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A REVIEW OF THE GENUS *XIPHINEMA* COBB, 1913 WITH DESCRIPTIONS OF SPECIES FROM INDIA

By

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(With 13 Text-figures)

INTRODUCTION

The present work gives an account of the morphology and systematics of *Xiphinema* species. The validity of subgenera and groups proposed by Cohn & Sher (1972), Roy & Gupta (1974) and Southey (1973) has been discussed. The descriptions of all the species of this genus so far recorded from India including first records of monodelphic species and one new species have been provided. It is for the first time that through this work the descriptions of all the Indian species of *Xiphinema* which are scattered in different journals have been brought together. Many of the diagnostic characters proposed in the original publications have been rechecked with the help of additional material comprising several populations from many parts of this country collected over the last several years. The description of each species is followed by a detailed discussion on its relationships, geographical distribution, economic importance, etc. Identification key to the nominal species of the genus *Xiphinema* known from the world has also been provided.

Observations were made on the specimens fixed in hot 4%formalin and processed to anhydrous glycerine by slow method.

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MORPHOLOGY OF *HIPYINEMA*

General Body Shape

The nematode species belonging to the genus *Xiphinema* Cobb, 1913 have long and slender bodies. The two sexes are similar in shape

and are almost of equal size. The body upon fixation may assume a variety of shapes which vary from slightly straight (*X. orthotenum*), or only slightly curved (*X. hygrophilum*) to a closed spiral shape (*X. americanum*), but the majority of the species take up a C-shaped, J-shaped or a loose spiral posture upon death or fixation. The body length ranges from 1.3 mm (*X. lambertii*) to 6.0 mm (*X. ingens*).

Cuticle and Hypodermis

Cuticle is marked with fine striae which can be detected only under very high magnification. The dorsal, ventral and lateral series of body pores are present. While dorsal and ventral pores are usually confined to the anterior end of the body, the laterals are present throughout the body length arranged either in single or double rows. The exact number and location of pores on the tail is very important for taxonomic purposes. The oblique striations, if present, can best be seen on tail, less clearly on the anterior end of the body, and rarely elsewhere. The thickness of the cuticle varies according to the region of the body, it is usually thickest on the tail.

The cuticle of *X. index* has revealed the presence of 8 layers when observed under electron microscope (*cf.* Roggen *et al.*, 1967). All the layers may not be present in all the species of *Xiphinema*, and if present, may not be visible on every region of the body in a particular species.

Hypodermis consists of a thin subcuticular layer and four small anucleate chords (2 laterals, 1 ventral and 1 dorsal). The hypodermis is separated from the cuticle by a cell membrane which forms invaginations penetrating the hypodermis.

Lip Region

The lip region may be continuous with the body (*X. zulu*) or slightly marked off (*X. diversicaudatum*) or may be clearly marked off from the rest of body (*X. opisthohysterum*). These differences are very useful in the identification of species. The contour of lip region may be truncated (*X. insigne/indicum*-form) or smooth (*X. monohysterum*).

The lip region consists of 6 lips of equal size, bearing a papilla each on the inner circlet and a papilla each on the outer circlet. The subdorsals, and subventrals (i.e., the 4 submedian lips) bear an additional papilla each. There are thus in all 16 papillae on the lip region. The papillae are innervated with nerve endings and consist of a number of centrally located nerve processes, most probably the dendrites which are surrounded by a membrane forming highly folded walls. These dendrites extend through a cuticular pore and their naked endings project for a small distance beyond the cuticle forming a papilla (Roggen *et al.*, l. c.).

Amphids are well developed, stirrup-shaped, covering about 1/2 3/5 of the labial-width. The amphidial pouches contain sensillae. The finer structure of sensillae are similar to those of papillae except that the dendrites do not extend beyond the cuticle but remain enclosed in the amphidial pouch.

Feeding Apparatus

The feeding apparatus consists of odontostyle, odontophore, guiding sheath and guiding ring. They are described below.

The odontostyle or spear is well developed, long and attenuated. It develops in a cell located in one of the submedian walls of the anterior slender part of oesophagus. This is formed by a compact cylinder containing acentric tube which communicates with odontophore by a longitudinal slit. The odontostyle is forked at its junction with odontophore. Its length ranges from 58 μm (*X. lambertii*) to 208μm (*X. filicaudatum*) but in majority of the species it is in the range of 100-130 μm.

The odontophore (spear extensions) is equally developed and provided with prominent flanges at the base. This portion which was believed to be a part of stoma (*cf.* Coomans, 1963) has clearly been shown with the help of electron microscopic studies (*cf.* Roggen *et al.*, 1967) to be intra-oesophageal structure formed by an outer cuticular layer of oesophagus and embedded in the oesophageal tissues. The odontophore becomes progressively widera nd the longitudinal lumen running parallel to it assumes a squarish shape in cross section. Its lumen again becomes cylindrical when it joins the oesophageal lumen Along with these changes in the lumen the extensions progressively becomes broader, thicker and triangular until the basal portion divides to form the three flanges.

A cuticularized piece referred to as 'mucro' but resembling the tip of spear and is supposed to represent a vestigeal odontostyle (*cf.* Coomans & De Coninck, 1963) may often be present in one of the submedian walls of oesophagus of the adults as in *X. americanum*, *X. basiri.*

The guiding apparatus is present near the base of the odontostyle and consists of a fixed and a movable ring connected to each other. The position of fixed ring is usually constant for a species and thus is of taxonomic significance. The length of the guiding sheath is variable depending upon the position of the odontostyle. Thei electron microscopic studies by Roggen *et al.* (l. c.) have shown this ring to be formed by the inter-digitation of cuticular walls of stoma with the basement membrane covering the oesophagus and protractor muscles of spear which appear in the form of distinct annulus with electron dense centre

at the base of thick cuticular walls of stoma. Its connection with the guiding sheath is thin and flexible. Anterior to the fixed guiding ring the guiding sheath is double and the surface next to the stomal wall is very much convoluted, but elsewhere it is smooth and fits closely with odontostyle. The guiding sheath becomes gradually thinner posteriorly and eventually fuses with odontostyle.

Digestive Organs

(i) *Oesophagus*: The oesophagus consists of an anterior slender part and a posterior expanded portion which is also known as basal bulb. The anterior part is very long, about 3/5th of the total oesophageal length and remains coiled when the odontostyle is withdrawn but straightens up during its protrusion. The lumen of the anterior par of the oesophageal bulb is rounded as in the slender part, but becomes tripartite behind the orifice of the dorsal oesophageal gland. The walls of the tripartite lumen are thickened, these thickenings disappear just above the oesophago-intestinal junction. Electron microscopic studies by Roggen *et al.* (l. c.) have shown that the lumen of oesophagus is formed by a double layered cuticle. The inner layer is thin and forms a continuous tube extending the entire length of oesophagus and lining the lumen of odontophore as well. It also separates the odontophore from the odontostyle and curves backward forming the guiding sheath and finally ending in an attachment with the guiding ring. The outer second layer of oesophageal lumen forms 6 rows of triangular platelets in the oesophageal bulb surrounding the tripartite lumen.

The oesophageal glands are located in the oesophageal bulb, opening into the oesophageal lumen usually near the gland nuclei. The ramified ducts of the glands run throughout the length of oesophageal bulb. The largest and the most conspicuous is the dorsal gland with its nucleus located near the anterior region of oesophageal bulb and its duct opening in the lumen just before the beginning of the tripartite platelets. There is a single pair of subventral gland nuclei, the second pair is represented only by their orifices. The position of gland nuclei and their orifices is important taxonomically (Loof & Coomans, 1972).

(ii) *Cardia*: It is usually well developed and extends into the anterior region of tubular intestine. It consists of two flaps, surrounding a slit-like aperture.

(iii) *Intestine*: It is sac-like, consisting of 5 or 6 cells in circumference at midbody. The truncated pyramidal cells which form the intestine are irregularly hexagonal at base enclosing a rather narrow lumen. In anterior most part of the intestine these cells are smaller while at intestine-prerectum junction, these cells become larger with irregular and narrow bases. Usually the intestinal lumen is slightly

wider at the ends, i.e., in anterior region and the region preceeding the junction with prerectum.

(iv) *Prerectum*: It is present in all the species and is separated from the intestine by a constriction. The cells of prerectum may or may not be different from those of intestine, thus often making it difficult to delimit the two regions. However, the epithelium of prerectum is usually more flattened.

(v) *Rectum*: It is dorso-ventrally flattened structure separated from the prerectum by a sphincter. The lumen of rectum is cuticularized and opens to the exterior through anus or cloaca as the case may be.

Nerve Ring

It encircles the anterior slender part of oesophagus at about 2/3rd of its length from the anterior end. In some species (*X. index*, *X. diversicaudatum*) there are two nerve rings instead of one, the first one located just posterior to the flanges of the odontophore, and the second one at its usual position (Goodey & Hooper, 1963).

Reproductive System

Although both the sexes occur, but it is only in some species (e.g., *X. diversicaudatum*) that the males are nearly as frequent as females. In species like *X. basiri* and *X. americanum* the males have been recorded only occasionally. Luc (1961) believes that species like *X. attorodorum* are perhaps protandric. The males are so rare in this genus or if present are so small in numbers that they would remain non-functional for the reproductive purposes. It, therefore, appears quite likely that a majority of the species are parthenogenetic.

(*i*) *Female reproductive organs*: The females are either didelphic, or monodelphic or pseudomonodelphic. The latter term was coined by Cohn & Sher (1972) for those species in which a gential branch lacks an ovary though having oviduct, uterus or parts of them. Southey (1973a) rejected this term on the suffix 'delphus' which refers to uterus rather than the gonad. Even in some didelphic species there is a tendency for the reduction of anterior sexual branch. In *X. insigne*, for example, the anterior ovary is very small and its capability of egg production is very much restricted, the uterus and oviduct are normally developed, but in *X. orbum* the entire anterior sexual branch is greatly reduced. *X. cubense* is the only species in which the posterior sexual branch is reduced. Each sexual branch of the female consists of an ovary, oviduct, uterus, vagina and vulva.

Ovary: Ovary is reflexed lying dorsal to the oviduct though occasionally this position may be reversed. A sac-like structure consistings

of spindle-shaped epithelial cells with a sheath of light coloured transversally striated connective tissue is present at the proximal or the reflexed end of the ovary. The ovary is telogonic, i.e., the proliferation of the germ cells takes place only at the apical end of the ovary.

Oviduct: It is subterminally connected to ovary in young females, but in older ones the distance between the proximal end of the ovary and the connection with oviduct is much larger. The lumen of the oviduct is narrow with the walls consisting of epithelial cells.

Sphincter: It divides the oviduct from the next region, i.e., the uterus. The sphincter is prominent in species like *X. basilgoodeyi*, *X. elongatum*, *X. index*, etc., and less so in *X. brevicolle*, etc.

Uterus: The proximal end of the uterus consists of a single layer of flattended or low columnar cells and is surrounded by a muscle layer with circular and oblique fibres. The distal region of uterus is enlarged and its lumen bordered with irregular cells which are glandular in nature. In bisexual species the spermatozoa are stored in the proximal part of the enlarged uterus as in *X. ebriense*, *X. diversicaudatum*, etc. In unfertilized females this region may be either expanded or slightly collapsed. The remaining part of the uterus may look very different in different species. It is usually partly constricted partly dilated, sometimes the entire region is dilated, constrictions usually occur near the vicinity of distal enlarged region.

'Z' *organ*: This structure was first described by Luc (1961) in *X. embriense* and is present at the junction of distal expanded part and proximal enlarged part of uterus. Luc (1975) has differentiated 2 types of 'Z' organs. The first type is the typical 'Z' organ which is usually quite distinct from the other parts of the uterus. It is provided with strong circular muscles and internal sclerotized walls finely striated longitudinally and having in its central lumen sclerotized, refringent apophyses which are well developed and often 4 in number. It is found in *X. embriense*, *X. hallei*, *X. imambaksi*, *X. rotundatum* and *X. manubriatum*. The second type is referred to as 'Z' pseudo organ which is not so distinct from the adjacent parts of uterus. It is provided with weakly developed muscles, sclerotization of uterine wall, is also weak or may be absent as are the longitudinal striations. There are no sclerotized apophyses but granules of various sizes, number, and forms. It has been recorded in *X. basiri*, *X. coxi*, *X. diversicaudatum*, *X. imitator*, *X. ingens*, *X. malagasi*, *X. marsupilami*, *X. parvistylus*, *X. pini*, *X. turcicum*, *X. variable* and *X. zulu*. The 'Z' organ of *X. pini* is interesting as it represents an intermediate condition between the two types with the uterine walls similar to 'Z' pseudo organ, while the internal bodies resembling the apophyses of a typical 'Z' organ.

The species *X. malagasi* and *X. spinuterus* exhibit a peculiar and different structure of uterus. In *X. spinuterus* the cylindrical part of the uterus is thin-walled with spines on the inner side which appear to be implanted on individual cells of the wall and are directed away from the vulva. In *X. malagasi* these spines are present only in the basal part of the 'Z' pseudo organ and on part of the length of the distal cylindrical part.

Vagina: The walls of the vagina are made up of a few cells which are larger in size. The vaginal lumen is lined with cuticle. The vaginal musculature is connected with that of the uterus, but it is usually thicker.

Vulva: This is ventral, usually a transverse slit formed by an invagination of the body cuticle and controlled by a set of muscles.

(ii) *Male reproductive organs*: The male genital branch consists of testis, vas deferens and cloaca.

Testis: The males are diorchic, with both the testes usually lying left to the intestine. Sometimes abnormal males with 1 or 3 testes are also found. One of the testes lies anteriorly, the other one directed posteriorly. The testes are telogonic, i.e., the proliferation of the germ cells takes place at the apical region. Each testis can be subdivided into a proximal germinal and a distal growth zone. The maturation of the sperm takes place at the end of growth zone.

Vas deferens: The testes are connected to each other by vas deferens which is made up of tubular and glandular regions. It is provided with obliquely arranged muscle bands (*X. basilgoodeyi*). The vas deferens is not differentiated into anterior slender and posterior ejaculatory duct. Posteriorly, it joins the intestine to form cloaca.

Cloaca: It is lined with cuticle and opens through the cloacal aperture on the ventral surface of the posterior region of the body.

Besides the primary sex organs described above, the males are also provided with accessary reproductive structures which consist of spicules, supplements, etc.

Spicules: The two spicules are similar in shape and size. The shape of the spicules may differ in the different species. They may be only slightly ventrally curved (*X. americanum*) or ventrally curved with a sharp curvature occurring in the middle (*X. basiri*). The spicules are distinctly cephalated in some species (*X. basiri*). Each spicule is guided in its movement by a set of protractor and retractor spicular muscles. The spicules may be further strengthened by accessary pieces. Lateral guiding pieces are present in *X. clavatum*, *X. pini*, etc.

Supplements: This consists of an adanal pair and a variable number of ventromedian papillae (one in *X. clavatum* three in *X. basilgoodeyi*, four in *X. pini*, eight in *X. mediterraneum*). The supplements may be

very distinct and elevated, and supplied with nerve endings as in *X. basiri* and *X. pini*, or may be rudimentary and indistinct, or reduced to indistinct pores as in *X. clavatum*.

The shape and length of spicules, the number and disposition of ventromedian supplements, the structure of lateral guiding pieces, etc. are fairly useful taxonomic characters in this genus.

Tails

The various species exhibit one of the largest intra-generic variations in length and shape of tail. It may vary from long attenuated tails with c′=10-15 (*X. filicaudatum*) to nearly hemispherical tails with c′=0.6 (*X. hygrophilum*). Its shape varies from long-attenuated (*X. filicaudatum*), long-conical (*X. insigne*), short conical with clavate terminus (*X. luci*), short conical (*X. americanum*), conoid digitate (*X. basiri*), conical rounded with a terminal peg (*X. index*), to regularly hemispherical (*X. arcum*) or rounded spatulate (*X. clavatum*). Inner surface of cuticle and tail tip may also vary. The length and shape of tail is one of the most important taxonomic characters in this genus.

SYSTEMATICS OF *XIPHINEMA*

Systematic Position of Xiphinema

Class NEMATODA
Subclass ADENOPHOREA
Order DORYLAIMIDA (de Man, 1876) Pearse, 1942
Suborder DORYLAIMINA (de Man, 1876) Pearse, 1942
Superfamily DORYLAIMOIDEA Thorne, 1934
Family LONGIDORIDAE (Thorne, 1935) Meyl, 1961
Subfamily XIPHINEMATINAE* Dalmasso, 1969
Genus **Xiphinema** Cobb, 1913

The genus *Xiphinema* was proposed by Cobb (1913) with *X. americanum* as its type species. Thorne (1939) placed this genus in the subfamily Longidorinae Thorne, 1935 along with *Longidorus* (Micoletzky, 1922) Filipjev, 1934 and *Longidorella* Thorne, 1939. Later, a fourth genus *Xiphinemella* Loos, 1950 was also added to this group. Chitwood (1957) synonymised Longidorinae with Tylencholaiminae Filipjev, 1934 owing to the similarities between *Xiphinemella* and *Longidorella* on one hand and the genera of Tylencholaiminae on the other. This synonymy was supported by Clark (1961). However, Meyl (1961) raised Longidorinae to familial rank and this view was as held by Thorne (1961). This family included only one subfamily Longidorinae and three genera, *Longi-*

*Xiphineminae emended

dorus, *Xiphinema* and *Longidorella*. Siddiqi *et al.* (1963) added one more genus *Paralongidorus* to this family. Jairajpuri & A. H. Siddiqi (1964) removed *Longidorella* from this group, placed it along with a new genus *Nordia*, and proposed a new subfamily Nordiinae under Dorylaimidae. Loos (1950) placed *Xiphinemella* in the subfamily Longidorinae, but Chitwood (1957), Clark (1961) and Goodey (1963) placed it in Tylencholaiminae. However, Baker (1962) included it in Longidorinae. Jairajpuri (1964) proposed a new subfamily Xiphinemellinae under the family Leptonchidae Thorne, 1935 for this genus and for *Botalium* Heyns, 1963. Siddiqi & Husain (1968) synonymised Xiphinemellinae with Tylencholaiminae and *Botalium* with *Xiphinemella*. However, Andrassy (1971) has considered Xiphinemellinae as a valid subfamily. Dalmasso (1969) proposed a new subfamily Xiphineminae (=Xiphinematinae emended) with *Xiphinema* as its type and only genus, a view which was upheld by Loof & Coomans (1972) chiefly on the basis of the differences in the positions of oesophageal gland nuclei and their orifices in *Xiphinema* and *Longidorus*/*Paralongidorus*. Very recently, S. H. Khan & Ahmad (1975) have raised Longidoridae to superfamily Longidoroidea with two families Longidoridae and Xiphinemidae (=Xiphinematidae emended), the former including *Longidorus* and *Paralongidorus* and the latter only *Xiphinema*. The proposal of the superfamily and the families seems premature at the moment since in genera like *Xiphinemella* and *Longidorella* the feeding apparatus is fairly similar to that of *Xiphinema* and *Longidorus*. It appears safer and appropriate to wait for further observations and findings in order to recognize Longidoroidea as a valid superfamily and Xiphinematidae as a family.

Diagnosis of Xiphinema

Body long and slender measuring not more than 6 mm. Amphids stirrup-shaped with slit-like apertures. Odontostyle long and attenuated, forked at the junction with odontophore. Odontophore provided with well developed flanges at base. Fixed guiding ring located near the base of odontostyle. Oesophageal bulb with 3 oesophageal gland nuclei, one dorsal and two subventrals, dorsal gland nucleus is larger than subventrals and is located near the orifice. Female genital tract didelphic or monodelphic or pseudomonodelphic, ovaries reflexed, uterus often showing peculiar differentiations. Males usually diorchic. Shape and length of tail very much variable.

Relationships of Xiphinema

Xiphinema is closely related to *Longidorus* (Micoletzky, 1922) Filipjev, 1934 and *Paralongidorus* Siddiqi *et al.*, 1963 but differs in the

shape of amphidial apertures, bifurcation of odontostyle at the junction with odontophore, in the positions of fixed guiding ring and oesophageal gland nuclei and their orifices. These differences are outlined below:

I. Form *Longidorus*.—

i) In having slit-like amphidial apertures,
ii) The odontostyle forked at the junction with odontophore,
iii) The odontophore provided with basal flanges,
iv) The fixed guiding ring located at the base of odontostyle,
v) In having DO and DN closer and DN larger than S_1 VN.

II. From *Paralongidorus*.—

i) The odontophore provided with basal flanges,
ii) The odontostyle forked at the junction with odontophore,
iii) The fixed guiding ring located at the base of odontostyle,
iv) In having DO and DN closer and DN larger than S_1 VN.

Subdivisions of Xiphinema

The genus *Xiphinema* was proposed by Cobb (1913). Goodey (1936), Thorne (1937) and Schuurmans-Stekhoven & Teunissen (1938) described some new species of this genus. Loos (1949) described some species of this genus from Ceylon. However, it was only when Hewitt *et al.* (1958) showed that *X. index* transmits grapevine fanleaf virus that the nematologists became very much interested in the study of this group. Siddiqi (1959, '61 & '64) described some new and some known species from India. Luc (1958, '61, '73 & '75) described many new species from South Africa. Heyns (1965, '66 & '74) also described several new species from South Africa. Tarjan (1964) described two new species from America. Luc & Tarjan (1963) published a note on the systematics of *Xiphinema* in which they included 29 valid and 9 *species inquirendae*. Dalmasso (1969) described *Xiphinema* species of France and put them in 4 groups viz., *X. americanum* group, *X. italiae* group, *X. diversicaudatum* group and *X. basiri* group. He used the following characters for the differentiation of these groups:— Body length, head profile, posture of body upon fixation, tail shape and differentiation of female genital tract. Loof & Maas (1972) described several species of this genus from Surinam and also gave a dichotomus key for the separation of the nominal species.

Cohn & Sher (1972) proposed 8 subgenera under *Xiphinema*, viz., *Xiphinema*, *Radiphinema*, *Krugiphinema*, *Halliphinema*, *Elongiphinema*, *Basiphinema*, *Diversiphinema* and *Rotundiphinema*. The different species were grouped under these subgenera on the basis of the type of genital tract, position of vulva, presence or absence of 'Z' organ, body

length, tail shape and value of c' The subgenera *Radiphinema* and *Krugiphinema* include species which lack either a complete anterior sexual branch or an anterior ovary. These subgenera include species which are short-tailed or long-tailed. The reduction of genital tract and the shortening of tail certainly have phylogenetic value. The regression of genital tract is evident by a line which can be traced from well developed ovaries as in *X. elongatum* to anterior genital branch completely missing as in *X. chambersi.* In between these two extremes we have species like *X. insigne* in which the anterior ovary is occasionally functional and *X. simillimum* having its anterior sexual branch reduced and lacking an ovary. The evolution of short-tailed species from those possessing long-tails is evident by the fact that all the intermediate shapes exist between short hemispheroid to long filiform tails. Also, the juveniles of almost all the species including long-tailed species have longer and thinner tails than their adults. Perhaps it was with this idea that Roy & Gupta (1974) added another new subgenus, *Filliphinema* for those species which have very long tails but were grouped under the subgenus *Krugiphinema.* They, however, included under the new subgenus only those species which have very long tails (c'=6.3-15) and retained all species having c=0.6-3.5 under *Krugiphinema.* Perhaps, it would have been better if they had differentiated the short-tailed species (c'>2.2, e.g., *X. krugi*) from the long-tailed species (c'<2.2, e.g., *X. simillimum*) under *Filliphinema.* If the subgenera are to be based only on the length and shape of tail, yet another subgenus has to be proposed for long-tailed species (e.g., *X. orthotenum*) of the subgenus *Radiphinema.*

The position of vulva in species of the subgenus *Xiphinema* is usually median or slightly postequatorial. In other subgenera which have didelphic species the position of vulva is greatly variable (V= 20-53 in *Elongiphinema*, 34-52 in *Rotundiphinema*). In those subgenera which have monodelphic or pseudomonodelphic (*Radiphinema* and *Krugiphinema*) species the value of V varies from 24-41%. It, therefore, becomes evident that the value of V overlaps in the different subgenera of this genus and thus is useless in the characterization of these subgenera.

The presence or absence of 'Z' organ was used to differentiate the subgenus *Diversiphinema* from other subgenera having didelphic genital tract and short tails keeping in view that this organ is present in some short-tailed species. Luc (1973) has shown the presence of this organ in long-tailed species also, e.g., in *X. hallei.* This organ is also present in *X. diversicaudatum* which is the type species of *Diversiphinema.* Thus this organ cannot be used for the differentiation of subgenera. Same is the case with total body length.

Thus, all the characters that were used by Cohn & Sher (1972) either overlap in different subgenera or are unrelated. The different subgenera have both long and short-tailed species and the genital tract in different stages of regression, e.g., *X. hygrophilum* under ***Rotundiphinema*** and *X. orbum* under *Elongiphinema.*

Southey (1973a), Luc & Dalmasso (1975) have objected to the subdivisions of *Xiphinema* as was proposed by Cohn & Sher (l.c.) on the grounds that the different subgenera do not show any definite phylogenetic relationship. Southey preferred to use the term 'groups' in place of subgenera which has no nomenclatorial involvement but is quite useful in assembling similar species into groups thereby facilitating their quick identification. These groupings are similar to that proposed by Cohn & Sher (1972) except for *Diversiphinema* which has been characterized only on the presence of protuberance on the tail. If we have to accept these groupings then another new subgenus has to be proposed for the sake of uniformity for those species of ***Radiphinema*** which have elongate-conoid or filiform tails. Roy & Gupta (1974) assigned *X. variable* to the subgeneus *Xiphinema* but Southey (l. c.) to *Halliphinema* group. The present authors agree with Southey on the position of this species since all the species of *Xiphinema* have short tails, become spiral upon fixation, their ovaries are thick-walled, genital tracts are simple and short, the germinal cells of ovary do not divide during non-breeding season and the oöcytes do not pile up during this season. If reduction of reproductive potential, as evidenced by the regression of anterior sexual branch and the shortening of tails, are evolutionary trends in *Xiphinema*, which actually is the case, the species of this subgenus or group, viz. *X. americanum*, *X. opisthohysterum*, *X. mediterraneum*, *X. lambertii*, *X. neoelongatum* and ***X. rivesi*** are perhaps highly evolved species of the genus.

The present authors concur with Luc & Dalmasso (1975) that the 8 subgenera proposed by Cohn & Sher (l.c.) and one by Roy & Gupta (l. c.) under *Xiphinema* have no phylogenetic relationships. Also, the various characters used by them to separate these subgenera overlap. Consequently, the proposals are rather premature at this stage and it would be better to regard some of them only as groups or subdivisions of *Xiphinema* without attaching any taxonomic significnce as was suggested by Southey (l. c.). Also, if these subgerera are accepted then perhaps we would have to review the systematics of many other genera of the Order Dorylaimida (e.g., *Dorylaimoides*, *Tylencholaimus*, *Tylencholaimellus*, *Basirotyleptus* etc., etc.) on similar lines which would account to creating more chaos rather than stability. The various species of ***Xiphinema*** can be regrouped under the following 5 subdivisions, primarily on the basis of tail shapes (long or short) and secondarily on

the regression and the nature of gential tract (short, simple or long and highly differentiated) and the piling up of oöcytes during non-breeding season. Only these characters have been taken for the grouping of different species since all the other characters which were used by Cohn & Sher, Southey and Roy & Gupta overlap to some extent as is mentioned above.

I. *Americanum*-Group

Species having short and simple genital tract in which both the sexual branches are equally developed, oöcytes do not pile up during non-breeding season, ovaries are thick-walled; and tails short (c'=less than 2.2).

This group includes all the species which were included by Cohn & Sher in the subgenus *Xiphinema* or group 5 of Southey.

Typical species : *X. americanum* Cobb, 1913

Other species : *X. brevicolle* Lordello & da Costa, 1961
X. opisthohysterum Siddiqi, 1961
X. mediterraneum Martelli & Lamberti, 1967
X. rivesi Dalmasso, 1969
X. inaequale Khan & Ahmad, 1976
X. lambertii Bajaj & Jairajpuri, 1976
X. neoelongatum Bajaj & Jairajpuri, 1976

II. *Elongatum*-Group

Species which are perhaps most primitive having both the sexua branches and ovaries equally developed and functional, genital branches are long and differentiated, oöcytes pile up during non-breeding season, ovaries are thin-walled; tails tapering, narrow and elongate (c'=more than 2.3).

This group includes species which were placed under the subgenera, *Halliphinema* and *Elongiphinema* by Cohn & Sher and in group 3 and 4 of Southey. These subgenera are grouped together since no clear-cut differences exist between them and the characters used by Cohn & Sher for their differentiation, viz. position of vulva, tail shape and c' ratio (V=28-48; tail conoid or elongate, c'=2.1-6.5 in *Elongiphinema* and V=44-56; tail conoid, elongate or filiform, c'=2.6-12 in *Halliphinema*) overlap considerably. In this group those species have not been included in which the anterior ovary is either greatly reduced and only occasionally functional, or non-functional, e.g., *X. insigne* and *X. orbum*.

Typical species : *X. elongatum* Schuurmans-Stekhoven & Tounissen, 1938

Other species : *X. italiae* Meyl, 1953
X. hallei Luc, 1958
X. attorodorum Luc, 1961
X. flagellicaudatum Luc, 1961
X. nigeriense Luc, 1961
X. vanderlindei Heyns, 1962
X. zulu Heyns, 1965
X. dimorphicaudatum Heyns, 1966
X. variable Heyns, 1966
X. bergeri Luc, 1973
X. cavenessi Luc, 1973
X. douceti Luc, 1973
X. malagasi Luc, 1973
X. marsupilami Luc, 1973
X. spinuterus Luc, 1973
X. vitis Heyns, 1974
X. luci n. sp.

III. *Chambersi*-Group

Species having anterior sexual branch and ovary in different stages of regression or completely absent, including species in which anterior ovary is greatly reduced in size and is occasionally functional, oöcytes pile up during non-breeding season, ovaries are thin-walled; tails tapering, thin and elongate, c' more than 2.5.

This group includes long-tailed species of the subgenera *Radiphinema* and *Krugiphinema*. These long-tailed species of the two subgenera are grouped together and separated from the short-tailed species of these subgenera in order to bring uniformity in the grouping since shortening of tail has definite phylogenetic significance.

Typical species : *X. chambersi* Thorne, 1939

Other species : *X. insigne* Loos, 1949
X. longicaudatum Luc, 1961
X. orbum Siddiqi, 1964
X. monohysterum Brown, 1968
X. simillimum Loof & Yassin, 1971
X. filicaudatum Loof & Maas, 1972
X. orthotenum Loof & Maas, 1972

IV *Rotundatum*-Group

Species in which both the sexual branches and ovaries are equally developed, genital branches are long and differentiated, oocytes pile

up during non-breeding season, ovaries are thin-walled; tails short, conoid, conoid-digitate or rounded with or without a protuberance, c'=0.4–2.3.

This group includes species which were placed under *Diversiphinema* *Basiphinema* and *Rotundiphinema*. They have been grouped together since no clear-cut differences exist between these subgenera. They have short tails and 'Z' organ is also present. The presence or absence of a protuberance or peg is a variable feature. *X. arcum*, *X. hygrophilum* and *X. cubense* which have a reduced sexual branch are not included in this group.

Typical species : *X. rotundatum* Schuurmans-Stekhoven & Teunissen, 1938

Other species : *X. mammillatum* Schuurmans-Stekhoven & Teunissen, 1938
X. diversicaudatum (Micoletzky, 1927) Thorne, 1939
X. index Thorne & Allen, 1950
X. ebriense Luc, 1958
X. setariae Luc, 1958
X. basiri Siddiqi, 1959
X. coxi Tarjan, 1964
X. bakeri Williams, 1961
X. ifacolum Luc, 1961
X. longidoroides Luc, 1961
X. turcicum Luc & Dalmasso, 1963
X. basilgoodeyi Coomans, 1965
X. ingens Luc & Dalmasso, 1964
X. vuittenezi Luc, Lima, Weischer & Flegg, 1964
X. clavatum Heyns, 1965
X. imitator Heyns, 1965
X. paulistanum Carvalho, 1965
X. pini Heyns, 1965
X. macrostylum Esser, 1966
X. neovuittenezi, Dalmasso, 1969
X. pyrenaicum Dalmasso, 1969
X. sahelense Dalmasso, 1969
X. meridianum Heyns, 1971
X. parvistylus Heyns, 1971
X. imambaksi Loof & Maas, 1972
X. tropicale Zullini, 1973
X. manubriatum Luc, 1975
X. seredouense Luc, 1975
X. tarjani Luc, 1975

V *Radicicola*-Group

Species having one sexual branch shorter than the other, or reduced to an undifferentiated sac, or completely absent, oöcytes pile up during non-breeding season, ovaries are thin-walled, tails short, conoid, conoid-digitate or rounded (c′=0.4-2.3).

This group includes all the short-tailed species of the subgenera *Radiphinema* and *Krugiphinema* and didelphic species in which one sexual branch is comparatively less developed.

Typical species : *X. radicicola*

Other species : *X. ensiculiferum* (Cobb, 1893) Thorne, 1937

X. brasiliense Lordello, 1951

X. krugi Lordello, 1955

X. arcum Khan, 1964

X. denoudeni Loof & Maas, 1972

X. surinamense Loof & Maas, 1972

X. cubense Razjivin in Razjivin, O'Relly & Millan, 1973

X. hygrophilum Southey & Luc, 1973

X. loosi Southey & Luc, 1973

X. costaricense Lamberti & Tarjan 1974

Key to groups and species of *XIPHINEMA*

During the last decade the number of new species of *Xiphinema* has considerably increased. Identification keys to species of this genus have been given from time to time by various authors. McLeod & Khair (1971) and Lamberti & Tarjan (1974) provided key to monodelphic species only. Loof & Maas (1972) gave a dichotomous key to all the species of *Xiphinema*. Cohn & Sher (1972) provided an identification key to all the species under the eight subgenera of *Xiphinema* which they proposed. Southey (1973a) gave a key to species of *Xiphinema* under various groups recognised by him along with their important biometric characters. Roy & Gupta (1974) have also provided a key to species grouped under nine subgenera. Luc & Dalmasso (1975) gave a polytomous key using a wider range of biometric characters However, all these keys are not good enough to give quick and easy identification of species. In the present work a dichotomous key to five groups of *Xiphinema* and the various species under these groups has been given.

KEY TO GROUPS OF *Xiphinema*

1. Genital tract simple and only slightly differentiated, ovary thick-walled, oöcytes do not pile up during non-breeding season; tail short and conoid *americanum*-group
   Genital tract well differentiated, ovary thin-walled, oöcytes pile up during non-breeding season; tail hemispheroid to long filiform. .2
2. Tail tapering, thin and elongate, c' more than 2.0 .3
   Tail short and conoid, conoid-digitate or rounded, c' less than 2.0 . .4
3. Anterior sexual branch and ovary in different stages of regression or completely absent, vulva usually pre-equatorial *.chambersi*-group
   Anterior sexual branch and ovary equally developed, vulva usually equatorial. *.elongatum*-group
4. Anterior or posterior sexual branches in different stages of regression or completely absent ..... *.radicicola*-group
   Anterior and posterior sexual branches normal and equally developed *.rotundatum*-group

KEY TO SPECIES OF *Xiphinema*

I. *Americanum*-Group

1. Body slender (a=56-72); V=55-61 .2
   Body robust (a=less than 50); V=48-55. .3
2. Odontostyle length avg. 80 μm; c=avg. 54; male with 5-8 ventromedian supplements .. *.mediterraneum*
   Odontostyle length avg. 67 μm; c=avg. 62; male with 2 ventromedian supplements *.opisthohysterum*
3. Tail less than one anal body-width long. *.brevicolle*
   Tail more than one anal body-width long. .4
4. Lip region offest by a constriction. . .5
   Lip region marked off by a depression. 7
5. Tail conoid-digitate; odontostyle length avg. 92 μm *.neoelongatum*
   Tail conoid or elongate-conoid; odontostyle length avg. less than 80 μm. .6
6. Odontostyle length avg. 78 um; tail conoid *.americanum*
   Odontostyle length avg. 62 μm; tail elongate-conoid. .. *.lambertii*
7. Female tail ventrally curved, male with 4 ventromedian supplements, first one located at about 1.5 times the distance between any two adjacent supplements from the adanal pair .. *.inaequale*
   Female tail almost straight; male with 5-8 ventromedian supplements, first one at about the same distance as between any two adjacent supplements from the adanal pair. *.rivesi*

II. *Elongatum*-Group

1. Uterine walls with spines .2
   Uterine walls without spines .3
2. Pseudo 'Z' organ present *.malagasi*
   Pseudo 'Z' organ absent *.spinuterus*

3. 'Z' organ present 4
   'Z' organ absent 7
4. Uterus with typical 'Z' organ ..... *hallei*
   Uterus with pseudo 'Z' organ 5
5. Tail long and filiform, c' more than 7.5 ..... *marsupilami*
   Tail elongate, c' less than 7.5 6
6. Odontostyle length avg. 68 μm; c=avg. 55 ..... *variable*
   Odontostyle length avg. 98 μm; c=avg. 29 ..... *zulu*
7. V=less than 45 8
   V=more than 45 10
8. Tail tip clavate, inner cuticular canal of tail stopping halfway to an inflated terminal part of tail tip.. *bergeri*
   Tail tip not clavate, inner cuticle of tail does not stop halfway 9
9. Inner surface of cuticle of tail forms a canal with a small vesicle at its end ..... *attorodorum*
   Inner surface of cuticle of tail devoid of such a structure ..... *elongatum*
10. c'=less than 4.5 11
    c'=more than 4.5 13
11. Tail tip clavate, inner surface of cuticle of tail forms a small vesicle at its end ..... *luci* n. sp.
    Tail tip pointed, inner surface of cuticle does not form such a structure 12
12. Lip region distinctly expanded; odontostyle length avg. 114 μm ..... *vitis*
    Lip region only slightly expanded; odontostyle length avg. 95 μm ..... *italiae*
13. Tail filiform, c=less than 12 ..... *flagellicaudatum*
    Tail elongate, c=more than 12 14
14. Lip region rounded ..... *cavenessi*
    Lip region truncated 15
15. Body length avg. more than 3.2 mm; males frequent 16
    Body length avg. less than 3.2 mm; males rare 17
16. Lip region expanded; tails showing no sexual dimorphism ..... *vanderlindei*
    Lip region not expanded; tails showing sexual dimorphism ..... *dimorphicaudatum*
17. Tail tip rounded more often clavate, hyaline portion 58-64% of tail length ..... *nigeriense*
    Tail tip pointed and never clavate, hyaline portion 18-29% of tail length ..... *douceti*

III. *Chambersi-Group*

1. Anterior sexual branch reduced and without an ovary 2
   Anterior sexual branch reduced but with an ovary 7
2. Anterior sexual branch completely absent 3
   Anterior sexual branch having uterus and oviduct and their parts 5
3. Lip region slightly offset; tail elongate-conoid or subdigitate, c'=3.1-4.4 4
   Lip region continuous; tail long and filiform, c'=avg.8.3 ..... *orthotenum*

4. Tail elongate-conoid, c'=avg. 4.4. *.chambersi*
   Tail subdigitate, c'=avg. 3.1. *.monohysterum*
5. Tail elongate-conoid. *.simillimum*
   Tail filiform. .6
6. Body length avg. 4.4 mm; odontostyle length avg. 206 μm .. *.filicaudatum*
   Body length avg. 2.9 mm; odontostyle length avg. 151 μm *.longicaudatum*
7. All organs of anterior sexual branch reduced; tail with 2 papillae, c'=2.7 .. *.orbum*
   All organs of anterior sexual branch normal except ovary which is reduced; tail with 3- 4 papillae, c'=3.0-8.5 *.insigne*

IV *Rotundatum*-Group

1. 'Z' organ present . 2
   'Z' organ absent .. .16
2. Uterus with typical 'Z' organ. .3
   Uterus with pseudo 'Z' organ. 8
3. Female tail hemispheroid without a terminal peg. ...4
   Female tail conoid-digitate or conical rounded with a terminal peg .5
4. Odontostyle length avg. 150 μm; vulva equatorial .. *rotundatum*
   Odontostyle length avg. 116 μm; vulva pre—equatorial . *tropicale*
5. Inner surface of the cuticle of the tail tip forms a thin, regular 'blind canal' surrounded apically by a muff *.ifacolum*
   Inner surface of the cuticle of the tail does not form such a structure . 6
6. V=40-46 7
   V=51-56 . . *.manubriatum*
7. Body length avg. 2.0 mm; odontostyle length avg. 113 μm; tail peg 10-13 μm long *.ebriense*
   Body length avg. 2.8 mm; odontostyle length avg. 127 μm; *.imambaksi*
8. Tail conoid-digitate, more than one anal-body width long . .9
   Tail conoid or hemispheroid, one anal body-width long or less 12
9. Lip region offset by a constriction; odontostyle length less than 110 μm 10
   Lip region marked off by a depression; odontostyle length more than 110 μm. 11
10. Body length avg. 2.5 mm; odontostyle length avg. 97 μm... ... *.meridianum*
    Body length avg. 2.8 mm; odontostyle length avg. 71 μm. .. ..*parvistylus*

11. Vulva equatorial (V=avg. 51) ..... *basiri*
Vulva pre-equatorial (V=avg. 44) ..... *coxi*
12. Body length avg. 2.2 mm; tail conoid or conoid-mammillate ..... *imitator*
Body length avg. more than 2.2 mm; tail rounded with or without a protuberance 13
13. Vulva pre-equatorial (V=avg. 43) ..... *diversicaudatum*
Vulva equatorial (V=avg. more than 48) 14
14. Odontostyle length avg. 110 μm; inner surface of cuticle of tail extending in the clear zone of tail tip ..... *pini*
Odontostyle length avg. 156 μm; inner surface of cuticle of tail not extending in the clear zone of tail tip 15
15. Female tail with internal mucro; males frequent; tail of first stage juvenile conoid ..... *ingens*
Female tail without internal mucro; males unknown; tail of first stage juvenile clavate ..... *turcicum*
16. Body length less than 2.5 mm 17
Body length more than 2.5 mm 19
17. Odontostyle length avg. 180 μm; tail without a peg.. ..... *macrostylum*
Odontostyle length avg. 124 μm; tail with a distinct peg 18
18. V=avg. 52 ..... *tarjani*
V=avg. 43 ..... *paulistanum*
19. Odontostyle length avg. 154 μm ..... *seredouense*
Odontostyle length avg. less than 150 μm 20
20. Tail conoid or conoid digitate 21
Tail hemispheroid with or without a protuberance 24
21. Tail conoid; V=avg. 54 ..... *longidoroides*
Tail conoid-digitate; V=avg. less than 50 22
22. V=less than 40 ..... *sahelense*
V=more than 40 23
23. Body length avg. 2.8 mm; odontostyle length avg. 120 μm ..... *setariae*
Body length avg. 4.0 mm; odontostyle length avg. 142 μm ..... *bakeri*
24. Vulva always pre-equatorial (V=avg. 40) 25
Vulva around equatorial (V=avg. 47-52) 26
25. Tail peg long and situated on the ventral part of the body ..... *index*
Tail peg short and situated along the axis of the body ..... *mammillatum*
26. Tail with a distinct peg 27
Tail without a distinct peg 28
27. Lip region expanded and offset by constriction; tail peg short ..... *vuittenezi*
Lip region neither expanded nor offset; tail peg long ..... *basilgoodeyi*
28. Tail spatulate ..... *clavatum*
Tail hemispheroid 29

29. Body length avg. 2.8 mm; males frequent ...*neovulttenezi*
Body length avg. 4.0 mm; males rare *.pyrenaicum*

V *Radicicola*-Group

1. Anterior sexual branch normal, posterior reduced *.cubense*
Anterior sexual branch reduced, posterior normal. .2
2. Anterior sexual branch with an ovary. 3
Anterior sexual branch without an ovary. .4
3. Body length 1.8 mm; odontostyle length avg. 150 μm; V=avg. 38. .. *.hygrophilum*
Body length avg. 2.5 mm; odontostyle length avg. 106 μm; V=avg. 35. *.arcum*
4. Anterior sexual branch completely absent. 5
Anterior sexual branch lacking an ovary but having uterus and oviduct or only a uterine sac. . 7
5. Tail hemispheroid less than one anal body-width long. ...*ensiculiferum*
Tail conoid-digitate or rounded-digitate, more than one anal body-width long .6
6. Tail rounded-digitate, c'=avg. 1.4... . .*brasiliense*
Tail conoid-digitate, c'=avg. 2.0. .. ..*radicicola*
7. Anterior genital tract usually more than 2 body-widths long and showing structural differentiation. .10
Anterior genital tract usually less than 2 body-widths long and showing no structural differentiation .. .8
8. Lip region offset; tail convex-conoid to digitate .. *.denoudeni*
Lip region marked off; tail conoid to hemispheroid. .9
9. V=avg. 31; c=avg. 76 . ..*loosi*
V=avg. 37; c=avg. 107 .. *.costaricense*
10. Lip region slightly offset; odontostyle length avg. 127 μm; tail hemispheroid in both adults and juveniles *.surinamense*
Lip region continuous; odontostyle length avg. 118 μm; tail conoid in both adults and juveniles. *.krugi*

NOT INCLUDED IN THE KEY

X. amarantum Macara, 1970: synonym of *X. sahelense* Dalmasso, 1969 (Macara, 1972); *X. arenarium* Luc & Dalmasso, 1963: synonymised with *X. italiae* Meyl, 1953 by Martelli *et. al.*, (1966); *X. australiae* McLeod & Khair, 1971: synonym of *X. radicicola* Goodey, 1936 (new synonymy); *X. brevicaudatum* Schuurmans-Stekhoven, 1951: transferred to *Longidorus* by Thorne (1961); *X. bulgariense* Stoyanov, 1964: synonym of *X. italiae* (Cohn & Sher, 1972); *X. campinense* Lordello, 1951; synonymised with *X. elongatum* Schuurmans-Stekhoven & Teunissen, 1938 by Tarjan & Luc (1963); *X. citri* Siddiqi, 1959: transferred to *Paralongidorus* by Siddiqi *et al.* (1963); *X. conurum* Siddiqi, 1964: synonym of *X. italiae* according to Cohn & Sher (l.c.); *X. ensiculiferoides* Cohn & Sher 1972: synonym of *X. ensiculiferum* (Cobb, 1893) Thorne, 1937 (Southey & Luc 1973); *X. indicum* Siddiqi, 1959: synonym of *X. insigne* according to Tarjan & Luc (l.c.) and Bajaj & Jairajpuri (1977); *X. itanhaense* Carvalho, 1962: synonymised with *X. brasiliense* Lordello, 1951 by Cohn & Sher (l.c.); *X. neoamericanum* Saxena *et al.*, 1973: synonym of *X. americanum* Cobb, 1913

(new synonymy); *X. paraelongatum* Altherr, 1958: synonym of *X. diversicaudatum* (Micoletzky, 1927) Thorne, 1939 according to Luc & Tarjan (1963); *X. saopaloense* Khan & Ahmad, 1975: synonym of *X. brevicolle* (Lamberti & Loof, 1977) and *X. pratense* Loos, 1949: synonymised with *X. elongatum* by Tarjan & Luc (l.c.).

Species Inquirendae

i) Because of inadequate description:

X. cylindricaudatum Schuurmans-Stekhoven & Teun issen, 1938, *X. dolichodorus* (de Man, 1907) Thorne & Swanger, 1936, *X. grande* Steiner, 1914, *X. lineum* (Grube, 1849) Thorne, 1939, *X. parasetariae* Luc, 1958, and *X. truncatum* Thorne, 1939.

ii) Species described on juveniles only.—

X. digicaudatus Schuurmans-Stekhoven, 1951, X. *effilatum* Schuurmans-Stekhoven, 1951, and *X. obtusum* Thorne, 1939.

iii) Due to absence of clear cut differences with the related species.—

X. vulgare Tarjan, 1964.

DESCRIPTIONS OF SPECIES OF *XIPHINEMA* FROM INDIA

Although the genus *Xiphinema* was proposed as early as 1913 but it was only in 1959 that Siddiqi reported some species of this genus from India. He reported *X. americanum* and *X. brevicaudatum* and described three new species, viz. *X. indicum*, *X. basiri* and *X. citri* from Aligarh, West Uttar Pradesh. Of these species, *X. brevicaudatum* and *X. citri* have been transferred respectively to the genera *Longidorus* and *Paralongidorus* and *X. indicum* has been synonymised with *X. insigne* Loos, 1949 by Tarjan & Luc (1963). Later on, Siddiqi (1961) described another new species, *X. opisthohysterum*, from Aligarh and reported *X. pratense* (=*X. elongatum*) from Banda and Madras. Jairajpuri & A. H. Siddiqi (1963) reported *X. brevicolle* for the first time from India. Siddiqi (1964) added another species, *X. orbum*, which was collected from Patna, Bihar. E. Khan described *X. arcum* from Ranikhet, U. P. Saxena *et al.* (1973) reported a new species *X. neoamericanum* from Ludhiana, Punjab and S. H. Khan & Ahmad (1975) described a species from Ranikhet, U. P. very close to *X. americanum-brevicolle* complex, first named it *X. neoamericanum* but changed the name to *X. inaequale*. Yadav & Verma (1967), Srivastava & Singh (1965), Prasad & Dasgupta (1964), Janarthanan *et al.* (1969), Sethi & Swarup (1969), F. A. Khan & A. M. Khan (1972) have also reported *X. basiri*, *X. americanum* and *X. insigne* from various parts of this country. Mukhopadhyaya & Haque (1974) have doubtfully recorded *X. index* from West Bengal. Recently, Bajaj & Jairajpuri (1976) have described *X. lambertii* and *X. neoelongatum*, two new species from India.

In the present work, all the species so far recorded from India have been thoroughly redescribed based on type material and on fresh material. Observations on the juvenile stages of most of the species have also been included. The relationships of these species with closely related species have also been discussed. The males of *X. opisthohysterum* and *X. inaequale* are described for the first time. Two monodelphic species, *X. radicicola* and *X. ensiculiferum* are first records from India. *X. index* which was doubtfully recorded from West Bengal by Mukhopadhayaya & Haque (l. c.) is described from Srinagar. One new species of the genus, viz. *X. luci* is also described. All these Indian species described here can be grouped as follows:—

(i) *americanum*-group.—*X. americanum, X. brevicolle, X. opisthohysterum X. inaequale, X. lambertii* and *X. neoelongatum.*

(ii) *elongatum*-group.—*X. elongatum* and *X. luci.*

(iii) *chambersi*-group.-*X. insigne* and *X. orbum.*

(iv) *rotundatum*-group.-*X. index* and *X. basiri.*

(v) *radicicola*- group-*X. radicicola, X. ensiculiferum, X. brasiliense* and *X. arcum.*

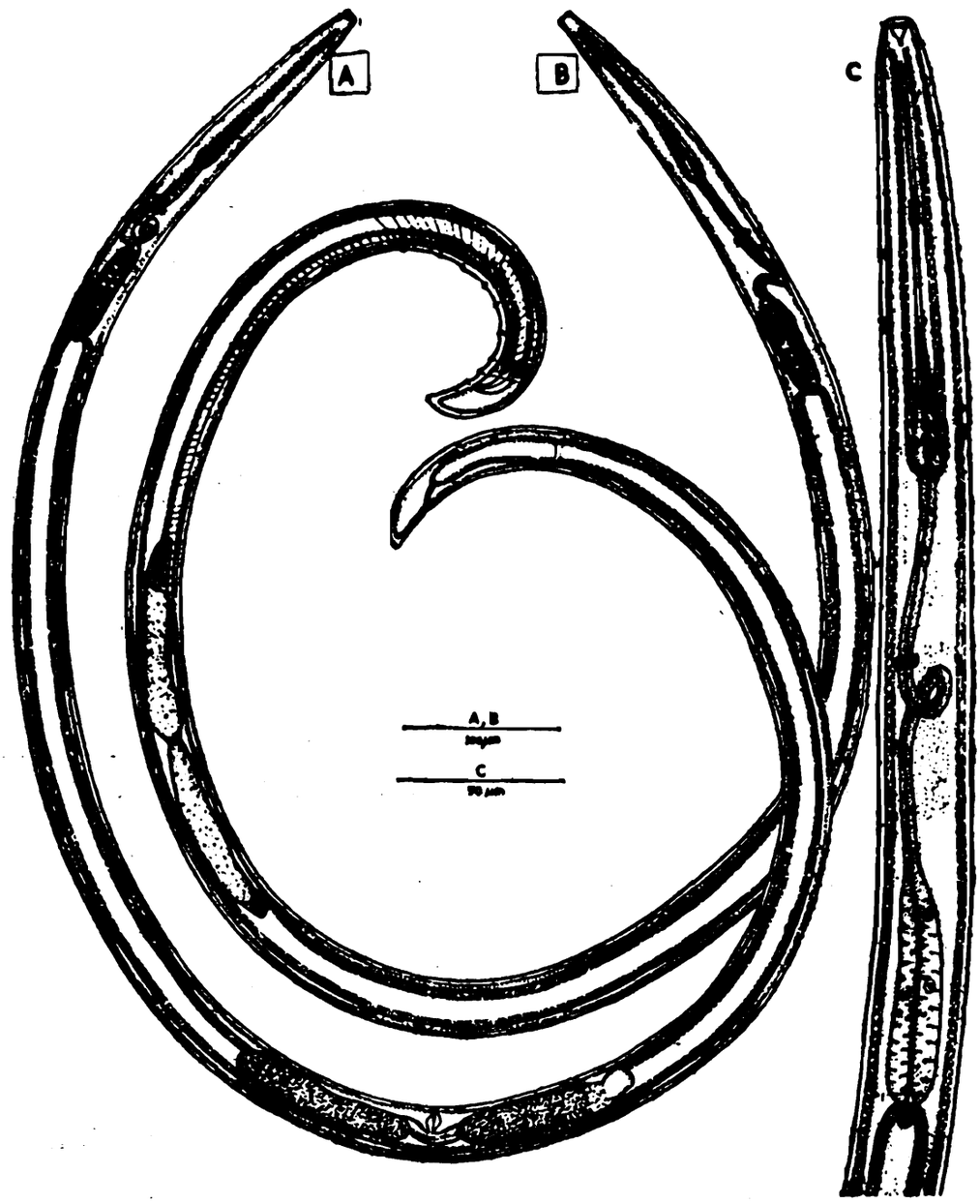
It is for the first time that through this work the descriptions of all the Indian species of *Xiphinema* which are scattered in different journals have been brought together. Many of the diagnostic characters proposed by the original authors have been rechecked with the help of additional material comprising of several populations from many parts of this country collected over the last several years. For every species described hereunder, detailed discussions have been provided giving its relationships, geographical distribution and economic importance, if already known.

1. Xiphinema americanum Cobb

(Text-figs. 1 & 2)

1913. *Xiphinema americanum:* Cobb, *J. Wash. Acad. Sci.*, 3 : 432.
1922. *Tylencholaimus americanus:* Micoletzky, *Arch. Naturg.*, (1921), Abt. A, 87 :
1939. *Xiphinema americanum*: Thorne, *Capita Zool.*, 8 : 110.
1949. *Xiphinema americanum*: Loos, *J. zool. Soc. India*, 1 : 23.
1950. *Xiphinema americanum*: Thorne, *Principles of Nematology*: 487.
1956. *Xiphinema americanum*: Tarjan, *Proc. helminth. Soc. Wash.*, 23 : 88.
1959. *Xiphinema americanum*: Siddiqi, *Proc. helminth. Soc. Wash.*, 26 : 155
1972. *Xiphinema americanum*: Siddiqi, *C.I.H. Description of Plant parasitic nematodes*, set 2, No. 29.
1973. *Xiphinema americanum*: Southey, Manual Worksh. Nemat. Group. Assoc. appl. Biologists: 48.
1973. *Xiphinema neoamericanum:* Saxena *et. al.*, *Zool. Anz.* 191: 130.
1974. *Xiphinema americanum:* Heyns, *Phytophylactica*, 6 : 157.

Dimensions: Aligarh citrus population: 4♀♀: L=1.58-1.64 mm; a=41-44; b=5.1-6.1; c=43-55; V=48-51; G_1=12-18; G_2=12-18; c′=1.3-1.6; Anterior end to guide ring=62-65 μm; Odontostyle=70-75 μm Odontophore=46-48 μm; DO=10.5-12.5; DN=10.5-12.5; RS_1N=45-50; LS_1N=45-50; S_2O=78-82.



Text-fig. 1.—*Xiphinema americanum* Cobb: (A) Entire female. (B) Entire male (C) Feeding apparatus and oesophagus.

2♂♂: L=1.60-1.62 mm; a=43; b=5.4-5.8; c=48; c′=1.5; Anterior end to spear guide ring=64 μm; odontostyle=74-78 μm; Odontophore=48 μm; DO=12; DN=12.5; RS_1N=46-54; LS_1N=46-54; S_2O=80; Spicule Length=33-38 μm.

Dehra Dun mango population: 4♀♀: L=1.60-1.70 mm; a=43; b=5.6; c=46-53; V=49-51; G_1=15-20; G_2=15-20; c′=1.5; Anterior

end to spear guide ring=64 μm; Odontostyle=73-75 μm; Odontophore=48 μm; DO=12.0; DN=13.5; RS_1N=48-52; LS_1N=48-52. S_2O=78-82.

Jaipur soursop population: 3♀♀: L=1.61-1.72 mm; a=42; b=5.4; c=45-55; V=50; G_1=13-17; G_2=12-15; c'=1.4-1.6; Anterior end to spear guide ring=63-66 μm; Odontostyle=72-76 μm; Odontophore 48 μm; DO=12.5; DN=15; RS_1N=49-52; LS_1N=49-52; S_2O=80.

Kulu grass population: 3♀♀: L=1.56-1.68 mm; a=41-44; b=5.2-6.0; c=46-56; V=49-52; G_1=12-18; G_2=12-18; c'=1.4; Anterior end to spear guide ring=64 μm; Odontostyle=76 μm; Odontophore=48 μm; DO=12.5; DN=13.5; RS_1N=50; LS_1N=50; S_2O=79.

Manipur mango population: 4♀♀: L=1.61-1.70 mm; a=41-43; b=5.3; c=48-52; V=50; G_1=13-18; G_2=13-15; c'=1.3-1.5; Anterior end to spear guide ring=64 μm; Odontostyle=74-78 μm; Odontophore=47 μm; DO=10.5-11.5; DN=11.5-13.5; RS_1N=50; LS_1N=50; S_2O=80.

Srinagar rose population: 4♀♀: L=1.61-1.73 mm; a=45; b=5.5-6.3; c=46-59; V=49-53; G_1=16-22; G_2=16-22; c'=1.5-1 7; Anterior end to spear guide ring=63-66 μm; Odontostyle=72-79 μm; Odontophore=47-50 μm; DO=10.5-11.0; DN=13.5; RS_1N=48-54; LS_1N=48-54; S_2O=80-83.

2♂♂: L=1.61-1.63 mm; a=43; b=5.8-6.2; c=48; c'=1.4-1.6; Anterior end to spear guide ring=64 μm; Odontostyle=76-78 μm; Odontophore=48 μm; .DO=12.0; DN=12.5; RS_1N=52-56; LS_1N=52-56; S_2O=80; Spicule length=35-40 μm

3L_1:L=0.63-0.68 mm; a=34-37; b=3.3-4.2; c=20-25; c'=2.3-2.7; Anterior end to spear guide ring=37 μm; Functional odontostyle=40-42 μm; Replacement odontostyle=49-51 μm; Odontophore=33μm; DO=13; DN=14.2; RS_1N=51; LS_1N=52; S_2O=78.

4L_2; L=0.91-0.97 mm; a=41-44; b=3.3-3.9; c=25-29; c'=2.2-2.5; Anterior end to spear guide ring=40-44 μm; Functional odontostyle= 50-53 μm; Replacement odontostyle=60-64 μm; Odontophore=33 μm; DO=16; DN=16; RS_1N=51; LS_1N=51; S_2O=75

4L_3: L=1 12-1.32 mm; a=46-50; b=4.0-4.8; c=30-38; c'=1.8-2.2; Anterior end to spear guide ring=50-57 μm; Functional Odontostyle=55-60 μm; Replacement odontostyle=70-75; μm; Odontophore=33-36 μm; DO=16; DN=17.5; RS_1N=52; LS_1N=52; S_2O=75.

5L_4: L=1.31-1.52 mm; a=44-48; b=4.7-6·3; c=44-48; c'=1.6-1.9; Anterior end to spear guide ring=54-60 μm; Functional odontostyle=65-76 μm; Replacement odontostyle=73-81 μm; Odontophore

=41-48 μm; DO=10.5-13.5; DN=10.5-13.5; RS_1N=48-56; LS_1N =48-56; S_2O=75-83.

Description: Female: Body upon fixation 'C' shaped with tapering extremities. Cuticle in two layers, thickest in the region of tail. Lateral chords about 1/4th of the midbody-width.

Lip region rounded, offset from the rest of body. Amphids stirrup-shaped with slit-like apertures which are nearly 3/5th of the labial-width and are located at the base of lip region. Odontostyle 8-9 labial-widths long, odontophore 1/1.6th of the odontostyle length. Fixed guiding ring is at 6-8 labial-widths from the oral aperture.

Basal bulb of oesophagus twice the corresponding body-width and 25% of neck length long. Positions of various oesophageal gland nuclei and their orifices as givena bove. Cardia short and conoid. Nerve ring surrounding the anterior slender part of oesophagus at about 2 labial-widths from the basc of odontophore. Prerectum 5-7 times the anal body-width long and is distinguishable from the intestine in being narrow and in having fewer granules in its cells. Rectum about one anal body-width long.

Genital tract amphidelphic, each sexual branch consisting of a reflexed ovary, a distal narrow and a proximal expanded part of oviduct and a short uterus. Vagina is about one-third of the corresponding body-width long. Vulva at 48-53% of total body length from the anterior extremity.

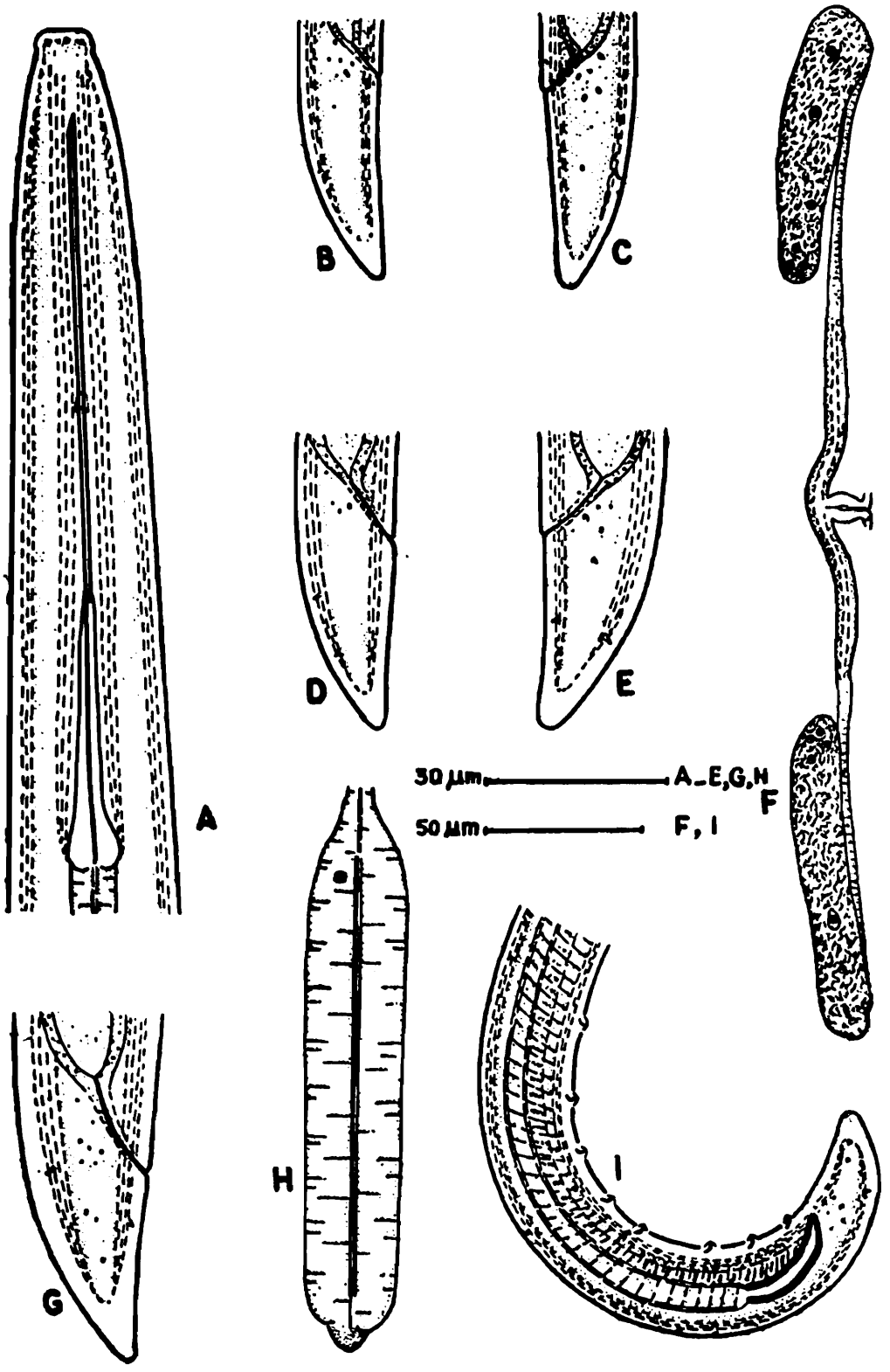
Tail short, convex-conoid, 1.4-1.6 times the anal body-width long and provided with 2 papillae on each side.

Male: The males collected in Aligarh and Srinagar resemble the females morphologically except for their more curved posterior extremity. Supplements consist of an adanal pair and a series of 5-7 ventromedians which are spaced as shown in Fig. 2, I. Spicules about 2 anal body-widths long. Lateral guiding pieces short and finger-like. Tail short and conoid, about 1.5 times the anal body-width long and provided with 2 papillae on each side.

Juveniles: The various juvenile stages differ from one another in total body length, length of odontostyles (both functional and replacement), position of fixed guiding ring from the anterior extremity, value of c′ ratio and tail shape.

Hosts and localities: i. Soil around roots of *Citrus sinensis* from Jawahar Park, Aligarh; ii. *Mangifera indica* from Gandhi Park, Dehra Dun (U. P.); iii. *Anona squamosa* from Jaipur, Rajasthan, iv. Grasses (unidentified) from Mandi, Kulu (H. P.); v. *Mangifera indica* from Leikei (Manipur) and vi. *Rosa indica* from Shalimar Garden, Srinagar (J & K).

Remarks: The type species of *Xiphinema* was described by Cobb in 1913, Loos (1949) reported it from Sri Lanka. After the loss of the type material Tarjan (1956) designated a male neotype of the species.



Text-fig. 2—*Xiphinema americanum* Cobb : (A) Anterior extremity. (B-E) Tails of L_1, L_2, L_3, & L_4 respectively. (F) Female genital tract. (G) Female tail. (H) Oesophageal bulb. (I) Male posterior extremity.

The present specimens from India as well as those described by Siddiqi (1959) are fairly similar to those of Cobb, Loss, and Tarjan, It is how-

ever, an exceedingly variable species and appears to comprise a collection of geographical isolates or closely related species (Tarjan, 1969).

Saxena *et al.* (1973) described a closely related new species, *X. neomericanum* from around the roots of *Prunus persica* from Ludhiana, Punjab. It was differentiated from *X. americanum* in having continuous lip region and a differently shaped convex-conoid tail with subarcuate terminus. The values of a, b, V, odontostyle length etc. are almost identical in the two species. The only difference being in the value of c (28:50) which appears to have been calculated wrongly in *X. neoamericanum.* These authors mention the tail to be as long as anal body-width which does not conform with the figure of the tail given by them. Also, the tail shapes of the two species are identical. *X. neoamericanum* in all probabilities is a junior synonym of *X. americanum.* Roy & Gupta (1974) have considered this species a *species inquirenda* as detailed information was not accessible to them. However, Luc & Dalmasso (1975) have considered *X. neoamericanum* a valid species perhaps on the basis of the description given by the authorst Our efforts to obtain the type material from the authors to settle the question of the validity of species met with no success. Finally, we regard it a synonym of *X. americanum* untill proved otherwise.

X. americanum has been reported from North, Central and South America, Carribbean, Britain, West Africa, Sri Lanka, India, USSR, Japan, Australia, New Zealand. This species was first reported from India by Siddiqi (1959) who also designated a neotype from the population collected from Aligarh. The neotype was later on devalidated because it did not come from a locality close to the type locality. The species has also been reported from India by other authors (*cf.* Janar. thanan *et al.*, 1969; Sethi & Swarup, 1969; Sharma *et al.*, 1969).

X. americanum is known to act as a vector of tobacco ring spot (Fulton, 1962) and tomato ring spot viruses (Teliz *et al.*, 1966). Both these viruses infect a wide range of crops and weeds, but despite the cosmopolitan distribution of the vectors the outbreaks of these viruses have so far been restricted to the American continent. This apparent anomaly may be explained by the recognition of *X. americanum* as a species complex (Tarjan, 1969). As an ectoparsite it is known to be associated with the necrosis and distortion of feeding roots of laure-oak (Christie, 1952), necrosis and swelling of roots and general symptoms of decline in maple (Disanzo & Rhode, 1969), unthriftiness of red clover (Noroton, 1967), black roots of strawberry (Perry, 1958), severe decline of periwinkle (Epstein & Baker, 1966), and general weaking and premature decline of various species of trees used in shelter belts in South Dakota (Malek, 1968).

2. Xiphinema brevicolle Lordello & Da Costa

(Text-fig. 3, G-J)

1961. *Xiphinema brevicolle:* Lordello & Da Costa, *Rev. Brasil. Biol.*, **21** : 363.
1963. *Xiphinema brevicolle:* Jairajpuri & Siddiqi, *Curr. Sci.*, **32** : 508.
1969. *Xiphinema brevicolle:* Cohn, *Nematologica*, **15** : 183.
1974. *Xiphinema brevicolle:* Heyns, *Phytophylactica*, **6** : 157.
1975. *Xiphinema saopaloense:* Khan & Ahmad, *Nematol. medit.*, **1** : 23.

Dimensions: 2♀ ♀ : L=2.0-2.2mm; a=41; b=7 5; c=76-80; V=51-53; G_1=8-12; G_2=8-12; c'=0.8-0·9; Anterior end to spear guide ring=71-75 µm; Odontostyle=99-103 µm; Odontophore=61-63 µm; DO=12; DN=15; RS_1N=51; LS_1N=52; S_2O=73-75.

Description: Female: Body upon fixation 'C' shaped with tapering extremities. Cuticle with fine radial striae, in 2 layers, thickest on tail. Lateral chords about 1/4 th of the midbody-width.

Lip region flattened, continuous with the rest of body. Amphids stirrup-shaped with slit-like apertures which are about one-half of the labial-width. Odontostyle 8-9 labial-widths long, odontophore 1/1.5-1/1.6th of the odontostyle length. Fixed guiding ring is at 5-6 labial-widths from the anterior extremity.

Basal bulb of the oesophagus 1.5-2.0 times of the corresponding body-width and 30% of neck length long. Position of oesophageal gland nuclei and their orifices as given above. Cardia short and conoid. Nerve ring surrounding the anterior slender part of the oesophagus at about one labial-width from the base of odontophore. Prerectum indistinguishable from intestine. Rectum about one anal body-width long.

Genital tract amphidelphic, each sexual branch consisting of a reflexed ovary, a distal narrow and a proximal expanded part of oviduct, and a short uterus. Vagina about 1/3rd of the corresponding body-width long. Vulva at about 52% of total body length from the anterior extremity.

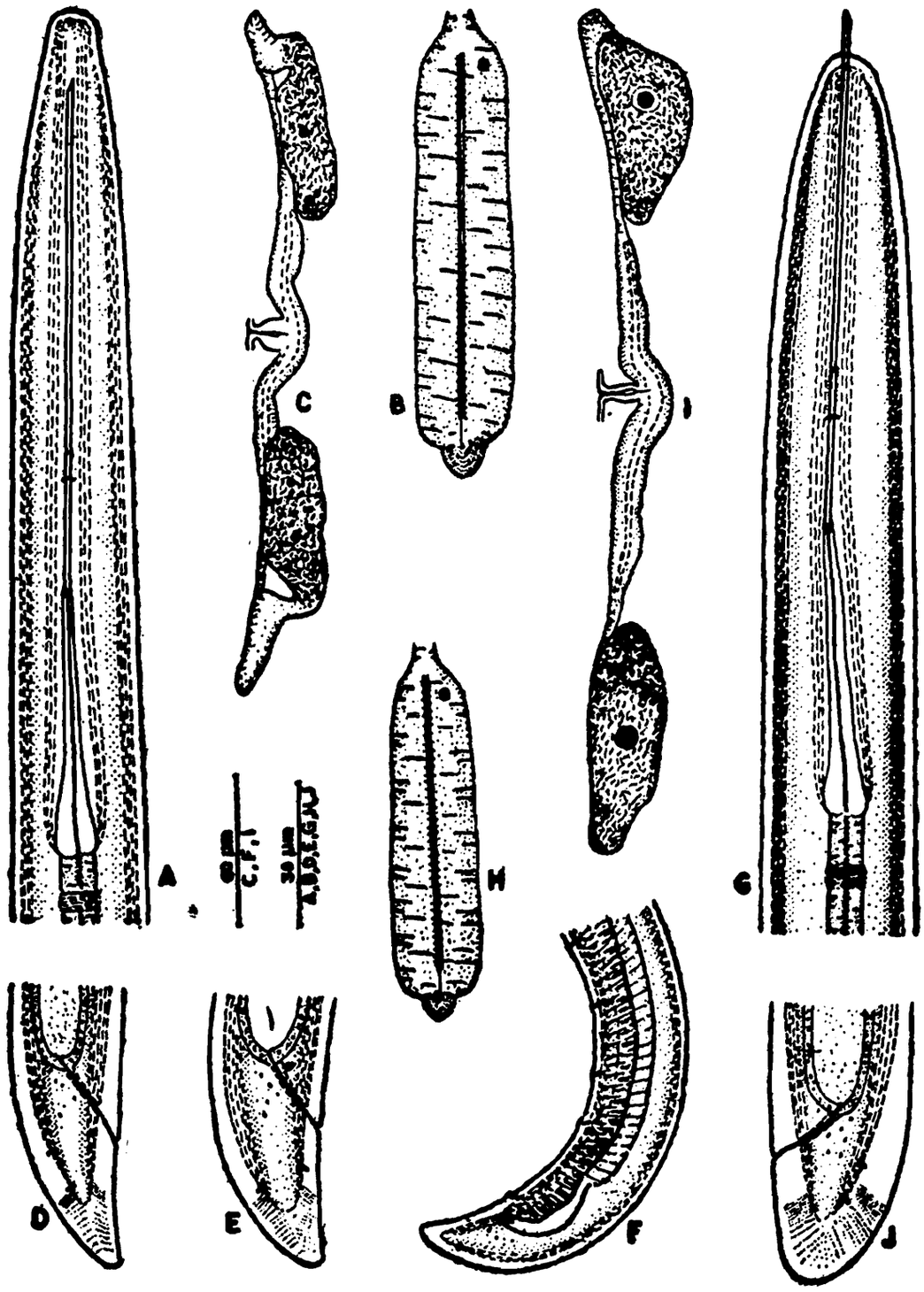
Tail short and rounded-conoid, its dorsal surface convex and ventral almost straight, about one anal body-width long and provided with 2 papillae on each side.

Male: Not found.

Host and locality: Soil around roots of *Berberis* sp., from Dalhousie, Himachal Pradesh.

Remarks: This species was described by Lordello & Da Costa (1961) from around the roots of *Coffea arabica* from Brazil. Jairajpuri & A. H. Siddiqi (1963) reported this species from around the roots of *Berberis*

sp., from Dalhousie, Himachal Pradesh, India. Cohn (1969) described the males of this species for the first time from Israel. It has also been reported from France, (Dalmasso, 1969), South Africa (Heyns, 1974) and Czechoslovakia (Liskova & Sabova, 1973). Heyns (l.c.) found that this species exhibits marked intraspecific variations which can be correlated with geographical distribution.



Text-fig. 3.—A—F *Xiphinema inaequale* (Khan & Ahmad): (A) Anterior extremity. (B) Oesophageal bulb. (C) Female genital tract. (D-E) Female tails. (F) Male posterior extremity. G-J *Xiphinema brevicolle* (G) Anterior extremity. (H) Oesophageal bulb. (I) Female genital tract. (J) Female tail.

Dalmasso (1969) described a new species, *X. rivesi* from France and differentiated it from *X. brevicolle* in being shorter and slender. But since the values of L and a are almost identical in both these species, the differences do not appear to be valid. In *X. brevicolle* there exists some doubt about the contour of lip region and tail shape. Our attempts to obtain some type material to confirm these characters met with no success. Lip region in specimens described by Lordello & Da Costa (l. c.) is slightly offset, tail is conoid with almost pointed terminus. Dalmasso (l. c.) who studied specimens from France described lip region to be slightly offset by a constriction which is not so pronounced and tail conoid with a rounded terminus. Specimens described by Jairajpuri & A. H. Siddiqi (l. c.) and those studied by the present authors from India have their lip region continuous with the rest of body and tail obtusely rounded. There is no alternative except to consider these differences as intraspecific variations, but it is quite likely that *X. brevicolle* may also represent a species-complex. This can only be ascertained by examination of the type material of this species and also by studying the variability among different populations of *Xiphinema* from the world which have been labelled as *X. brevicolle*.

3. **Xiphinema opisthohysterum** Siddiqi

(Text-fig. 4)

1961. *Xiphinema opisthohysterum* Siddiqi, *Z. Parasitkde.*, **20** : 458.

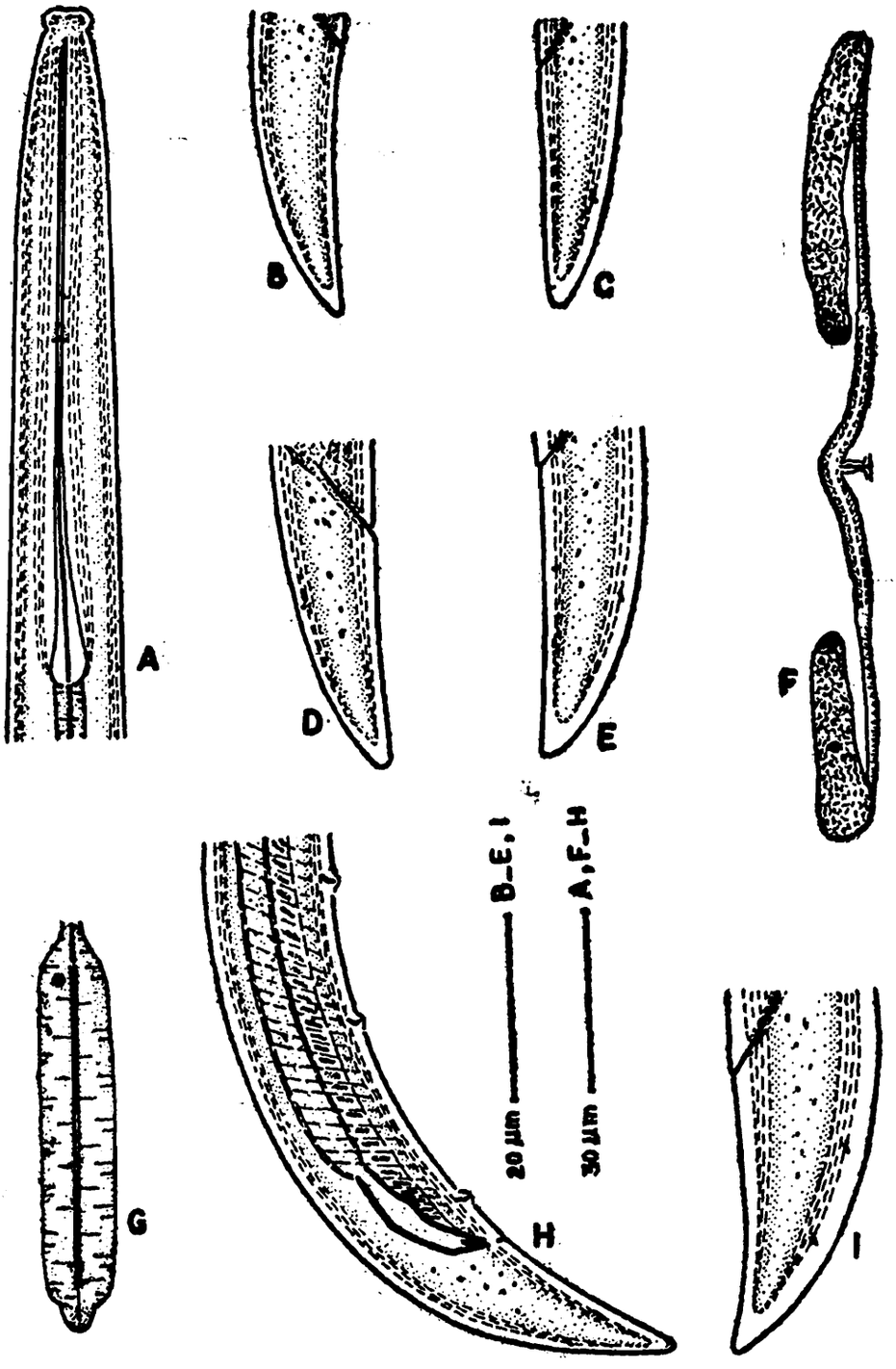
Dimensions: Aligarh citrus population: 5 ♀ ♀ : L=1·64-1·76 mm; a=60-65; b=6·5; c=52-57; V=60-61; G_1=13-15; G_2=13-15; c'=1·5-1·8; Anterior and to spear guide ring=53 μm; Odontostyle=64-68 μm; Odontopnore=38 μm; DO=12·5-13·5; DN=13·5-14·5; RS_1N=48-52; LS_1N=48-52; S_2O=73.

Bareilly mango population: 5 ♀ ♀ : L=1·61-1·78 mm; a=59-68; b=6; c=52-59; V=58-62; G_1=10-16; G_2=10-16; c'=1.4-1·8; Anterior end to spear guide ring=51-55 μm; Odontostyle=62-68 μm; Odontophore = 37-40 μm; DO=13·5; DN=14.5; RS_1N=48-51; LS_1N=48-51; S_2O=73-75.

3 L_1: L=0.69-0.73 mm; a=42-44; b=4.4-5.1; c=20-28; c'=2.5-3.0; Anterior end to spear guide ring=26-28 μm; Odontostyle (Functional=31-33 μm; Odontostyle (Replacement)=42 μm; Odontophore=18-20 μm; DO=15.5; DN=16.0; 16.0; RS_1N=47; LS_1N=48; S_2O=66-69.

1 L_2: L=0.85 mm; a=54; b=4.5; c=32; c'=2.7; Anterior end to spear guide ring=35 μm; Odontostyle (functional)=41 μm; Odontostyle (replacement)=49 μm; Odontophore=24 μm; DO=15.5; DN=16.0; RS_1N=48; LS_1N=49; S_2O=70.

5 L_3: L=0.87-1.12 mm; a=54-65; b=4·5-5.3; c=34-36; c'=2.2-2.8; Anterior end to spear guide ring=44 μm; Odontostyle (functional)=46-53 μm; Odontostyle (replacement)=60-64 μm; Odontophore=35-39 μm; DO=11.5-13.5; DN=13·5-16.5; RS_1N=48-53; LS_1N=48-53; S_2O=69-75.



Text-fig. 4.—*Xiphinema opisthohysterum* Siddiqi: (A) Anterior extremity. (B-E) Tails of L_1, L_2, L_3 & L_4 respectively. (F) Female genital tract. (G) Oesophageal bulb. (H) Male posterior extremity. (I) Female tail.

8 L_4: L=1·41-1·54 mm; a=64-70; b=6·7-7·3; c=40-52; c'=2·0-2.6; Anterior end to spear guide ring=44-50 μm; Odontostyle (functional)=55-63 μm; Odontostyle (replacement)=66-68 μm; Odon-

tophore=37-40 μm; DO=11.5-13·5; DN=11.5-14·5; RS_1N=50-55; LS_1N=50-53; S_2O=71-75.

Bareilly sugar cane population: 3 ♀ ♀ : L=1.61-1 71 mm; a=65; b=6.5; c=54-59; V=61-62; G_1=13-18; G_2=13-18; c'=1.6; Anterior end to spear guide ring=51 μm; Odontostyle=62-68 μm; Odontophore =37-39 μm; DO=12.5; DN=14.5; RS_1N=50; LS_1N=50; S_2O=73.

Nainital wild plant population: 5♀♀: L=1·66-1·84 mm; a=66-77; b=6.4-6.7; c=55-59; V=58-62; G_1=10-14; G_2=10-14; c'=1.4-1.8; Anterior end to spear guide ring=51-55 μm; Odontostyle=64-70 μm; Odontophore=37-40 μm; DO=12.5; DN=14.0; RS_1N=48-53; LS_1 N=48-53; S_2O=71-75.

1 ♂ : L=1.68 mm; a=76; b=6.5; c=48; c'=1.7; Anterior end to spear guide ring=52 μm; Odontostyle=64 μm; Odontophore=46 μm; DO=13.5; DN=14.0; RS_1N=50; LS_1N=50; S_2O=70; Spicule length=26 μm.

Pilibhit citrus population: 3 ♀♀: L=1·68-1.75 mm; a=67-77; b=6.5; c=52-59; V=59-62; G_1=12-17; G_2=12-17; c'=1.5-1.8; Anterior end to spear guide ring=53 μm; Odontostyle=62-67 μm; Odontophore=38 μm; DO=12.5-13.5; DN=13.5-14.5; RS_1N= 50; LS_1N=50; S_2O=71-75.

Description: Female: Body upon fixation 'C' shaped, long and attenuated with tapering extremities. Cuticle in 2 layers. Lateral chords about 1/3rd of the midbody-width.

Lip region rounded, well set off from the rest of body. Amphids stirrup-shaped with slit-like apertures which are nearly 3/5th of the labial width. Odontostyle 7.0-7 5 labial-widths long, odontophore nearly 1/1·7-1/1.9th of the odontostyle length. Fixed guiding ring is at 6 labial-widths from the oral aperture.

Basal bulb of oesophagus 2.0-2.6 times of the corresponding body-width and 20% of neck length long. Position of oesophageal gland nuclei and their orifices as given above. Cardia short and conoid. Nerve ring surrounding the anterior slender part of oesophagus at about 2 labial-widths from the base of odontophore. Prerectum 8-12 times of the anal body-width long. Rectum about one anal body-width long.

Genital tract amphidelphic, each sexual branch consisting of a reflexed ovary, a distal narrow and a proximal expanded part of oviduct and a uterus. Vagina about 1/3rd of the corresponding body-width long. Vulva post-equatorial, about 58-62% of total body length from the anterior extremity.

Tail elongate-conoid, about twice the anal body-width long and provided with 2-3 papillae on each side.

Male: A single male was collected from around the roots of some wild plants (unidentified) from Kicha, Nainital. This resembles the females morphologically. Male genital tract is monorchic with single reflexed testis. The monorchic condition is considered here as an abnormality rather than a rule. Supplements consist of an adanal pair and 2 ventromedians which are spaced as shown in Text-fig. 4, H. Spicules about 1.5 anal body-widths long. Lateral guiding pieces small and finger-like. Tail more pointed than in females, about twice the anal body-width long and provided with 2 papillae.

Juveniles: The various juvenile stages differ from one another in total body length, length of odontostyles (both functional and replacement), position of fixed guiding ring from anterior extremity and in value of c' ratio.

Hosts and localities: Soil around roots of i. *Citrus sinensis* from gardens in front of Victoria Gate, Aligarh Muslim University, Aligarh, U. P. ii. *Mangifera indica* from Baheri, Bareilly, U. P. iii. *Saccharum officianarum* from Baheri, Bareilly, U. P. iv. Wild plants (unidentified) from Kicha, Nainital, U. P. and v. *Citrus limnoia* from Pota, Pilibhit, U. P.

Remarks: *X. opisthohysterum* was described by Siddiqi (1961) from this country based only on females. Stoyanov (1964) described from Bulgaria several females and a male of a species of *Xiphinema* and identified it as *X. opisthohysterum*, but this identification was not accepted by Martelli & Lambertii (1967) who redesignated it as *X. mediterraneum*. The view of Martelli and Lamberti was accepted by Cohn (1969) as well as Heyns (1974). The description of a male by the present authors is therefore the first record of this sex in *X. opisthohysterum*. This species has not been reported from outside India.

This species comes very close to *X. americanum* Cobb, 1913 and *X. mediterraneum* Martelli & Lamberti, 1967. Tarjan (1969) has stated that the range of various characters of *X. americanum* and *X. opisthohysterum* overlap and it is quite difficult to separate them from each other. The only important difference between the two species being the position of vulva which is further post-equatorial (V=58-62) in *X. opisthohysterum*. *X. opisthohysterum* is morphologically very similar to *X. mediterraneum* the only points of difference being the length of odontostyle (67:87) and of tails (c=52:62). Luc & Dalmasso (1975) have indicated that the two species might be synonyms, but the present discovery of a male of *X. opisthohysterum* helps in distinguishing it from the related species. The male of this species has only 2 ventromedian supplements against 5-8 in *X. americanum* and *X. mediterraneum*. However, even this distinguishing character shall have limited value because of the rarity of males in these species.

4. Xiphinema inaequale (Khan & Ahmad)

(Text-fig. 3, A-F)

1975. *Xiphinema neoamericanum:* Khan & Ahmad *Nematol medit.* 3 : 24.

Dimensions: Almora grass population: 5♀♀: L=1·7-1·9 mm; a=35-39; b=5·6-5·9; c=61-64; V=50-52; G_1=10-14; G_2=10-15; c'=1·1-1·4; Anterior end to spear guide ring=70-78 μm; Odontostyle=92-98 μm; Odontophore=53 μm; DO=9-12; DN=10-13; RS_1N=48-51; LS_1N=48-51; S_2O=71-77.

Chamba grass population: 6♀♀: L=1·8-2·0 mm; a=38-41; b=5·8-6·3; c=61-65; V=50-53; G_1=12-15; G_2=12-15; c'=1·2-1·5; Anterior end to spear guide ring=73-81 μm; Odontostyle=95-101 μm; Odontophore=51-55 μm; DO=11-15; DN=12-15; RS_1N=48-52; LS_1N=49-53; S_2O = 77-84.

1 ♂ : L=1·7 mm; a=37; b=5·2; c=63; c'=1·0; Anterior end to spear guide ring=86 μm; Odontostyle=97 μm; Odontophore=55 μm; DO=12; DN=15; RS_1N=51; LS_1N=51; S_2O=75; Spicule length=43 μm.

Mussoorie wild plant population: 4♀♀: L=1·8-2·0 mm; a=36-38; b=5·7-5·9; c=63; V=52; G_1=11-14; G_2=11-14; c'=1 1-1·3; Anterior end to spear guide ring=73 μm; Odontostyle=92-98 μm; Odontophore=53 μm; DO=10-12; DN=11-14; RS_1N=50; LS_1N=50; S_2O=80.

Palampur *Camellia* population: 3♀♀: L=1.9 mm; a=37-39; b=5.8; c=63; V=50-52; G_1=11-13; G_2=11-13; Anterior end to spear guide ring=75 μm; Odontostyle=93-96 μm; Odontophore=53 μm; DO=9-12; DN=10-12; RS_1N=51; LS_1N=51; S_2O=77-81.

Description: Female: Body upon fixation 'C' shaped with tapering extremities. Cuticle in 2 layers, thickest in the region of vulva and on tail. Lateral chords about 1/4th of the body-width near middle.

Lip region rounded, almost continuous with the rest of body. Amphids stirrup-shaped with slit-like apertures which are nearly 3/5th of the labial-width. Odontostyle 8·0-9.5 labial-widths long, odontophore nearly 1/1. 8th of the odontostyle length. Fixed guiding ring is at 6.5-8.0 labial-widths from the oral aperture.

Basal bulb of oesophagus 2.0-2.5 times of the corresponding body-width and 20% of neck length long. Position of oesophageal gland nuclei and their orifices as given above. Nerve ring surrounds the anterior slender part of oesophagus at about one labial-width from the base of odontophore. Prerectum 4-5 anal body-widths long and is distin-

guishable from the intestine in being narrow and in having fewer granules in its cells. Rectum about one anal body-width long.

Genital tract amphidelphic, each sexual branch consisting of a reflexed ovary, a distal narrow and a proximal expanded part of oviduct and a short uterus. Vagina about 1/3rd of the corresponding body-width long. Vulva at 48-53% of total body length from the anterior extremity.

Tail short and conoid, 1 1-1.5 anal body-widths long and provided with 2 caudal papillae on each side.

Male: A single male specimen was collected from soil around the roots of grasses (unidentified) from Banikhet, near Dalhousie, Chamba, H. P. Morphologically it is similar to the females except for more stronger curvature of its posterior end. Genital tract triorchic with two anteriorly directed and one reflexed testis. This triorchic condition is considered an abnormality rather than a rule. Supplements consist of an adanal pair and a series of 4 ventromedians which are spaced as shown in Text-fig. 3, F. Spicules about 1 5 anal body-widths long.

Tail short and conoid, about one anal body-width long, provided with 2 papillae on each side.

Hosts and localities: Soil around roots of i. grasses (unidentified from Ranikhet, Almora, U. P. ii. grasses (unidentified) from Banikhet, Chamba, H. P. iii. wild plant (unidentified) from Mussoorie, Dehra Dun, U. P. and iv. *Camellia sinensis* from Bandla Tea Estate, Palampur, H. P.

Remarks: *Xiphinema inaequale* first described as *X. neoamericanum* by S. H. Khan & Ahmad (1975) was later renamed *X. inaequale* as it was found to be a junior hononym of *X. neoamericaum* Saxena *et al.*, 1973. This species is very closely related to *X. americanum* and *X. brevicolle*. In fact, Luc & Dalmasso (1975) have synonymised it with *X. americanum* as the shape of lip region, and the position of guiding ring mentioned as points of difference between the two species by S. H. Khan & Ahmad are not acceptable to them. Loof & Lamberti (1976) also consider this species to be a synonym but of *X. brevicolle*. The study of the male of *X. inaequale* reported here for the first time shows that this species can be separated on the characters of male from both *X. americanum* and *X. brevicolle* (*cf.* Cohn, 1969). The males of these two species have robust spicules and the supplements consist of an adanal pair and a series of 5-8 ventromedians which are regularly spaced with the distance between adanal pair and the first supplement being equal to the space between any two adjacent ventromedians. In *X. inaequale* on the other hand the spicules are less robust and the first supplement is spaced at about twice the distance between any two adjacent ventromedians. The total number of ventromedians is also only 4.

5. Xiphinema lambertii Bajaj & Jairajpuri

(Text-fig. 5, F-J)

1976. *Xiphinema lambertii:* Bajaj & Jairajpuri, *Nematol. medit.*, 4 : 195

Dimensions: Dehra Dun piegon pea population: 6♀♀: L=1.31 1.41 mm; a=47-51; b=5.2-5.7; c=37-46; V=49-52; G_1=10-13; G_2=10-13; c'=1.6-1.9; Anterior end of spear guide ring=48-54 μm; Odontostyle=55-63 μm; Odontophore=39 μm; DO=12-15; DN=13-15; RS_1N=55-60; LS_1N=55-60; S_2O=75-80.

Bareilly mango population: 8♀♀: L=1.32-1.46 mm; a=47-51; b=5.4-5.9; c=40-50; V=51-53; G_1=10-12; G_2=10-13; c'=1 7-2.0; Anterior end to spear guide ring=52 μm; Odontostyle=56-64 μm; Odontophore=38-40 μm; DO=12-15; DN=13-15; RS_1N=57-59; LS_1N=57-60; S_2O=75-80.

Description: Female: Body upon fixation 'C' shaped, tapering towards both the extremities. Cuticle in 2 layers, thickest on tail. Lateral chords about 1/4th of the midbody-width.

Lip region rounded, slightly offset from the rest of body. Amphids stirrup-shaped with slit-like apertures which are nearly 3/5th of labial width and located at the base of lip region. Odontostyle 6-7 labial-widths long, odontophore nearly 2/3rd of the odontostyle length. Fixed guiding ring is at 5-6 labial-widths from the anterior extremity.

Basal bulb of oesophagus 2.4 times of the corresponding body-width and 24% of neck length long. Position of oesophageal gland nuclei and their orifices as given above. Cardia short and conoid. Nerve ring surrounding the anterior slender part of oesophagus at about 2 labial-widths from the base of odontophore. Prerectum 5-6 times of the anal body-width long. Rectum about one anal body-width long.

Genital tract amphidelphic, each sexual branch consisting of a reflexed ovary, a distal narrow and a proximal expanded part of oviduct, and a uterus. Vagina is about 1/3rd of the corresponding body-width long. Vulva is at 49-53% of total body length from anterior extremity.

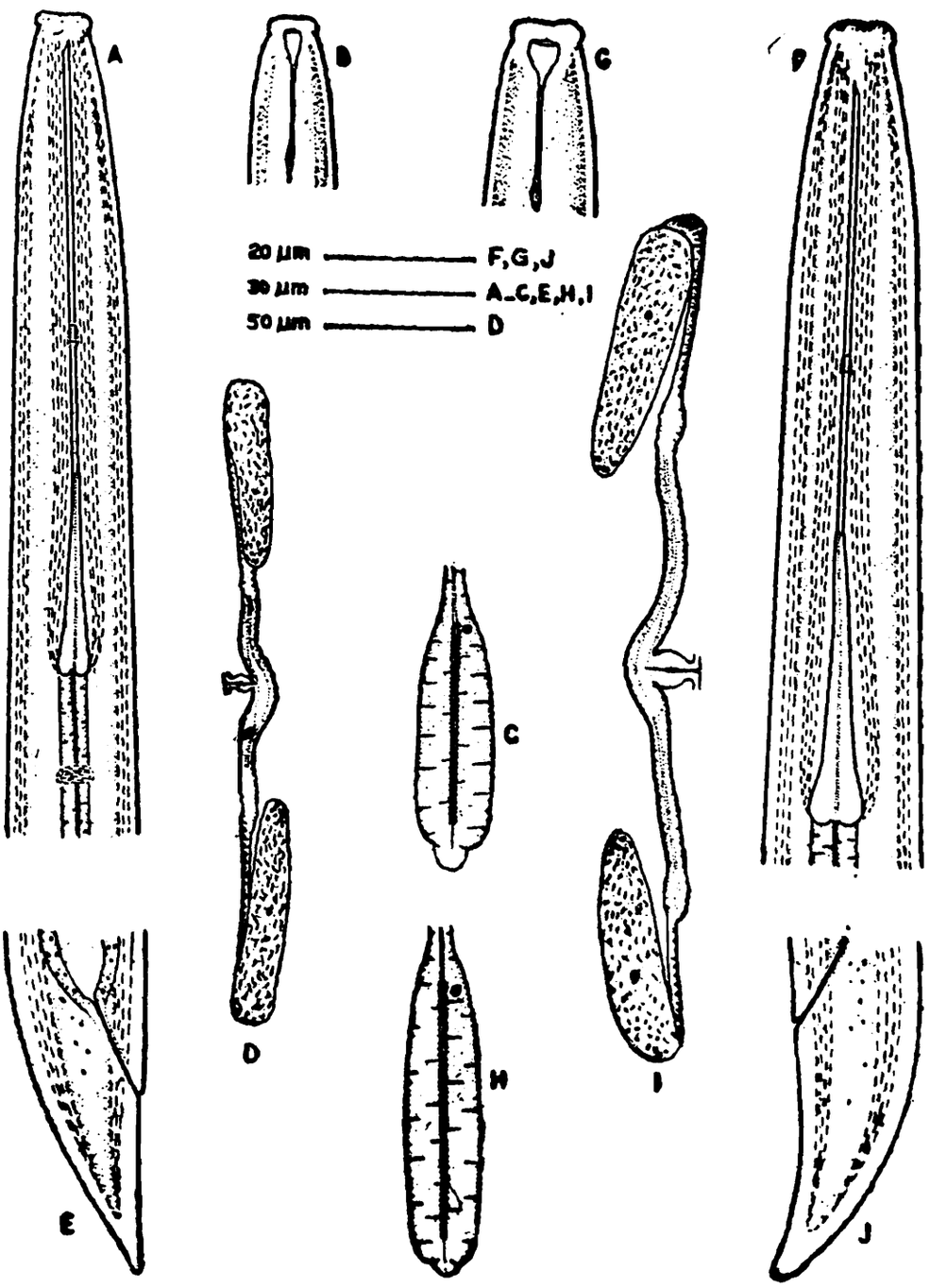
Tail narrow, elongate-conoid, 1 6-2.0 times of the anal body-width long and provided with 2 papillae on each side.

Male: Not found.

Hosts and localities: Soil around roots of i. *Cajanus cajan* from Rajpur, Dehra Dun, U. P. and ii. *Mangifera indica* from Bareilly, U. P.

Remarks: This species is closely related with *X. americanum* Cobb,

1913 from which it differs in being smaller, in having smaller spear and a differently shaped tail (L=1.6-1.8 mm; spear=120-140 μm; tail conoid with sharp curvature on dorsal surface in *X. americanum*). This species has so far been reported from India only.



Text-fig. 5.—A-E *Xiphinema neoelongatum* Bajaj & Jairajpuri: (A) Anterior extremity. (B) Lip region. (C) Oesophageal bulb (D) Female genital tract. (E) Female tail. F-J *Xiphinema lambertii* Bajaj & Jairajpuri: (F) Anterior extremity. (G) Lip region. (H) Oesophageal bulb. (I) Female genital tract. (J) Female tail.

6. Xiphinema neoelongatum Bajaj & Jairajpuri

(Text-fig. 5, A.—E)

1976. *Xiphinema neoelongatum:* Bajaj & Jairajpuri, *Nematol. medit.*, 4 : 198.

Dimensions: 4♀♀: L=1.4-1.7 mm; a=37-46; b=4.3-6.9; c=40-50; V=54-55; G_1=12-14; G_2=12-14; c'=1.4-1.8; Anterior end to spear guide ring=64-69 μm; Odontostyle=92-96 μm; Odontophore=42-46 μm; DO=12; DN=13; RS_1N=60-63; LS_1N=60-63; S_2O=77-80

Description: Female: Body upon fixation 'C' shaped with tapering extremities. Cuticle in 2 layers, thickest on tail. Fine radial striae clearly visible in the region of neck and on tail. Lateral chords about 1/4th of the midbody-width.

Lip region low, slightly offset from body. Amphids stirrup-shaped with slit-like apertures located at the base of lip region. Odontostyle 8-9 labial-widths long, odontophore nearly one-half of the odontostyle length. Fixed guiding ring is at 7-8 labial-widths from the anterior extremity.

Basal bulb of oesophagus 1.5 times of the corresponding body-width and 17% of neck length long. Position of oesophageal gland nuclei and their orifices as given above. Cardia short and conoid. Nerve ring surrounds the anterior slender part of oesophagus at about 2 labial-widths from the base of odontophore. Prerectum indistinguishable from intestine. Rectum about one anal body-width long.

Genital tract amphidelphic, each sexual branch consisting of a reflexed ovary, distal narrow and proximal expanded parts of oviduct, and a short uterus. Vagina is about 1/3rd of the corresponding body-width long. Vulva is at 55% of total body length from anterior extremity.

Tail short, convex-conoid ending in a subdigitate terminus, 1.4-1.8 times of the anal body-width long and provided with 2 papillae on each side.

Male: Not found.

Host and locality: Soil around roots of *Psidium guajava* from Ambala, Punjab.

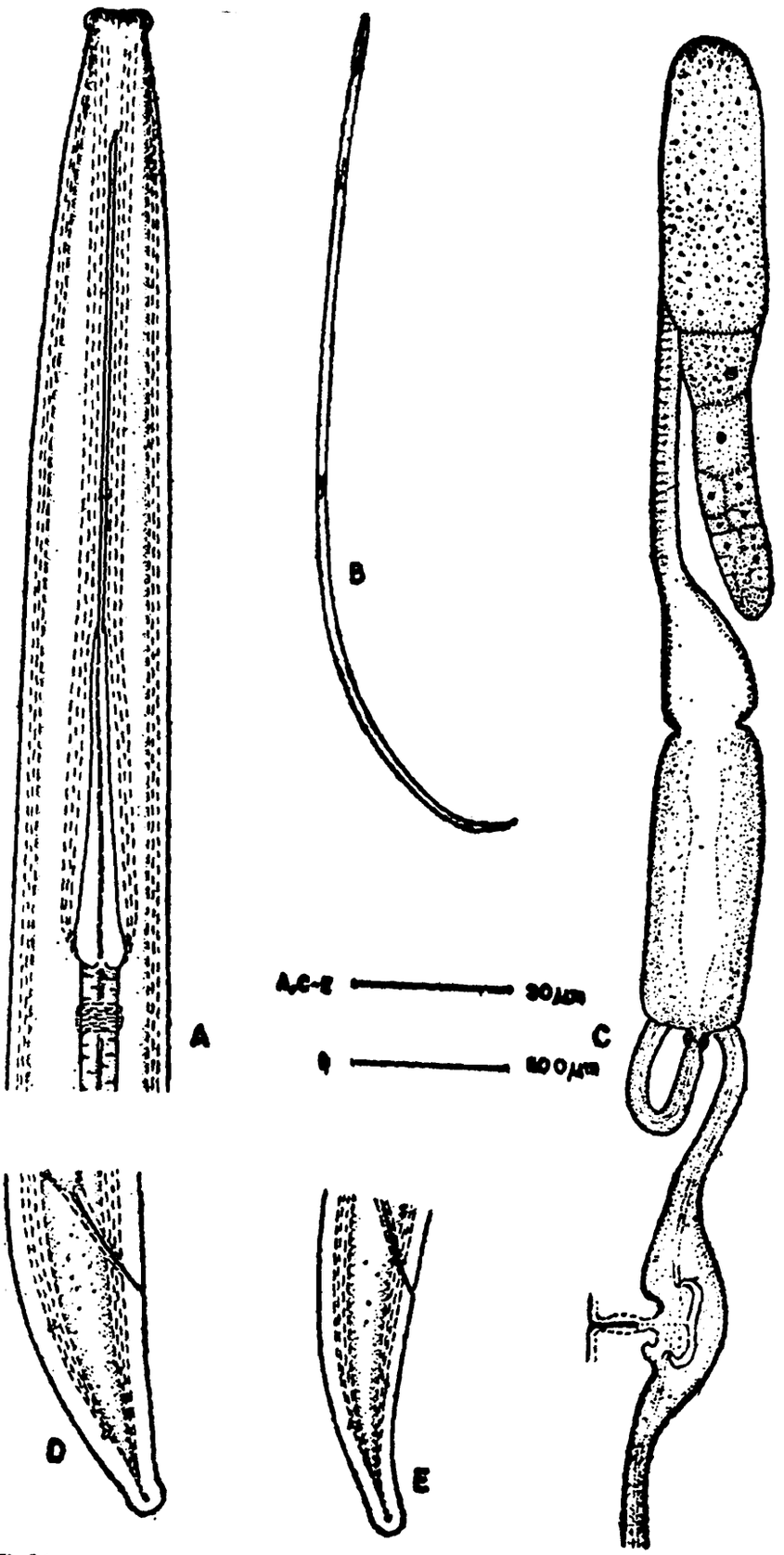
Remarks: This species is closely related with *X. mediterraneum* Martelli & Lamberti, 1967 from which it differs in being more robust, having a differently shaped and less offset lip region; in tail shape; and in lower value of c ratio. This species has not so far been reported from outside India.

7. **Xiphinema luci** sp. n.

(Text-fig. 6)

Dimensions: Paratypes (5♀♀): L=3.03-3.19 mm; a=90-100; b=8.1-9.0; c=76-91; V=49-54; G_1=6-8; G_2=6-8; c'=1 7-2.0; Anterior end to spear guide ring=77-83 μm; Odontostyle=83-86 μm; Odontophore=56-58 μm; DO=7.5-9.0; DN=7 5-10.4; RS_1N=46.5-53.2; S_2O=77.5-85.5; LS_1N=47.0-53.2.

Holotype ♀: L=3.03 mm; a=90; b=8.1; c=76; V=50.5; G_1=6 G_2=6; c′=2.0; Anterior end to spear guide ring=77 μm; Odontostyle =86 μm; Odontophore=58 μm; DO=9; DN=9; RS_1N=52; LS_1N =51; S_2O=81



Text-fig. 6.—*Xiphinema luci* sp. n.: (A) Anterior extremity. (B) Entire female (C) Female anterior sexual branch: (D) Female tail. (E) Tail of L_4.

Description: Female: Body upon fixation 'C' shaped, almost cylindrical with tapering extremities. Cuticle in 2 layers, thickest in the region of tail. Lateral chords about 1/4th of the body-width near middle.

Lip region expanded and offset from the rest of body by a deep constriction. Amphids stirrup-shaped with slit-like apertures which are nearly 3/5th of the labial-width. Odontostyle about 7 labial-widths long, odontophore about 4/7th of the odontostyle length. Fixed guiding ring is at about 7 labial-widths from the oral aperture.

Basal bulb of oesophagus about thrice the corresponding body width and 25% of neck length long. Position of oesophageal gland nuclei and their orifices as given above. Cardia short and conoid. Nerve ring surrounding the anterior slender part of the oesophagus at about one labial-width from base of odontophore. Prerectum indistinguishable from intestine. Rectum about 1.4 times of the anal body-width long.

Genital tract amphidelphic, each sexual branch consisting of a reflexed ovary, distal narrow and proximal expanded parts of the oviduct, an expanded part and a narrow portion of uterus. A distinct sphincter is present between the expanded and narrow parts of uterus. Expanded part of uterus rectangular in shape, measuring 53-58 × 18-20 µm. Vagina about one-half of the corresponding body-width long. Vulva at 48-53% of total body length from the anterior extremity.

Tail elongate-conoid with clavate terminus. Inner core of the cuticle extends just up to the tip of the tail and forms a vesicle. It is 1.8-2.0 times of the anal body-width long and provided with 2 papillae on each side.

Male: Not found.

Type host and locality: Soil around roots of *Phaseolus aureus* from Mukhapur, Ajmer, Rajasthan.

Type material: Holotype on slide *Xiphinema luci* sp. n./1, paratypes on slides *X. luci* sp. n./2-4; deposited with the Zoology Department of Aligarh Muslim University.

Differential diagnosis: The new species comes close to *Xiphinema italiae* Meyl, 1953, but differs in the shape of expanded part of uterus position of sphincter muscles, shape of tail and in values of c and c' ratios (in *X. italiae* expanded part of the uterus is rounded, sphincter is present between the oviduct and uterus, tail is more elongate-conoid or conoid-digitate with pointed terminus, inner core of the cuticle does not extend up to the tail tip and also does not form a vesicle, and the values of c and c' ratios are 43 and 3.0 respectively).

This new species is named in honour or Dr. M. Luc, Museum National d'Historie Naturelle, Laboratorie de Zoologie (Vers), Paris, France.

8. **Xiphinema elongatum** Schuurmans-Stekhoven & Teunissen

(Text-fig. 7, I-L)

1938. *Xiphinema elongatum:* Schuurmans-Stekhoven & Teunissen, *Expl. Natl. Albert.*, 22 : 229.
1949. *Xiphinema pratensis:* Loos, *J. zool. Soc. India*, 1 : 24.
1951. *Xiphinema campinense:* Lordello, *Bragantia*, 4 : 313.
1961. *Xiphinema pratense:* Siddiqi, *Z. Parasitkde*, 20 : 461.
1963. *Xiphinema elongatum:* Tarjan & Luc, *Nematologica*, 9 : 167.
1972. *Xiphinema elongatum:* Cohn & Sher, *J. Nematol.*, 4 : 56.
1972. *Xiphinema elongatum:* Loof & Maas, *Nematologica*, 18 : 109.
1974. *Xiphinema elongatum*: Heyns, *Phytophylactica*, 6 : 249.

Dimensions: 5♀♀: L=2.05-2.15 mm; a=53-56; b=5.0-5.4; c=40-46; V=43.8-44.6; G_1=10-14; G_2=10-14; c'=2.0; Anterior end to spear guide ring=94-97 μm; Odontostyle=103-105 μm; Odontophore=59-63 μm; DO=12-13; DN=12-13; RS_1N=51-55; LS_1N=51-55; S_2O=77-80.

Description: Female: Body upon fixation only slightly ventrally curved, long and slender with tapering extremities. Cuticle with fine radial striae which are thickest on the tail. Lateral chords about 1/4th of the corresponding body-width.

Lip region rounded, slightly offset. Amphids stirrup-shaped with slit-like apertures which are nearly 3/5th of the labial-width and located at base of lip region. Odontostyle 9-10 labial-widths long; odontophore nearly 1/1 7th of the odontostyle length. Fixed guiding ring is at 8-9 labial-widths from the oral aperture.

Basal bulb of oesophagus nearly 2.5 times of the corresponding body width and 20% of neck length long. Position of oesophageal gland nuclei and their orifices as given above. Cardia short and conoid. Nerve ring surrounding the anterior slender part of oesophagus at about 2 labial-widths from the base of odontophore. Prerectum distinct in being narrow and in having fewer granules in its cells. Rectum about one anal body-width long.

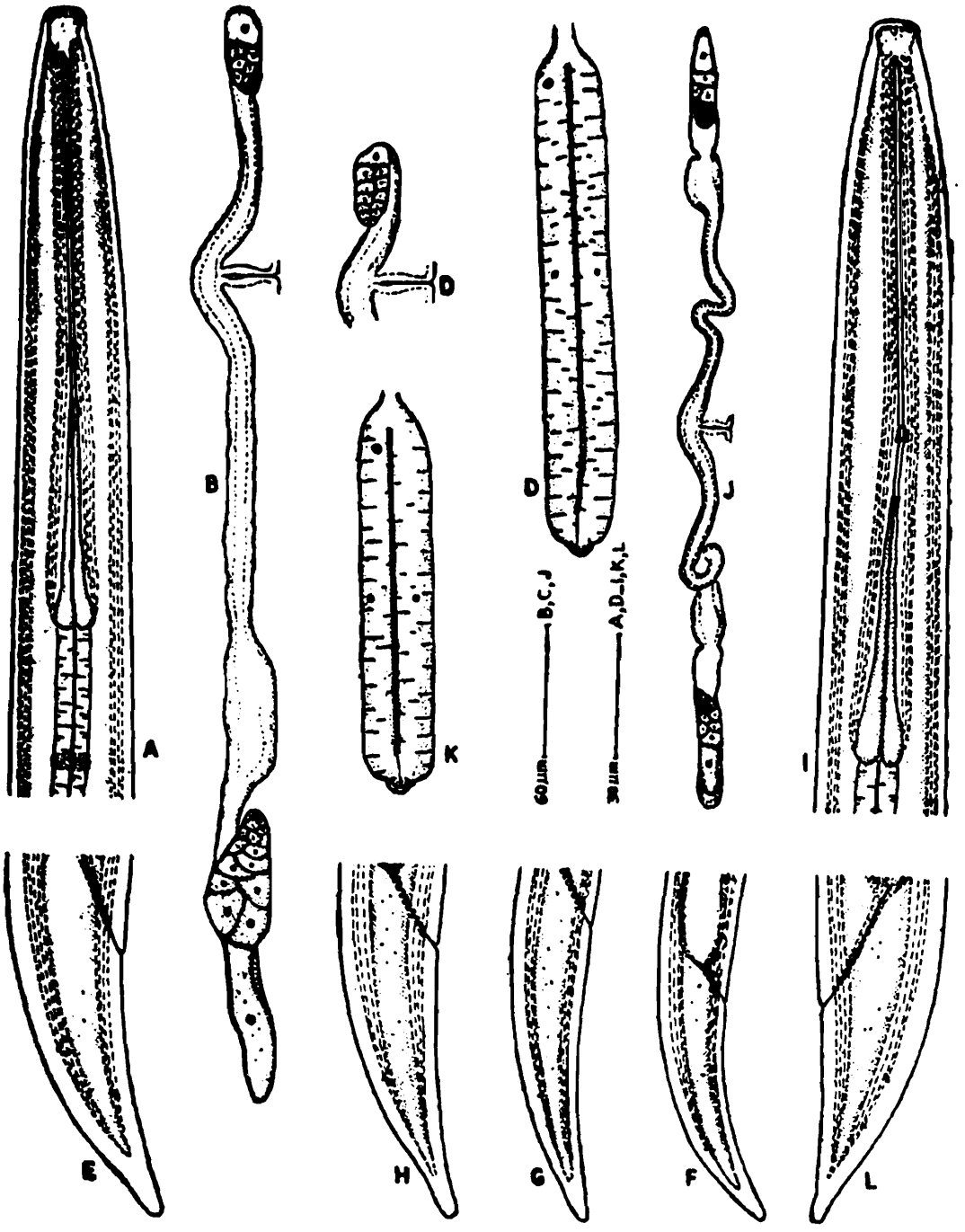
Genital tract amphidelphic, both the sexual branches being equally developed. Each sexual branch consists of a reflexed ovary, distal narrow and a proximal expanded part of oviduct, and a long convoluted uterus which also consists of distal expanded part and proximal narrow portions. The vagina is thick-walled, about one-half of the corresponding body-width. Vulva at 40-44% of total body length from the anterior extremity.

Tail elongate-conoid with subdigitate terminus, 2.0-2.5 times of the anal body-width long and provided with 2-3 papillae on each side,

Male: Not found.

Host and locality: Soil around roots of *Hibiscus rosasinensis* from Shahjanpur, U. P.

Remarks: This species was reported by Siddiqi (1961) from India but was labelled as *X. pratense* Loos, 1949 which was later on syno-



Text-fig. 7.—A-H *Xiphinema orbum* Siddiqi: (A) Anterior extremity (B) Female genital tract. (C) Anterior sexual branch in one of the females. (D) Oesophageal bulb. (E) Female tail. (F-H) Tails of L_2, L_3 & L_4 respectively. (I-L) *Xiphinema elongatum* Schuurmans Stekhoven & Teunissen: (I) Anteiror extremity. (J) Female genital tract. (K) Oesophageal bulb. (L) Female tail.

nymised with *X. elongatum* by Tarjan & Luc (1963). Loof & Maas (1972) have reported this species from Surinam. They observed weakly de-

veloped sclerotized apophyses in the uteri of a female specimen. Heyns (1974) has reported this species from South Africa and has studied its intraspecific variations. However, the South African specimens are longer than those described by Tarjan & Luc, Loof & Maas or Siddiqi. The present specimens from India are very similar to those described by Siddiqi, Tarjan & Luc or Loof & Maas except that the weakly developed sclerotized apophyses observed by Loof & Maas are not present in Indian females of this species as is also the case with the specimens studied by other authors.

Xiphinema elongatum is very closely related to *X. insigne* Loos, 1949 differing only in the position of vulva (V=30:40) and in the size of the tail (c′=5:2.5).

Xiphinema elongatum is cosmopolitan in distribution. It has been described under the name of *X. pratense* Loos, 1949 and *X. campinense* Lordello, 1951 from different parts of the world.

9. **Xiphinema insigne** Loss

(Text-fig. 8)

1949. *Xiphinema insigne*: Loos, *J. zool. Soc. India*, **1** : 25.
1959. *Xiphinema indicum*: Siddiqi, *Proc. helminth. Soc. Wash.*, **26** : 152.
1963. *Xiphinema insigne*: Tarjan & Luc, *Nematologica*, 9 : 163.
1969. *Xiphinema insigne*: Cohn, *Nematologica*, **15** : 183.
1971. *Xiphinema insigne*: Saigusa & Yamamoto, *Res. Bull. Pl. Prot. Serv. Japan*, 9 : 27.
1972. *Xiphinema insigne*: Cohn & Sher, *J. Nematol.*, **4** : 60
1977. *Xiphinema insigne*: Bajaj & Jairajpuri, *Nematologica*, **23** : 33

Dimensions: 171♀♀: L=1.9-2.5 mm; a=50-70; b=5.2-8.1; c=15-35 V=28-36; c′=3.0-8.5; Anterior end to spear guide ring.= 80-110 μm; Odontostyle=80-111 μm; Odontophore=55-64 μm;

5♂♂: L=2.1-2.3 mm; a=52-65; b=5.3-6.3; c=47-54; c′=1.4-1 7; Anterior end to spear guide ring=87-98 μm; Odontostyle=93-104 μm; Odontophore=51-61 μm; Spicule length=53-58 μm.

7L_1 :L=0.7-0.9 mm; a=40-52; b=2.9-3.8; c=11-14; c′=6.2-8.0. Anterior end to spear guide ring=33-37 μm; Functional odontostyle= 36-45 μm; Replacement odontostyle=55-57 um; Odontophore=33-35 μm.

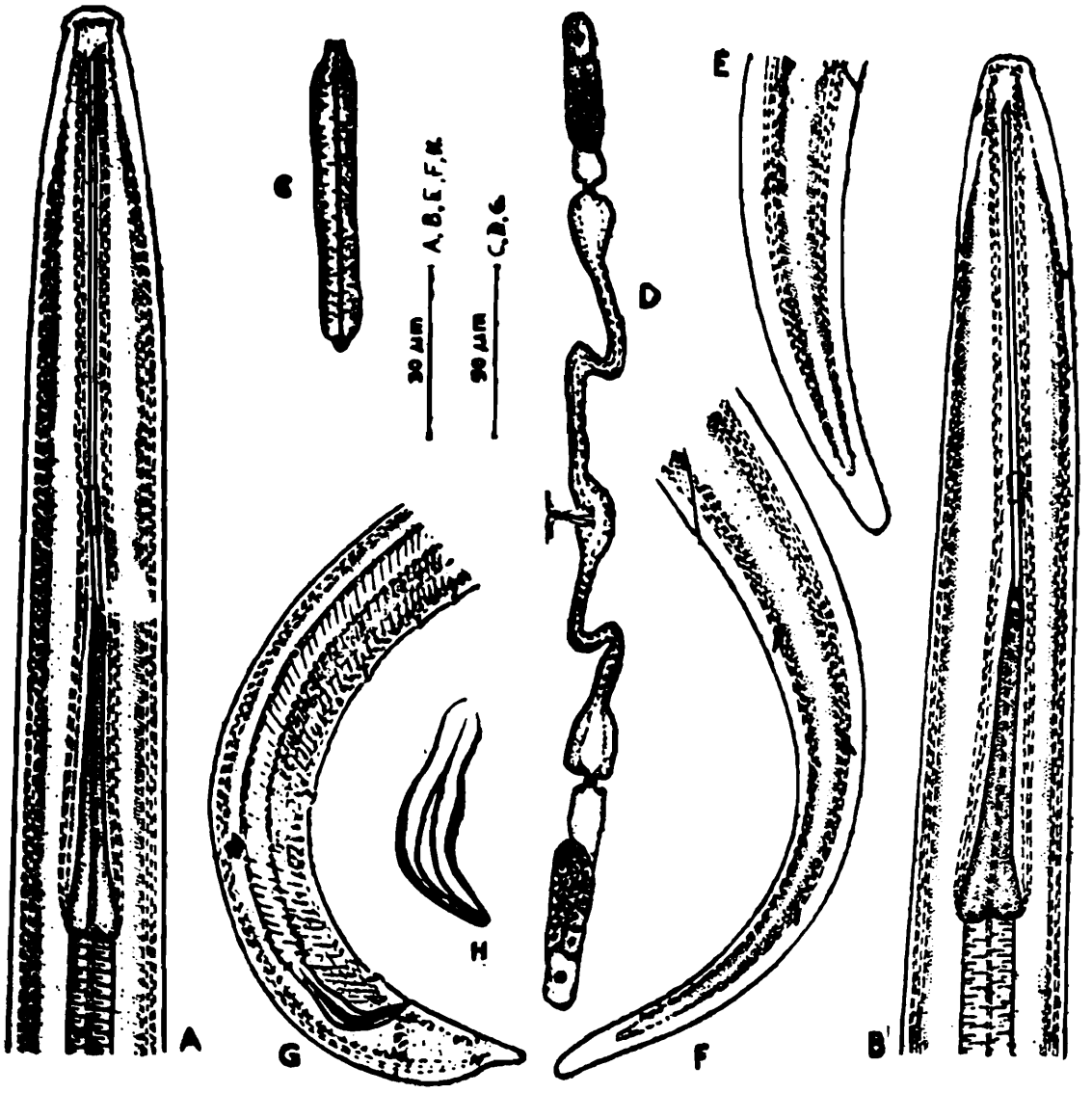
19L_2: L=0.8-1 1 mm; a=43-52; b=3.3-4.7; c=11-15; c′=5-8; Anterior end to spear guide ring=36-50 μm; Functional odontostyle=50-55 μm; Replacement odontostyle=66-74 μm; Odontophore=36-42 μm.

68L_3: L=1 1-1 5 mm; a=46-72; b=4.2-5.0; c=12-18; c′=4-9

Anterior end to spear guide ring=55-66 μm; Functional odontostyle=60-72 μm; Replacement odontostyle=77-95 μm; Odontophore=42-51 μm.

75L_4: L=1 5-1 7 mm; a=49-69; b=4.3-6.0; c=13-36; c'=4-8; Anterior end to spear guide ring=66-83 μm; Functional odontostyle=75-94 μm; Replacement odontostyle=90-106 um; Odontophore=48-55 μm

Description: Female: Body long and slender with rounded anterior and elongate-conoid posterior extremity. Outer cuticle smooth, inner finely striated. It is thickest in region of vulva and on tail. Lateral chords about 1/4th of the body-width near middle.



Text-fig. 8.—*Xiphinema insigne* Loos: (A & B) Anterior extremities. (C) Oesophageal bulb. (D) Female genital tract. (E & F) Female tails. (G) Male posterior extremity. (H) Spicule.

Lip region almost flat or rounded and slightly offset to well offset. Amphids stirrup-shaped with slit-like apertures which are nearly 3/5th of the labial-width and are located at the base of lip region. Odonto-

style 7.3-10.0 labial-widths long, odontophore nearly 2/3rd of the odontostyle length. Fixed guiding ring is at 7.3-10.0 labial-width from the oral aperture.

Basal bulb of oesophagus 1 7-2.9 times of the corresponding body-width and 20% of the neck length long. Position of oesophageal gland nuclei and their orifices as follows:

DO=7 5-13	RS_1N=53-58	S_2O=80-91
DN=7 5-13	LS_1N=53-59	

Cardia short and conoid. Nerve ring surrounding the anterior slender part of the oesophagus at about 2 labial-widths from the base of odontophore. Prerectum 18-25% of total body length and 18-20 times of the anal body-width long. It is distinguishable from the intestine in being narrow and in having fewer granules in its cells. Rectum 1.2-1.5 times of the anal-body-width long.

Genital tract amphidelphic, each sexual branch consisting of a reflexed ovary, distal narrow and proximal expanded parts of oviduct. a distinct sphincter, and an expanded and a convoluted part of uterus The anterior ovary in most of the specimens is greatly reduced. The vagina about one-half of the corresponding body-width long and opening through a conspicuous vulva at 29-32% of total body length from the anterior extremity.

Tail narrow, conoid to elongate filiform, 3.0-8.5 times of the anal body-width long and provided with 3-4 papillae on each side.

Male: They resemble the females except for stronger curvature at hinder end. Spicules well developed and sharply ventrally curved. Lateral guiding pieces finger-like, 16 μm long. Supplements consist of an adanal pair and a series of 3-5 ventromedians which are spaced as shown in Text-fig. 8.

Tail conoid, ending in a digitate terminus. It is 1.4-1.7 times of the anal body-width long and provided with 2 papillae on each side.

Juveniles: The various juvenile stages differ from one another in total body length, in length of functional and replacement odontostyles, position of fixed guiding ring from the anterior extremity and in values of c and c′ ratios.

For discussion and detailed description of intraspecific variations of this species see Bajaj & Jairajpuri (1977).

10. **Xiphinema orbum** Siddiqi

(Text-fig. 7, A-H)

1963. *Xiphinema orbum*: Siddiqi, *Nematologica*, 9 : 632.

Dimensions: Bareilly maize population: 5♀♀: L=2.8-3.1 mm; a=72-80; b=7.6-8.0; c=41-45; V=28-30; G_1=1-6; G_2=9-15; c'=2.5-2.8; Anterior end to spear guide ring=75-80 μm; Odontostyle=82-88 μm; Odontophore=57-59 μm; DO=7-11; DN=9-14; RS_1N=52-54; LS_1N=51-55; S_2O=77-80.

$4L_2$: L=1.1-1.5 mm; a=51-58; b=4.2-5.1; c=50-27; c'=3.3-3.7 Anterior end to spear guide ring=40-48 μm; Functional odontostyle =46-50 μm; Replacement odontostyle=60-66 μm; Odontophore= 42 μm; DO=8; DN= 10-13; RS_1N=46-50; LS_1N=48-52; S_2O= 74-76.

$4L_3$: L=1.8-2.2 mm; a =63-72; b=8.0-9.0; c=28-30; c'=3.4-3.9; Anterior end to spear guide ring=53-58 μm; Functional odontostyle= 57-65; μm; Replacement odontostyle=70-75 μm; Odontophore=46-50 μm; DO=8; DN=11-16; RS_1N=52; LS_1N=51-53; S_2O=76-80.

$4L_4$: L=2.0-2.4 mm; a=73-83; b=5.6-7.1; c=30-38; c'=2.4-2.7 Anterior end to spear guide ring=62-68 μm; Functional odontostyle= 70-77 um; Replacement odontostyle=82-88 um; Odontophore=55 μm; DO=9; DN=10-12; RS_1N=52-58; LS_1N=51-54; S_2O=78-83.

Bareilly wild plants population: 5♀♀: L=2.9-3.1 mm; a=75-86; b=7.6-8.0; c=44-47; V=28-29; G_1=3-4; G_2=11-15; c'=2.6-2.8; Anterior end to spear guide ring=77-81 μm; Odontostyle=83-87 μm; Odontophore=58 μm; DO=7-10; DN=10-13; RS_1N=53; LS_1N= 53; S_2O=77-80.

Description: Female: Body long and slender with tapering extremities. Cuticle thickest on tail, in 2 layers, outer smooth, inner with fine striae. Lateral chords about 1/4th of the body-width near middle.

Lip region rounded, well offset. Amphids strirup-shaped with slit-like apertures which are nearly 3/4th of the labial-width and are located just above the base of lip region. Odontostyle 7-8 labial widths long, odontophore nearly 1/1.4 of the odontostyle length. Fixed guiding ring is at 7 labial-widths from the oral aperture.

Basal bulb of oesophagus thrice the corresponding body-width and 20% of neck length long. Position of oesophageal gland nuclei and their orifices as given above. Cardia short and conoid. Nerve ring surrounding the anterior slender part of oesophagus at about 4 labial-widths from the base of odontophore. Prerectum indistinguishable from intestine. Rectum about one anal-body-width long.

Genital tract amphidelphic, but the anterior sexual branch including the ovary is greatly reduced. In one of the present specimens the anterior sexual branch is very short and is represented by an ovary only (Text-fig. 7, C). Each sexual branch consists of a reflexed ovary, distal

narrow and proximal expanded parts of oviduct, and expanded and narrow portions of uterus. The vagina is thick-walled, one-half of the corresponding body-width long. Vulva located at 28-30% of total body length from the anterior extremity.

Tail elongate conoid, 2.5-2.8 times of the anal body-width long and provided with 2 papillae on each side.

Male: Not found.

Juveniles: Various juvenile stages differ from one another in lengths of odontostyles (both functional and replacement), position of fixed guiding ring from the anterior extremity, shape and size of tail and in values of c and c′ ratios. Tail is more elongate and narrow in L_2 and L_3 than L_4 which very much resemble the adult tail.

Hosts and localities: Soil around roots of *Zea mays* and wild plants (unidentified) from Rudrapur, Bareilly, U. P.

Remarks: This species was described from India by Siddiqi (1964) from soil around the roots of *Oryza sativa* from Patna, Bihar and has not so far been reported from any other country.

This species is unique among Indian species of *Xiphinema* because of its greatly reduced organs of the anterior sexual branch. Some other species of *Xiphinema* may also have greatly reduced ovary but other structures are normal or may lack anterior sexual branch altogether. This species is also unique in having a very long expanded part of uterus in its posterior sexual branch and its amphidial aperture located slightly anterior to the base of lip region.

11. **Xiphinema basiri** Siddiqi

(Text-figs. 9 & 10)

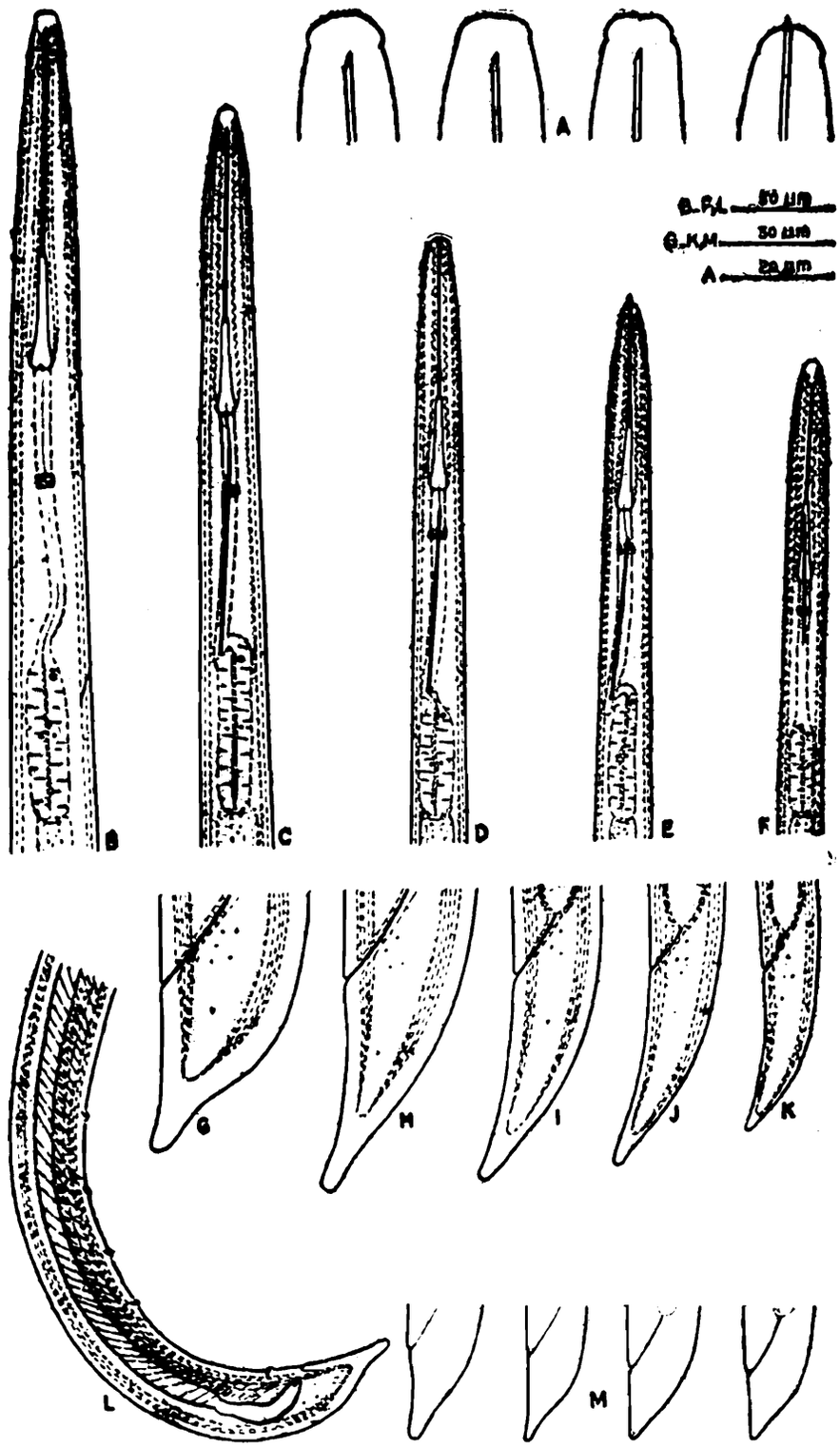
1959. *Xiphinema basiri*: Siddiqi, *Proc. helminth. Soc. Wash.*, **26** : 156.
1971. *Xiphinema basiri*: Loof & Yassin, *Nematologica*, **16** : 544.
1972. *Xiphinema basiri*: Cohn & Sher, *J. Nematol.*, **4** : 54.

Dimensions: 26♀♀: L=2.5-3.6 mm; a=54-75; b=5.8-9.6; c=59-95; V=48-53; G_1=12-16; G_2=12-16; c′=1.1-1.7; Anterior end to spear guide ring=81-113 μm; Odontostyle=103-127 μm; Odontophore=59-70 μm.

4♂♂: L=2.8-3.0 mm; a=63-72; b=6.8-7.3; c=87-92; c′=1.5; Anterior end to spear guide ring=110-115μ m; Odontostyle=117-124 μm; Odontophore=64-67 μm.

5 L_1: L=0.8-0.9 mm; a=38-45; b=4.8-4.9; c=21-22; c′=3.1; Anterior end to spear guide ring=42-44 μm; Functional Odontostyle=46-48 μm; Replacement odontostyle=60-63 μm; Odontophore=33 μm.

11 L_4: L=0.9-1.3 mm; a=30-55; b=3.7-5.6; c=21-30; c′=2.4-3.2; Anterior end to spear guide ring=48-67 μm; Functional odontostyle= 59-66 μm; Replacement odontostyle=70-85 μm; Odontophore =37-44 μm.



Text-fig. 9.—*Xiphinema basiri* Siddiqi: (A) Lip regions. (B) Oesophageal region of adult. (C-F) Oesophageal regions of L_4, L_3, L_2 & L_1 respectively. (G) Female tail. (H-K) Tails of L_4, L_3, L_2; & L_1 respectively. (L) Male tail. (M) Female tail.

15 L_3: L=1.4-2.0 mm; a=46-63; b=4.7-7.6; c=28-38; c′=2.1-2.8; Anterior end to spear guide ring=53-84 μm; Functional odonto

style=74-84 μm; Replacement odontostyle=93-103 μm; Odontophore =41-56 μm.

16 L_4: L=1.8-2.8 mm; a=45-76; b=5.1-7.6; c=40-62; c'=1.6-2.3 Anterior end to spear guide ring=79-96 μm; Functional odontostyle= 92-105 μm; Replacement odontostyle=107-128 μm; Odontophore= 48-65 μm.

Description: Female: Body long and slender with tapering extremities. Cuticle in 2 layers, thickest in the region of tail peg. Fine radial striae clearly visible on tail. Lateral chords about 1/3rd of the midbody-width.

Lip region rounded, usually slightly offset from the rest of body. Amphidsstirrup-shaped with slit-like apertures which are nearly 3/5th of the labial-width wide and are located at the base of lip region. Odontostyle 8.5-10.0 labial-widths long, odontophore nearly one-half of the odontostyle length. The fixed guiding ring is at 7.0-9.5 labial-widths from the oral aperture.

Basal bulb of the oesophagus 2.5 times of the corresponding body-width and about 25% of neck length long. Positions of various oesophageal gland nuclei and their orifices as follows:

DO = 7.5-12.5	RS_1N = 47-55	S_2O = 71-76
DN = 9.9-13.5	LS_1N = 47-55	

Nerve ring surrounding the anterior slender part of the oesophagus at about 2 labial-widths from the base of odontophore. Prerectum 12-17% of total body length and 12-20 times of anal body-width long. It is distinguishable from the intestine in being narrow and in having fewer granules in its cells. Rectum about one anal body-width long.

Genital tract amphidelphic, each sexual branch consisting of a reflexed ovary, distal narrow and proximal expanded parts of oviduct, a distinct sphincter, and expanded and convoluted portions of uterus. Globular pieces usually present in the convoluted part of uterus near its junction with expanded part. These pieces form 'pseudo Z organ'. The vagina about one-half of the corresponding body-width long and opening through conspicuous a vulva at 48-53% of total body-length from the anterior extremity.

Tail conoid-digitate, 1.1-1.7 times of the anal body-width long and provided with 2-3 papillae on each side.

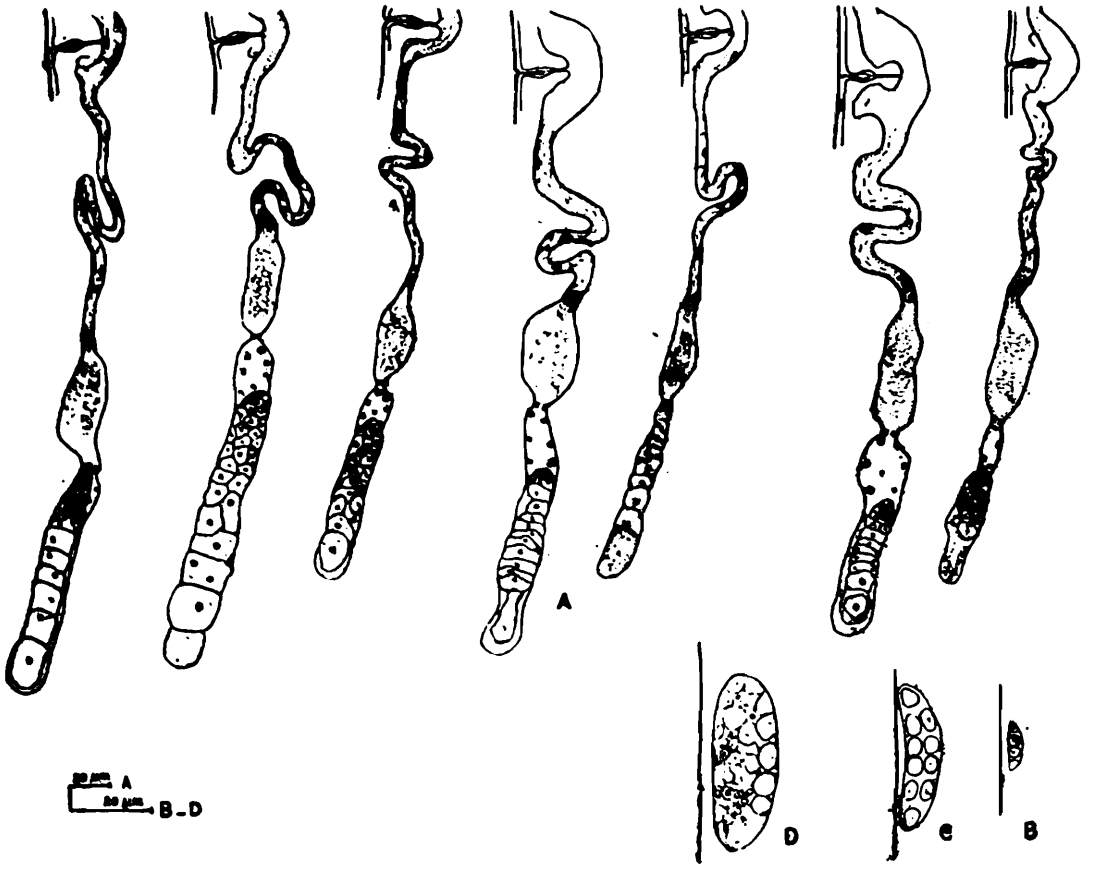
Male: Males resemble the females except for the more curvature at their posterior ends. Spicules well developed, ventrally arcuate and cephalated. Lateral guiding pieces 16 μm long. Supplements consist of an adanal pair and a series of 3-5 ventromedians which are spaced as shown in Text-fig. 9, H.

Tail conoid, ending in a digitate terminus. It is about 1.5 times of the anal body-width long and provided with two papillae on either side.

Juveniles: The various juvenile stages differ from one another in total body length, in lengths of functional and replacement odontostyles, position of fixed guiding ring from the anterior extremity, values of c and c′ ratios and tail shape.

Hosts and localities: Soil around roots of *Cirtus limnoia* from Jawahar Park, Aligarh.

Remarks: Siddiqi (1959) described this species from the roots of citrus from Aligarh, India. Yadav & Varma (1967) reported its frequent occurrence in Rajasthan in association with fruit-trees. It is also found in some other countries, e.g., Sudan (Yassin, 1974), Sri Lanka, Mexico, Rhodesia (Cohn & Sher, 1972).



Text-fig.10.—*Xiphinema basiri* Siddiqi: (A) Female posterior sexual branches. (B-D) Genital primordia of L_2, L_3 & L_4 respectively.

Xiphinema basiri is closely related with *X. coxi* Tarjan, 1964 and *X. ifacolum* Luc, 1961. Cohn & Sher (l.c.) synonymised *X. ifacolum* with *X. basiri* owing to overlapping values of L, a, b, c, V, length of spear and tail shape and in the presence of 'Z' organ. Luc & Dalmasso (1975) rejected this synonymy on the basis of differences in 'Z' organs (*X. ifacolum* has a 'Typical Z organ' while *X. basiri* a 'pseudo Z Organ'), and the structure of the tail tip of the two species (in *X.*

ifacolum the inner surface of the tail tip forms a thin and regular blind canal surrounded apically by a thin muff but in *X. basiri* the tail tip is without a large conical blind canal or any apical muff). *X. bastri* and *X. coxi* differ only in the position of vulva (V=40-44 in *X. coxi* and 48-53 in *X. basiri*) with range showing some overlap in the two species (*cf.* Cohn & Sher, l.c.). It is quite possible that the two species may be synonyms.

This species causes galling of the root of tomato (*cf.* Roy, 1974 & Bajaj & Jairajpuri, 1979) and is known to transmit cowpea mosaic virus in Western Nigeria (*cf.* Caveness *et al.*, 1975).

12. **Xiphinema index** Thorne & Allen

(Text-fig. 11, A-H)

1950. *Xiphinema index*: Thorne & Allen, *Proc. helminth. Soc. Wash.*, **17** : 27.
1961. *Xiphinema index*: Thorne, *Principles of Nematology*: 489.
1973. *Xiphinema index*: Southey, In *The Longidoridae;* 45.

Dimensions: 10♀♀: L=2.9-3.4 mm; a=51-65; b=6.9-8.0; c=67-88; V=38-41; G_1=8-13; G_2=8-13; c′=1.1-1.2; Anterior end to spear guide ring=118-121 μm; Odontostyle=123-132 μm; Odontophore=75-81 μm; DO=7-10; DN=10-14; RS_1N=55-68; LS_1N=55-68; S_2O=75—85.

$4L_2$: L=1.1-1.2 mm; a=40-46; b=3.9-4.2; c=21-27; c′=Anterior end to spear guide ring=55-59 μm; Functional odontostyle=62-66μm; Replacement odontostyle=83-85 μm; Odontophore=46-48 μm; DO=10; DN=10; RS_1N=47; LS_1N=47; S_2O=79.

$1L_3$: L=1.6 mm; a=55; b=4.3; c=35; c′= ?; Anterior end to spear guide ring=79 μm; Functional odontostyle=92 μm; Replacement odontostyle=106 μm; Odontophore=55 μm; DO=11; DN=13; RS_1N=42; LS_1N=48; S_2O=80.

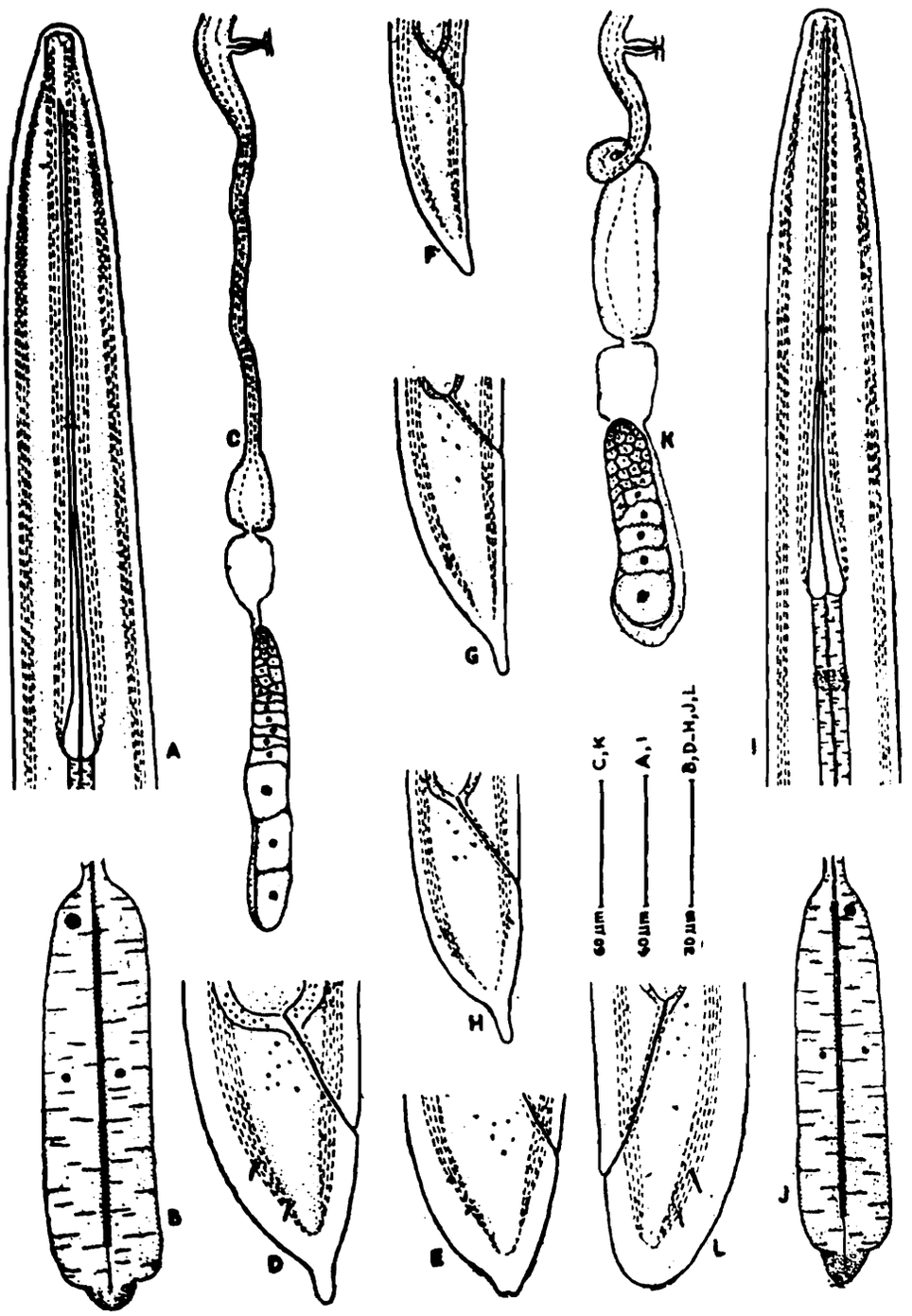
$6L_4$: L=1.9-2.3 mm; a=55-62; b=4.6-4.9; c=45-48; c′= ? Anterior end to spear guide ring=90-92 μm; Functional odontostyle =108-110 μm; Replacement odontostyle=128-132 μm; Odontophore=61-65 μm; DO=8-11; DN=9-14; RS_1N=45-55; LS_1N=45-55; S_2O =75-84.

Description: Female: Body long and slender with tapering anterior and rounded posterior extremity. Cuticle in 2 layers, inner one being thicker than the outer. Fine radial striae clearly visible on tail. Lateral chords about 1/4th of the body-width near middle.

Lip region rounded, slightly offset. Amphids stirrup-shaped with slit-like apertures which are nearly 3/5th of the labial-width and are located at the base of lip region. Odontostyle 8-9 labial-widths long,

odontophore nearly 1/1.6th of the odontostyle length. Fixed guiding ring is at 8 labial-widths from the oral aperture.

Basal bulb of oesophagus 2.0-2.5 times of the corresponding body-width and 25% of neck length long. Position of oesophageal gland nuclei and their orifices as given above. Cardia short and conoid. Nerve ring surrounding the anterior slender part of oesophagus at 1-2 labial widths from the base of odontophore. Prerectum about 9 anal body-widths long and is distinguishable from intestine in being narrow and



Text-fig. 11.—A-H *Xiphinema index* Thorne & Allen: (A) Anterior extremity. (B) Oesophageal bulb. (C) Female posterior sexual branch. (D & E) Female tails. (F-H) Tails of L_2, L_3 & L_4 respectively. I-L *Xiphinema arcum* Khan: (I) Anterior extremity. (J) Oesophageal bulb. (K) Female posterior sexual branch. (L) Female tail.

in having fewer granules in its cells. Rectum about one anal body-width long.

Genital tract amphidelphic, each sexual branch consisting of a reflexed ovary, distal narrow and proximal expanded parts of oviduct, a distinct sphincter followed by distal expanded and proximal convoluted portions of uterus. Vagina about one-half of the corresponding body-width long. Vulva is at 38-41% of total body length from the anterior extremity.

Tail short, dorsally convex, ventrally almost straight or slightly convex with a mammillate peg, about one anal body-width long and provided with 2-3 papillae on each side.

Male: Not found.

Juveniles: The various juvenile stages differ from one another in body lengths, length of odontostyles (both functional and replacement), position of fixed guiding ring from the anterior extremity, value of c and c′ ratios and in tail shape. Tail in L_2 is long, in L_3 is less thinner and with a digitate terminus while in L_4 it is short and conoid with a mammillate terminus.

Host and locality: Soil around roots of *Pyrus malus* from Ladakh Road, near university campus, Srinagar, Jammu & Kashmir.

Remarks: This species was first described by Thorne & Allen (1950) from soil around the roots of *Ficus carica* from California, U.S.A., but was later reported from many other parts of the world. Its distribution is closely related to that of its most important host, grapevine. So far it is known to occur in U.S.A., Argentina, Chile, France, Germany, Hungary, Italy, Greece, Turkey, Iran, Iraq, Israel, and North Africa. Mukhopadhayaya & Haque (1974) doubtfully mentioned its occurrence in West Bengal, India and it is here reported for the first time from Jammu & Kashmir, India.

This species is closely related to *X. basilgoodeyi* Coomans, 1964. The two species differ in the position of vulva (V=38.0-42.5 in *X. index* and 43.5-52.0 in *X. basilgoodeyi*).

This species is historically important because it was the first nematode which was demonstrated to act as vector of soil-borne viruses by Hewitt *et al.* (1958) who proved that this species transmits grapevine fanleaf virus. As an ectoparasite it reduces the growth of grapevine and causes darkening of its roots (Cohn & Orion, 1970).

13. **Xiphinema arcum** Khan

(Text-fig. 11, I-L)

1964. *Xiphinema arcum*: Khan *Nematologica*, **10** : 316.

Dimensions: 1♀: L=2.2 mm; a=50; b=5.4; c=76; V=35.6; G_1=9.2; G_2=15; c'=?; Anterior end to spear guide ring=90 μm; Odontostyle=110 μm; Odontophore=70 μm; DO=12.5; DN=12.5; RS_1N=52; LS_1N=52; S_2O=83

Description: Female: Body long and slender with tapering anterior end and rounded posterior extremity. Cuticle in 2 layers, thickest in the region of lips and on tail. Fine radial striae clearly visible on tail. Lateral chords about 1/3rd of the body-width near middle.

Lip region rounded, only slightly offset. Amphids stirrup-shaped with slit-like apertures which are nearly one-half of the labial-width and are located at the base of lip region. Odontostyle 9 labial-widths long, odontophore nearly 1/1.5th of the odontostyle length. Fixed guiding ring is at 7.5 labial-widths from the oral aperture.

Basal bulb of the oesophagus twice the corresponding body-width and 20% of neck length long. Position of oesophageal gland nuclei and their orifices as given above. Cardia short and conoid. Nerve ring surrounding the anterior slender part of oesophagus at about 2 labial-widths from the base of odontophore. Prerectum indistinguishable from intestine. Rectum twice the anal body-width long.

Genital tract amphidelphic, anterior sexual branch and anterior ovary shorter than the posterior sexual branch. Each sexual branch consists of a reflexed ovary, distal narrow and proximal expanded parts of oviduct, a distinct sphincter followed by expanded and narrow portions of uterus. Vagina about one-half of the corresponding body-width long. Vulva is at 35% of total body length from the anterior extremity.

Tail short, hemispheroid, about one anal body-width long and provided with 2 papillae on each side.

Male; Not found.

Host and locality: Soil around roots of *Aegle marmelos* from Ranikhet, U.P.

Remarks: Khan (1964) described 'Z' organ in each sexual branch but did not show in the figures. Actually, no 'Z' organ is present in the sexual branches of the holotype that was studied by the present authors. Also, Khan described two pairs of subventral gland nuclei but only one, the first pair is present and the second pair of subventral glands is represented only by their orifices as is typical of all the *Xiphinema* species.

This species is closely related to *Xiphinema hygrophilum* Southey & Luc. 1973 from which it differs in having longer body (L=1.8 mm

in *X. hygrophilum*) and shorter odontostyle (odontostyle=150 μm in *X. hygrophilum*).

This species is so far reported from India only.

14. **Xiphinema ensiculiferum** (Cobb)

(Text-fig. 12, A-D)

1893. *Tylencholaimus ensiculiferus*: Cobb, *Macleay Mem. Vol., Linn. Soc. N. S.W.* : 252.

1937. *Xiphinema ensiculiferum*: Thorne, *Proc. helminth. Soc. Wash.*, **4** : 14.

1939. *Xiphinema ensiculiferum*: Thorne, *Capita Zool.* **8** : 111.

1972. *Xiphinema ensiculiferoides*: Cohn & Sher, *J. Nematol.*, **4** : 50.

1973. *Xiphinema ensiculiferoides*: Yeates, *N. Z. Jl. Sci.*, **15** : 673.

1973. *Xiphinema ensiculiferum*: Southey & Luc, *Nematologica*, **19** : 294.

Dimensions: 6♀♀: L=1.6-1.9 mm; a=29-42; b=3.8-4.2; c=66-84; V=30-34; G_2=8-16; c′=0.5-0.8; Anterior end to spear guide ring= 116-132 μm; Odontostyle=138-151 μm; Odontophore=66-74 μm; DO=9-15; DN=13-16; RS_1N=47-53; LS_1N=47-53; S_2O=75-81.

Description: Female: Body upon fixation almost straight, cylindrical except for the slight tapering towards lip region. Cuticle in 2 layers, thickest in the tail region. Lateral chords about 1/4th of the body-width near middle.

Lip region flat, continuous with the rest of body. Amphids stirrup-shaped with slit-like apertures which are nearly 3/5th of the labial-width. Odontostyle 10-12 labial-widths long, odontophore about half of the odontostyle length. Fixed guiding ring is at 9-10 labial-widths from the oral aperture.

Basal bulb of oesophagus about 1.5 times of the corresponding body-width and about 15% of neck length long. Position of oesophageal gland nuclei and their orifices as given above. Cardia short and conoid. Nerve ring surrounding the anterior slender part of oesophagus at about one labial-width from the base of odontophore. Prerectum about 7 anal body-widths long and is distinguishable from intestine in having fewer granules in its cells. Rectum about one anal body-width long.

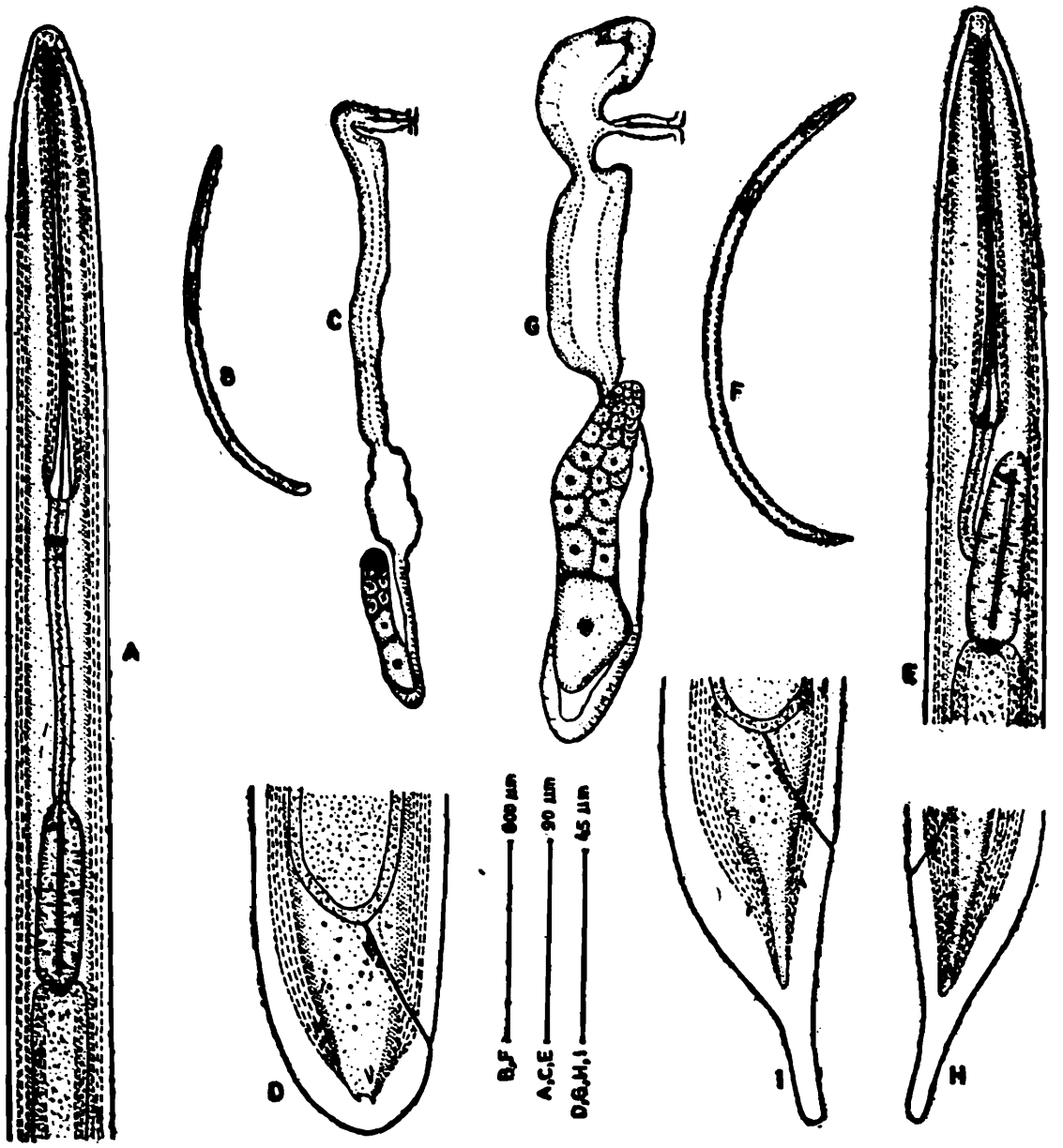
Genital tract mono-opisthodelphic, anterior sexual branch completely absent. Posterior sexual branch consists of a reflexed ovary, distal narrow and proximal expanded parts of oviduct, a distinct sphincter and a uterus. Vagina is less than one-half of the corresponding body-width long. Vulva is at 30-34% of total body length from the anterior extremity.

Tail hemispheroid, 0.5-0.8 times of the anal body-width long and provided with 2 papillae on each side.

Male: Not found.

Host and locality: Soil around roots of *Artocarpus heterophyllus* from Trivandrum, Kerala.

Remarks: This species was first described as *Tylencholaimus ensiculiferus* by Cobb (1893). Thorne (1937) transferred it to *Xiphinema*. Due to the loss of type material there was some uncertainity regarding the degree of reduction of anterior sexual branch as given in the original drawings and description by Cobb. Loos (1949) and Williams (1959) described populations of *Xiphinema* having tail similar to *X. ensiculiferum* and anterior sexual branch reduced to an undifferentiated sac as *X. ensiculiferum*. Luc (1961) redescribed this species from a population collected from Ivory Coast. These specimens possess two sexual branches, both having ovaries, the anterior branch being shorter



Text-fig.12.—A-D *Xiphinema ensiculiferum* (Cobb): (A) Oesophageal region (B) Entire female. (C) Female genital tract. (D) Female tail. E-I *Xiphinema radicicola* Goodey: (E) Oesophageal region. (F) Entire female. (G) Female genital tract. (H & I) Female tails.

than the posterior one. Cohn & Sher (1972) defined this species as having two complete sexual branches and also proposed a closely related new species *X. ensiculiferoides* based on the specimens collected from Hawaii which have only posterior sexual branch and no trace of an anterior sexual branch. They also synonymised *X. ensiculiferum* apud Loos and *X. ensiculiferum* apud Williams with *X. krugi* Lordello, 1955 which also has a reduced undifferentiated anterior sexual branch. *X. ensiculiferoides* was accepted valid by Yeates (1973) and Roy & Gupta (1974). Southey & Luc (1973) redefined *X. ensiculiferum* on the basis of topotypes and designated a new neotype of this species. Specimens of this population lack anterior sexual branch and so they synonymised *X. ensiculiferoides* with *X. ensiculiferum*. They also proposed two new species, viz., *X. loosi* (=*X. ensiculiferum* apud Loos, 1949 and Williams, 1959) and *X. hygrophilum* (=*X. ensiculiferum* apud Luc, 1961 and Cohn & Sher, 1972). These three species differ from one another in the degree of reduction of anterior sexual branch (completely absent in *X. ensiculiferum*, reduced to undifferentiated sac in *X. loosi*, and though reduced but differentiated and with an ovary in *X. hygrophilum*) and in tail shape (tail completely hemispherical without internal mucro in *X. ensiculiferum* and *X. hygrophilum* and somewhat conoid with an internal mucro in *X. loosi*).

The specimens from India resemble the topotypes described by Southey & Luc (l.c.) differing from it in having smaller spear (total spear length=224-238 μm in topotypes) and in complete absence of anterior uterine sac (very short uterine sac has been shown in the drawings given by Southey & Luc).

This species has so far been recorded from Fiji (Southey & Luc), Philippines (Cohn & Sher) and New Herbrides (Yeates) and is here reported for the first time from India.

15. **Xiphinema radicicola** Goodey

(Text-fig. 12, E-I)

1936. *Xiphinema radicicola*: Goodey, *J. Helminth.*, **14** : 69.
1939. *Xiphinema radicicola*: Thorne, *Capita Zool.*, **8** : 109.
1949. *Xiphinema radicicola*: Loos, *J. zool. Soc. India*, **1** : 26.
1963. *Xiphinema radicicola*: Goodey, *Soil and freshwater nematodes;* 447.
1971. *Xiphinema australiae*: McLeod & Khair, *Nematologica*, **17** : 58.
1971. *Xiphinema radicicola*: McLeod & Khair, *Nematologica*, **17** : 64.

Dimensions: Jorhat sugar cane population: 5♀♀: L=2.1-2.3 mm; a=38-42; b=8.3-10.2; c=38-42; V=23-24; G_2=10-13; c'=1·4-2.0; Anterior end to spear guide ring=85-90 μm; Odontostyle=96-101 μm;

Odontophore=63-66 μm; DO=8-11; DN=10-13; RS_1N=42; LS_1N =42; S_2O=78-82.

Manipur population: 10♀♀: L=2.0-2.4 mm; a=35-46; b=7.2-11.2; c=36-46; V=23-26; G_2=8-15; c′=1.4-2.0; Anterior end to spear guide ring=84-92 μm; Odontostyle=96-101 μm; Odontophore=62-66 μm; DO=8-12; DN=9-14; RS_1N=40-43; LS_1N=41-46: S_2O=76-83.

Description: Female: Body slightly ventrally curved with tapering extremities. Cuticle in 2 layers, thickest on tail. Lateral chords about 1/4th of body-width near middle.

Lip region flat, continuous with the rest of body. Amphids stirrup-shaped with slit-like apertures which are nearly 3/5th of the labial-width. Odontostyle 9 labial-widths long, odontophore nearly 1/1.6th of odontostyle length. Fixed guiding ring is at about 8 labial-widths from the oral aperture.

Basal bulb of oesophagus about 1.6 times of the corresponding body-width and 26% of neck length long. Position of oesophageal gland nuclei and their orifices as given above. Cardia short and conoid. Nerve ring surrounding the anterior slender part of oesophagus at about 2 labial-widths from the base of odontophore. Prerectum 15 times of the anal body-width long. Rectum about one anal body-width long.

Genital tract mono-opisthodelphic, anterior sexual branch reduced to a sac-like structure, its length about 1/3rd of the corresponding body-width. In one specimen this sac-like structure is completely missing. Posterior sexual branch consists of a reflexed ovary, distal narrow and proximal expanded parts of oviduct, a sphincter and a uterus. Vagina is thick-walled and may be inclined posteriorly. Vulva is far forward, at 23-26% of total body length from the anterior extremity.

Tail dorsally convex-conoid, ventral surface being almost straight ending in a digitate terminus, 1.5-2.0 times of the anal body-width and provided with 2-3 papillae on each side.

Male: Not found.

Hosts and localities: Soil around roots of *Saccharum officinarum* from Jorhat, Assam, and from around unidentified plants from Manipur.

Remarks: The present specimens from India and those described by Loos (1949) from Sri Lanka are slightly different from the type specimens described by Goodey (1936) from Java, and also from those by by McLeod & Khair (1971) from New Wales. The lip region is well offset and the tail is tapering gradually to a conoid terminus with equal dorsal and ventral curvature in the type specimens whereas in our specimens and those described by Loos the lip region is not offset and the tail is more or less straight on the ventral surface with a sharp

curvature on the dorsal side. They are also more robust (a=52-67 in type specimens), and have a more anteriorly located vulva (V=27-30% in type specimens).

Xiphinema radicicola is closest to *X. monohysterum* Brown, 1968, *X. chambersi* Thorne, 1939 and *X. australiae* McLeod & Khair, 1971, These species differ from one another in the length of body, position of vulva, length of spear and in values of c and c′ ratios. However. as indicated by Cohn & Sher (1972) all these biometric characters overlap in different populations of these species and there are no clear-cut differences on the basis of which they can be differentiated. Between *X. australiae* and *X. radicicola* only the length of spear is slightly different (199-210 μm in *X. australiae*), but as shown by Cohn & Sher it may vary in *X. radicicola* from 136-180 μm in syntypes that were studied by them. At the moment it seems best to accept the synonymy of *X. australiae* with *X. radicicola* as also suggested by Luc & Dalmasso (1975) unless proved otherwise.

This species has already been reported from Java, Australia and Sri Lanka and is here reported for the first time from India.

16. **Xiphinema brasiliense** Lordello

(Text-fig. 13)

1951. *Xiphinema brasiliense*: Lordello, *Bragantia*, **11** : 87.
1962. *Xiphinema itanhaense*: Carvalho, *Archos. Inst. biol. Paulo*, **29** : **223**.
1972. *Xiphinema brasiliense*; Cohn & Sher, *J. Nematol.*, 4 : 40.

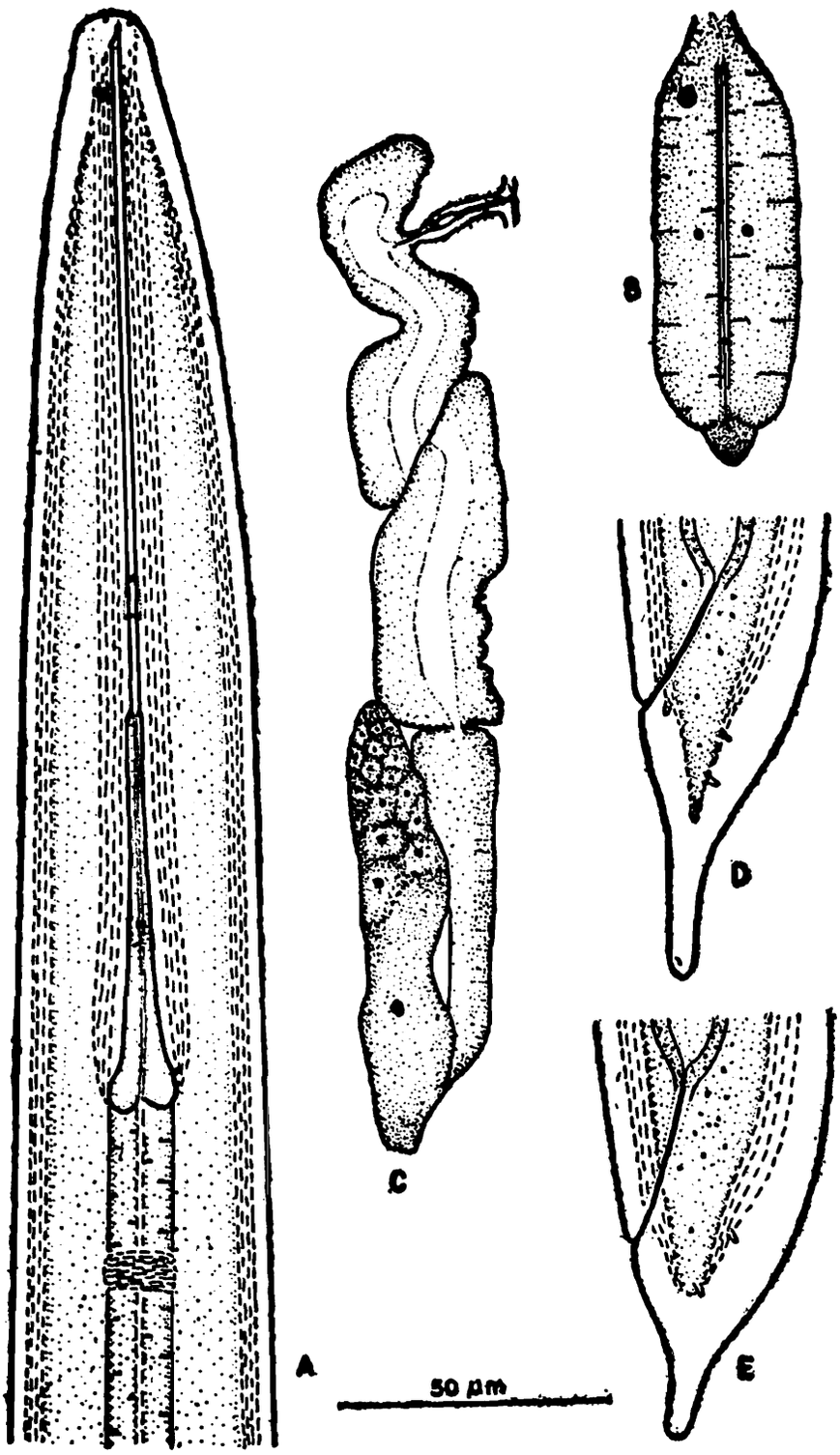
Dimensions: 4♀♀: L=2.1-2.3 mm; a=35-42; b=5.4-5.8; c=45-60; V=23.8-25.6; G_2=8-18; c′=1.2-1.5; Anterior end to spear guide ring=106-115 μm;/ Odontostyle=130-136 μm; Odontophore=68-76 μm; DO=9-11; DN=13-16; RS_1N=49-50; LS_1N=49-50; S_2O=74-80.

Description: Female: Body only slightly ventrally curved upon fixation, cylindrical except for slight tapering towards the extremities. Cuticle in 2 layers, thickest on tail. Lateral chords about 1/4th of the body-width near middle.

Lip region rounded, slightly set off from the rest of body. Amphids stirrup-shaped with slit-like apertures which are nearly 3/5th of the labial-width. Odontostyle 10-12 labial widths long, odontophore 1/1.9 of the odontostyle length. Fixed guiding ring is at about 9 labial-widths from the oral aperture.

Basal bulb of oesophagus about 1.5 times of the corresponding body-width and about 20% of neck length long. Position of oesophageal gland nuclei and their orifices as given above. Nerve ring surrounding

the anterior slender part of oesophagus at about 2 labial-widths from the base of odontophore. Prerectum indistinguishable from the intestine. Rectum about one anal-body width long.



Text-fig.13.—*Xiphinema brasiliense* Lordello: (A) Anterior extremity. (B) Oesophageal bulb. (C) Female genital tract. (D & E) Female tails.

Genital tract mono-opisthodelphic, anterior sexual branch completely absent. Posterior sexual branch consists of a reflexed ovary, distal narrow and proximal expanded parts of oviduct, sphincter and expanded and narrow portions of uterus. Vagina is about one-half of the corresponding body-width long. Vulva is at 24 -26% of total body length from anterior extremity.

Tail rounded-digitate with both the dorsal and ventral surfaces convex, about 1.2-1.5 anal body-widths long and provided with 2 papillae on each side.

Male: Not found.

Host and locality: Soil around the roots of tea plants from Darjeeling.

Remarks: This species was first described by Lordello (1951) from around the roots of potato from Brazil. Carvalho (1962) reported a new species, *X. itanhaense* from Brazil which was later synonymised with *X. brasiliense* by Cohn & Sher. (1972).

This species is closely related to *X. radicicola* Goodey, 1936 from which it differs only in having differently shaped tail (tail with convex ventral surface in *X. brasiliense*, ventral surface straight or concave in *X. radicicola*).

X. *brasiliense* has already been reported from Brazil, Guatemala and Sri Lanka and is here reported for the first time from India.

Distribution of *Xiphinema* species in India

Species of *Xiphinema* are widespread in India which is evident from the fact that these species were found from all the regions of the country that were surveyed in the present study. In 27% of all the samples collected, species of this genus were present. This genus is very common in Jaipur where 75% of the samples yielded three species, viz., *X. americanum*, *X. basiri* and *X. insigne*. This does not agree with the observations of F. A. Khan & A. M. Khan (1972) who failed to collect the species of *Xiphinema* from this district. The genus is on the other hand rare in Jammu, Garhwal, and Pilibhit and was found in only 10% of the samples collected from these places. At other places, it was usual to find it in 20-40% of the samples. The species of this genus are polyphagous and usually attack fruit trees (71%). The flowering plants (9%) and cereals (20%) were also found to harbour *Xiphinema* sepcies.

Xiphinema species differ in their distribution in this country. While some species are widely distributed the others are less frequent and some are restricted to a particular region. *X. insigne* and *X. americanum* are most commonly occurring species present in 37% and 24% of the samples respectively that were positive for *Xiphinema* species. *X. insigne* was collected from soil around the roots of a variety of plants from banks of hot-water sulphur springs, marshy land, foot-hills, hills as well as from the plains. Some of these regions from where *X. insigne* was recorded have temperature below O°C in winter while in other regions it may rise to 40-45°C during summer. It clearly gives an impression of the temperature tolerance limit of this species. In some

samples its population constituted 90-95% of total nematode fauna. It usually attacks fruit trees (74% in the present study) but is also occasionally found associated with the roots of flowering plants (7%), grasses and other seasonal crops (19%). Although widely distributed elsewhere it is rare in Jammu & Kashmir where only 8% of the samples were positive for this species. However, in Pithoragarh it was the only species of the genus that was found during the survey. There are two distinct morphological forms of this species: *indicum*-form and *insigne*-form (Bajaj & Jairajpuri, 1977). While *insigne*-form is restricted to certain areas of high altitude of India, viz. Rajpur (Dehra Dun), Palampur and Manipur, *indicum*-form is widespread, including in the hills.

Xiphinema americanum is also widespread in India. It was recorded from nearly all the regions that were surveyed except Pithoragarh and was found in the soils collected from marshy places, plains, foot-hills and hills. This species is usually found in heavy populations and occasionally constitutes 95% of total nematode population. It is more common around fruit trees (74%) less around flowering (12%) and seasonal crops and grasses (14%). However, in a soil sample from around roots of ornamental plants at Nishat gardens, Srinagar it occurred in very heavy population. In Western Uttar Pradesh also it is common around the roots of citrus and other fruit trees.

Other species of *americanum*-group that were recorded are *X. brevicolle X. opisthohysterum*, *X. inaequale*, *X. lambertii* and *X. neoamericanum*. Of these, *X. opisthohysterum* and *X. inaequale* are more common in India. *X. opisthohysterum* is also common in soil around the roots of fruit trees in Bareilly, Pilibhit and Nainital districts of Uttar Pradesh and constituted 43%, 50% and 20% respectively of the samples positive for the presence of *Xiphinema* species. This species was not found in any sample collected from other parts except for a single instance when it was present around the roots of citrus at Aligarh. *X inaequale* was found only from high altitudes around grasses and forest and fruit trees. *X. lambertii* was present in the soil samples collected from Rajpur and Bareilly attacking *Cajanus cajan* and some wild plants. *X. neoelongatum* was collected from soil around the roots of *Psidium guajava* at Ambala (Punjab). *X. brevicolle* was collected rom around the roots of grasses from Dalhousie.

The large-sized species like *X. basiri* and *X. index* are less common' They were found in 20 and 9% of the samples positive for *Xiphinema*· *X. basiri* is common in plains and in the samples collected at Jammu' Jaipur, Aligarh, Bareilly, Dehra Dun, Saharanpur, but was absent in the samples from high altitude, e.g., Manipur, Chamba, Dalhousie,. Srinagar, Mussorie (Dehra Dun). It usually attacks fruit-trees (77%) and is only seldom found around other plants. *X. index* which is here

reported for the first time from India was found only from soil around roots of apples from Srinagar.

Xiphinema orbum was present in two samples from Bareilly attacking *Zea mays* and wild plants. This species is perhaps restricted in its distribution. *X. luci* was found around the roots of *Phaseolus aureus* from Ajmer, Rajasthan. *X. elongatum* was found in the soil around the roots of flowering plants in Shahjahanpur, U. P.

Three monodelphic species of *Xiphinema*, viz. *X. radicicola*, *X. ensiculiferum* and *X. brasiliense* have been reported here for the first time from India. *X. radicicola* is very common in Manipur (27% of the samples positive for *Xiphinema* species) and attacks fruit trees. This species was not found in any other region of the country. *X. ensiculiferum* was collected from around the roots of *Artocarpus heterophyllus* from Trivandrum only, and *X. brasiliense* from around roots of tea plants from Darjeeling.

Summary

In the present work an account is given of the morphology and systematics of *Xiphinema* species. The validity of the groups/subgenera proposed by Dalmasso (1969), Cohn & Sher (1972), Southey (1973) and Roy & Gupta (1974) has been discussed and the species of this genus have been re-arranged in 5 groups, viz. *americanum*-group, *elongatum*-group, *chambersi*-group, *rotundatum*-group, and *radicicola*-group. The descriptions of all the species of *Xiphinema* so far recorded from India based on the type material and or fresh material collected from different parts of this country (mainly from Uttar Pradesh, Himachal Pradesh, Rajasthan, Jammu & Kashmir, Arunachal Pradesh, etc.) during the last several years have been provided and their distribution given. The description of each species is followed by a detailed discussion on its relationships, geographical distribution, economic importance, etc. In all, the following 15 known species were recorded: *X. americanum* Cobb, 1913, *X. brevicolle* Lordello & Da Costa, 1961, *X. opisthohysterum* Siddiqi, 1961, *X. inaequale* Khan & Ahmad, 1975, *X. elongatum* Schuurmans-Stekhoven & Teunissen, 1938, *X. lambertii* Bajaj & Jairajpuri, 1976, *X. neoelongatum* Bajaj & Jairajpuri, 1976, *X. insigne* Loos, 1949, *X. orbum* Siddiqi, 1964, *X. basiri* Siddiqi, 1959, *X. index* Throne & Allen, 1950, *X. acrum* Khan, 1964, *X. ensiculiferum* Cobb, 1893) Thorne, 1937, *X. radicicola* Goodey, 1936 and *X. brasiliense* Lordello, 1951. While *X. index* was previously recorded in West Bengal doubtfully (Mukhopadhayaya & Haque, 1974), *X. ensiculiferum*, *X. radicicola* and *X. brasiliense* are first records of monodelphic species from India. The males of *X. opisthohysterum* and *X. inaequale* have monorchic and triorchic gonads respectively. In addition to the already

known species, *X. luci*, a new species was also found during the course of investigations. This new species is described in detail along with its diagnostic characters and relationships.

The synonymy of *X. australiae* McLeod & Khair, 1971 with *X radicicola* and *X. neoamericanum* Saxena *et al.*, 1973 with *X. americanum* is proposed.

X. insigne, *X. americanum* and *X. basiri* are the widespread species in this country, while *X. ensiculiferum*, *X. arcum X. luci*, *X. brasiliense* and *X. neoelongatum* are very much restricted in their distribution. The other species are also fairly distributed.

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