain.

³ *X. paulistanum* was described as bearing a tail with "a short mammillate peg ... (situated) ... more or less ventrally (5)." The illustration of the female tail, however, does not show a distinct peg. Specimens were inaccessible to us for closer study.

to *Xiphinema* and *Longidorus* and are not included in this classification.

KEY TO THE SUBGENERA OF *XIPHINEMA*

1. Gonad didelphic (V = 28-61%) 3
 Gonad pseudomonodelphic or monodelphic (V = 22-35%) 2
2. Uterus, oviduct and ovary absent in anterior gonad (monodelphic) . . . *Radiphinema* n. subg.
 Uterus and oviduct (or parts) present, ovary absent in anterior gonad (pseudomonodelphic) *Krugiphinema* n. subg.
3. Tail tapering, thin and elongate ($c' = 2.1-11$) 4
 Tail short, conical, rounded or with protuberance or peg ($c' = 0.5-2.3$) 5
4. Vulva premedian (V = 28-48%); tail elongate ($c' = 2.1-4.5$) *Elongiphinema* n. subg.
 Vulva median (V = 44-53); tail long and thin ($c' = 3-11$) *Halliphinema* n. subg.
5. Tail short, conical; body length < 2.4 mm *Xiphinema* n. subg.
 Tail short, rounded or with slight protuberance or peg; body length 1.8-5.5 mm 6
6. Tail sub-digitate, rounded or with slight protuberance; Z organ often present 7
 Tail with distinct peg; Z organ absent *Diversiphinema* n. subg.
7. Tail short, sub-digitate ($c' = 1.1-2.3$) *Basiphinema* n. subg.
 Tail very short, rounded, sometimes with slight protuberance ($c' < 1$) . *Rotundiphinema* n. subg.

LITERATURE CITED

1. ANDRÁSSY, I. 1960. Zwei bemerkenswerte Nematoden-Arten aus Belgisch Kongo. *Opuscula Zool.*, (Budapest) 3:101-110.
2. BROWN, R. H. 1967. *Xiphinema monohysterum* n. sp. (Nematoda: Dorylaimidae) from Southern New South Wales. *Nematologica* 13:633-637.
3. CARVALHO, J. C. 1955. Plantas ornamentais parasitadas por espécies do gênero *Xiphinema*. *Rev. Inst. Adolfo Lutz, São Paulo* 15:180-185.
4. CARVALHO, J. C. 1962. *Xiphinema itanhaense* n. sp. (Nematoda: Dorylaimidae). *Arq. Inst. Biol., São Paulo* 29:223-225.
5. CARVALHO, J. C. 1965. *Xiphinema paulistanum* uma nova espécie de Nematóide. *Arq. Inst. Biol., São Paulo* 32:77-79.
6. COBB, N. A. 1893. Nematodes, mostly Australian and Fijian. *MacLeay Mem. Vol., Linn. Soc., N.S.W.*:252-308.
7. COHN, E., E. TANNE, and F. E. NITZANY. 1970. *Xiphinema italiae*, a new vector of grapevine fanleaf virus. *Phytopathology* 60:181-182.
8. COOMANS, A. 1964. Structure of the female gonads in members of the Dorylaimina. *Nematologica* 10:601-622.
9. DALMASSO, A. 1969. Etude anatomique et taxonomique des genres *Xiphinema*, *Longidorus* et *Paralongidorus* (Nematoda: Dorylaimidae). *Mem. Mus. Nat. Hist. Natur., Paris, Ser. A, Zool.* 61:33-82.
10. ESSER, R. P. 1966. *Xiphinema macrostylum* n. sp. (Nematoda: Longidoridae). *Proc. Helminthol. Soc. Wash.* 33:162-165.
11. FLEGG, J. J. M. 1966. The Z-organ in *Xiphinema diversicaudatum*. *Nematologica* 12:174.
12. GOODEY, T. 1936. A new dorylaimid nematode, *Xiphinema radicola* n. sp. *J. Helminthol.* 14:69-72.
13. HEWITT, W. B., D. J. RASKI and A. C. GOHEEN. 1958. Nematode vector of soil-borne fanleaf virus of grapevines. *Phytopathology* 48:586-595.
14. HOLTZMANN, O. V. 1964. Nematodes and sugar cane. In: Hughes G. G. *et al.* (eds.) *Sugar Cane Diseases of the World*. Vol. 2 Elsevier Publishing Co., New York. 354 p.
15. HOLTZMANN, O. V. 1968. Plant-nematode associations previously unreported from Hawaii. *Plant Dis. Rep.* 52:515-518.
16. INTERNATIONAL CODE OF ZOOLOGICAL NOMENCLATURE. 1961. Eds.: Stoll, N. R. *et al.* Int. Trust for Zool. Nomenclature, London, 176 p.
17. KHAN, E. 1964. *Longidorus afzali* n. sp. and *Xiphinema arcum* n. sp. (Nematoda: Longidoridae) from India. *Nematologica* 10:313-318.
18. LIMA, M. B. 1965. Studies on species of the genus *Xiphinema* and other nematodes. Ph.D. Thesis presented to University of London. Mimeo. 165 p.
19. LOOF, P. A. A., and A. M. YASSIN. 1970. Three new plant-parasitic nematodes from Sudan, with notes on *Xiphinema basiri* Siddiqi, 1959. *Nematologica* 16:537-546.
20. LOOS, C. A. 1949. Notes on free-living and plant-parasitic nematodes from Ceylon. No. 5. *J. Zool. Soc. India* 1:23-29.
21. LORDELLO, L. G. F. 1951. *Xiphinema brasiliense*, nova espécie de nematóide do Brasil, parasita de *Solanum tuberosum* L. *Bragantia* 11:87-90.
22. LORDELLO, L. G. E. 1951. *Xiphinema campinense*, nova espécie (Nematoda, Dorylaimidae). *Bragantia* 11:313-316.
23. LORDELLO, L. G. E. 1955. *Xiphinema krugi* n. sp. (Nematoda, Dorylaimidae) from Brazil with a key to the species of *Xiphinema*. *Proc. Helminthol. Soc. Wash.* 22:16-21.
24. LUC, M. 1958. *Xiphinema* de l'ouest africain: Description de cinq nouvelles espèces (Nematoda; Dorylaimidae). *Nematologica* 3:57-72.
25. LUC, M. 1961. *Xiphinema* de l'ouest africain (Nematoda-Dorylaimoidea). Deuxième note. *Nematologica* 6:107-122.
26. LUC, M. 1961. Structure de la gonade femelle chez quelques espèces du genre *Xiphinema* Cobb, 1913 (Nematoda-Dorylaimoidea). *Nematologica* 6:144-154.
27. LUC, M., and A. DALMASSO, 1963. Trois nouveaux *Xiphinema* associés à la vigne

- (Nematoda-Dorylaimidae). *Nematologica* 9:531-541.
28. LUC, M., and A. C. TARJAN. 1963. Note systematique sur le genre *Xiphinema* Cobb, 1913 (Nematoda: Dorylaimidae). *Nematologica* 9:111-115.
29. MARTELLI, G. P., E. COHN, and A. DALMASSO. 1966. A redescription of *Xiphinema italiae* Meyl, 1953 and its relationship to *Xiphinema arenarium* Luc et Dalmasso, 1963 and *Xiphinema conurum* Siddiqi, 1964. *Nematologica* 12:183-194.
30. MC LEOD, R. W., and G. T. KHAIR. 1971. *Xiphinema australiae* n. sp., its host range, observations on *X. radicicola* Goodey, 1936 and *X. monohysterum* Brown, 1968 and a key to monodelphic *Xiphinema* spp. (Nematoda: Longidoridae). *Nematologica* 17:58-68.
31. MEYL, A. H. 1953. Beiträge zur Kenntnis der Nematodenfauna vulkanisch erhitzter Biotope. I Mitt., Die Terrikolen Nematoden im Bereich von Fumarolen auf der Insel Ischia. *Z. Morph. Ökol. Tiere* 42:67-116.
32. SCHUURMANS STEKHOVEN, J. H., and R. J. H. TEUNISSEN. 1938. Nématodes libres terrestres. Expl. Parc. Nat. Albert; Mission G. F. De Witte; Inst. Parcs Nat. Congo Belge, Bruxelles 22, 229 p.
33. SHER, S. A. 1968. Plant Parasitic Nematodes: Report to the Government of Thailand. U.N. Development Prog. No. TA2562, FAO, Rome.
34. SIDDIQI, M. R. 1959. Studies on *Xiphinema* spp. (Nematoda: Dorylaimoidea) from Aligarh (North India), with comments on the genus *Longidorus* Micoletzky, 1922. *Proc. Helminthol. Soc. Wash.* 26:151-163.
35. SIDDIQI, M. R. 1961. On *Xiphinema opisthohysterum* n. sp., and *X. pratense* Loos, 1949, two dorylaimid nematodes attacking fruit trees in India. *Z. Parasitenk.* 20:457-465.
36. SIDDIQI, M. R. 1963. Three new species of *Dorylaimoides* Thorne & Swanger, 1936, with a description of *Xiphinema orbum* n. sp. (Nematoda: Dorylaimoidea). *Nematologica* 9:626-634.
37. SIDDIQI, M. R. 1964. *Xiphinema conurum* n. sp. and *Paralongidorus microlaimus* n. sp., with a key to the species of *Paralongidorus* (Nematoda: Longidoridae). *Proc. Helminthol. Soc. Wash.* 31:133-137.
38. STOYANOV, D. 1964. A contribution to the nematode fauna of the grapevine. *Rast. Zasht.* 12:16-24. (In Bulgarian with English summary).
39. STURHAN, D. 1963. Beitrag zur Systematik der Gattung *Xiphinema* Cobb, 1913. *Nematologica* 9:205-214.
40. TARJAN, A. C. 1964. Two new American dagger nematodes (*Xiphinema*: Dorylaimidae) associated with citrus, with comments on the variability of *X. bakeri* Williams, 1961. *Proc. Helminthol. Soc. Wash.* 31:65-76.
41. TARJAN, A. C., and M. LUC. 1963. Observations on *Xiphinema insigne* Loos, 1949 and *Xiphinema elongatum* Schuurmans Stekhoven & Teunissen, 1938 (Nematoda: Dorylaimidae). *Nematologica* 9:163-172.
42. THORNE, G. 1937. Notes on free-living and plant-parasitic nematodes. III. *Proc. Helminthol. Soc. Wash.* 4:16-18.
43. THORNE, G. 1939. A monograph of the nematodes of the super-family Dorylaimoidea. *Capita Zool.* 8:1-261.
44. WEISCHER, B. 1969. Identifying *Xiphinema* species. *Nematology News* No. 16:20-23.
45. WILLIAMS, J. R. 1959. Studies on the nematode soil fauna of sugar cane fields in Mauritius. 3. Dorylaimidae (Dorylaimoidea, Enoplida). *Mauritius Sugar Ind. Res. Inst., Occ. Pap.* 3, 28 p.