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COMMENTS ON THE OCCURRENCE AND GEOGRAPHICAL DISTRIBUTION OF LONGIDORID NEMATODES IN EUROPE AND THE MEDITERRANEAN REGION

by
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The longidorid nematodes are included in the family Longidoridae in accordance with the classification established by Luc and Doucet (1984). In Europe all the species so far recorded are in the genera *Longidorus, Xiphinema* and *Paralongidorus*. The earliest records of longidorids are *Dorylaimus maximus* (Butschli, 1874), now referred to as *Paralongidorus maximus*, and *D. elongatus* (de Man, 1876) now *Longidorus elongatus*. Filipjev (1934) raised *Longidorus* to generic rank in the family Dorylaimidae de Man, 1876, and the first list of species was published by Thorne and Swanger (1936). Micoletzky (1927) described *L. diversicaudatum* which Thorne (1939) subsequently transferred to *Xiphinema*, erected by Cobb (1913) with *X. americanum* as the type species.

Interest in the longidorids was stimulated by the discovery that some species are vectors of plant viruses (Hewitt *et al.*, 1958). Many new species have been described since 1958 and much research has been undertaken on their morphology, ultrastructure, general biology, control (Lamberti *et al.*, 1975b) and geographical distribution (Taylor and Brown, 1976; Alphey and Taylor, 1986). In Europe, participants in many countries collaborated in the production of national atlases of nematode distribution, with particular reference to longidorids and trichodoris (Brown *et al.*, 1978; Alphey *et al.*, 1979) and this culminated in the pubblication of the European Atlas of the Longidoridae and Trichodoridae (Alphey and Taylor, 1986). In this paper we attempt to collate all the available published, and some unpublished, information on the occurrence of longidorid nematodes in Europe (with the exclusion of the USSR) and comment on those aspects of the biology of the species that seem relevant to an understanding of their geographical distribution.

Organisation of the data

In addition to the European countries, north African countries bordering the Mediterranean are also included, as also are Israel and Jordan because they are within the Mediterranean region. Where atlases of longidorid distribution have been published (Arias, 1979; Brown and Taylor, 1977; Dalmasso, 1970; Seinhorst and van Hoof, 1981; Alphey and Taylor, 1986) they have been used as the primary data source but for many countries the data have been obtained from a scan of several hundreds of publications. The USSR has not been included because available information relates to a few scattered areas e.g. Moldavia (Koev *et al.*, 1971), the Moscow area (Romanenko, 1971), Tadzhikistan (Ivanova, 1971) and the Ukraine (Milkus *et al.*, 1974, 1975; Kudinskaja and Milkus, 1980). Kirjanova and Krall (1969) list 2,877 titles of nematological papers published in the USSR up to 1966, and some of these contain information about longidorids in the USSR, but many of the papers are unobtainable and also have not been summarised in the *Helminthological Abstracts*, Series B (C.A.B., St. Albans, England). Information on longidorids in the USSR, obtained from 50 publications, is discussed elsewhere (Brown, 1983).

Standardised, pre-printed base maps of Europe as used by the European Invertebrate Survey (Monks Wood Experimental Station, Abbots Ripton, England) have been used for presentation of the geographical distribution of selected species; these include the virus vectors and some species such as *X. pachtaicum* that are widely distributed. Symbols representing the nematode species were placed by hand in the 50 km squares of the map, but when completed the grid on each map was removed photographically, leaving only the outline of the countries, the course of major rivers, and with sea areas stipled.

It has been assumed that the publications used contain reports of correctly identifed species, although it is acknowledged that some misidentifications are likely, particularly of early records of what now might be regarded as species complexes.

The longidorid nematodes reported in Europe are listed in Tables I, II and III. *L. elongatus* was the most frequently occurring of the 44 *Longidorus* species reported from Europe. *X. pachtaicum* and *X. diversicaudatum* were the most widespread of the *Xiphinema* species, with *X. index* present in most countries where grapevines are grown commercially. Two *Paralongidorus* species have been recorded in continental Europe with a third in Algeria and a fourth recorded from the Nile Delta, Egypt.

Table I - Xiphinema *species reported to occur in European and Mediterranean countries.*

X. algeriense	Luc *et* Kostadinov, 1981
*X. americanum**	Cobb, 1913
X. basilgoodeyi	Coomans, 1964
X. barense	Lamberti, Roca, Agostinelli *et* Bleve-Zacheo, 1986
*X. brevicolle***	Lordello *et* Da Costa, 1961
X. conurum	Siddiqi, 1964
*X. coxi**	Tarjan, 1964
X. dentatum	Sturhan, 1978
*X. diversicaudatum**	(Micoletzky, 1927) Thorne, 1939
X. elongatum	Schuurmans Stekhoven *et* Teunissen, 1938
X. ensiculiferum	(Cobb, 1913) Thorne, 1937
X. globosum	Sturhan, 1978
X. incertum	Lamberti, Choleva *et* Agostinelli, 1983
*X. index**	Thorne *et* Allen, 1939
X. ingens	Luc *et* Dalmasso, 1963
X. insigne	Loos, 1949
X. israeliae	Luc, Brown *et* Cohn, 1982
*X. italiae**	Meyl, 1953
X. krugi	Lordello, 1955
X. lusitanicum	Sturhan, 1983
X. melitense	Lamberti, Bleve-Zacheo *et* Arias, 1982
X. neovuittenezi	Dalmasso, 1969
X. opisthohysterum	Siddiqi, 1961
X. pachtaicum	(Tulaganov, 1938) Kirjanova, 1951
X. pachydermum	Sturhan, 1983
X. pini	Heyns, 1965
X. porosum	Roca *et* Agostinelli, 1986
X. pseudocoxi	Sturhan, 1984
X. pyrenaicum	Dalmasso, 1969
X. radicicola	Goodey, 1936
*X. rivesi**	Dalmasso, 1969
X. rotundatum	Schuurmans Stekhoven *et* Teunissen, 1938
X. sahelense	Dalmasso, 1969
X. simile	Lamberti, Choleva *et* Agostinelli, 1983
X. surinamense	Loof *et* Maas, 1972
X. turcicum	Luc *et* Dalmasso, 1963
*X. vuittenezi***	Luc, Lima, Weischer *et* Flegg, 1964
X. vulgare	Tarjan, 1964

* Virus vector species

** Reported to be virus vector species but do not fulfill the criteria for virus vectors as stipulated by Trudgill, Brown and McNamara (1983).

Table II - Longidorus *species reported to occur in European and Mediterranean countries.*

L. aetnaeus	Roca, Lamberti, Agostinelli *et* Vinciguerra, 1986
L. africanus	Merny, 1966
*L. apulus**	Lamberti *et* Bleve-Zacheo, 1977
*L. attenuatus**	Hooper, 1961
*L. caespiticola***	Hooper, 1961
L. carpetanensis	Arias, Andres *et* Navas, 1986
L. closelongatus	Stoyanov, 1964
L. cohni	Heyns, 1969
L. congoensis	Aboul-Eid, 1970
L. cylindricaudatus	Kozlowska *et* Seinhorst, 1979
L. distinctus	Lamberti, Choleva *et* Agostinelli, 1983
L. edmundsi	Hunt *et* Siddiqi, 1977
*L. elongatus**	(de Man, 1876) Thorne *et* Swanger, 1936
L. eridanicus	Roca, Lamberti *et* Agostinelli, 1984
*L. euonymus***	Mali *et* Hooper, 1974
*L. fasciatus**	Roca *et* Lamberti, 1982
L. globulicauda	Dalmasso, 1969
L. goodeyi	Hooper, 1961
L. intermedius	Kozlowska *et* Seinhorst, 1979
L. iuglandis	Roca, Lamberti *et* Agostinelli, 1984
L. juvenilis	Dalmasso, 1969
L. laevicapitatus	Williams, 1959
L. latocephalus	Lamberti, Choleva *et* Agostinelli, 1983
*L. leptocephalus***	Hooper, 1961
L. lusitanicus	Macara, 1986
*L. macrosoma**	Hooper, 1961
L. macroteromucronatus	Altherr, 1974
L. magnus	Lamberti, Bleve Zacheo *et* Arias, 1982
L. major	Roca *et* D'Errico, 1987
L. moesicus	Lamberti, Choleva *et* Agostinelli, 1983
L. nevesi	Macara, 1986
L. paraelongatus	Altherr, 1974
L. picenus	Roca, Lamberti *et* Agostinelli, 1984
L. pisi	Edward, Misra *et* Singh, 1964
L. poessneckensis	Altherr, 1974
*L. profundorum***	Hooper, 1966
L. protae	Lamberti *et* Zacheo, 1977
L. proximus	Sturhan *et* Argo, 1983
L. pseudoelongatus	Altherr, 1976
L. sylphus	Thorne, 1939
L. taniwha	Clark, 1963
L. tarjani	Siddiqi, 1962
L. unedoi	Arias, Andres *et* Navas, 1986
L. vineacola	Sturhan *et* Weischer, 1964

* Virus vector species

** Reported to be virus vector species but do not fulfill the criteria for virus vectors as stipulated by Trudgill, Brown and McNamara (1983).

Table III - Paralongidorus *species reported to occur in European and Mediterranean countries.*

P. epimikis	Dalmasso, 1969
P. georgiensis	Tulaganov , 1937
*P. maximus**	Butschli, 1874
P. remeyi	Altherr, 1963

* Reported to be a virus vector species but does not fulfill the criteria for virus vectors as stipulated by Trudgill, Brown and McNamara (1983).

Xiphinema

Of the 150 described species of *Xiphinema*, 38 species are reported from 36 European and Mediterranean countries. Eight of the species have been recorded as virus vectors (Taylor and Brown, 1981; Lamberti and Roca, 1987).

1. *X. algeriense* Luc *et* Kostadinov, 1981 was identified from the rhizosphere of grapevine near Mostaganem, Algeria; certain morphological features indicate that it represents a transitional species towards *Longidorus*.

2. *X. americanum* was originally described by Cobb (1913) as the type species of the genus but only a brief description was given. Further descriptions were provided by Imamura (1931), Thorne (1939), Loos (1949), Carvalho (1955) and Tarjan (1956) and in 1965 Lima concluded that *X. americanum* was a species complex comprising seven parthenogenic species, four of which he described as new; this view was supported by Tarjan (1969) who concluded that the complex consisted of four closely related species, one of which was *X. mediterraneum* as described by Lima. *X. mediterraneum* was later synonymised with *X. pachtaicum* (Tulaganov, 1938) Kirjanova, 1951 (Siddiqi and Lamberti, 1977). Heyns (1974) described the «*X. americanum-group*» species from South Africa and concluded that demarcation of species was problematical and unsatisfactory but that several of the species proposed by Lima (1965) were justified. Lamberti and Bleve-Zacheo (1979) took a bolder approach and concluded that the denomination *X. americanum sensu lato* need no longer be retained. They recognised 25 species, 15 of them new, subdivided into six groups of species. *X. americanum sensu stricto* is limited in its distribution to the eastern part of the North American continent, and also South Africa

(Heyns, 1974; Loots and Heyns, 1984); most of the records of *X. americanum* reported from European countries are referred to *X. pachtaicum* or *X. brevicolle*.

X. americanum and *X. pachtaicum* have both been reported from soils from vineyards in Yugoslavia (Hrzic, 1978) although the published morphometrics for *X. americanum* allow it to be identified as one of several species within the species complex, including *X. brevicolle* and *X. rivesi* which both occur in Europe. An extensive survey of cultivated soils and natural habitats in Bulgaria revealed *X. brevicolle* in eight locations (Lamberti *et al.*, 1983); the morphometrics of the populations were similar to those from other eastern European countries but slightly smaller than from western Europe. *X. americanum, X. brevicolle, X. pachtaicum* and *X. rivesi* also have been recorded in Spain but morphological data were not given (Alphey and Taylor, 1986).

3. *X. barense* Lamberti, Roça, Agostinelli *et* Bleve-Zacheo, 1986 is a bisexual species described from a population in the rhizosphere of *Olea europaea* L. and *Rubus fruticosus* L. at Modugno, province of Bari, Italy.

4. *X. basilgoodeyi* Coomans, 1964 is mainly a tropical species but it has been reported once from Yugoslavia (Hrzic, 1978). Again, the published morphometrics allow an alternative identification as one of several other *Xiphinema* species present in Europe e.g. *X. index, X. neovuittenezi* and *X. vuittenezi*.

5. *X. brevicolle* Lordello *et* Da Costa, 1961 has a widespread but sporadic distribution in Europe, ranging from Germany F.G.R. and Poland in the north to Israel in the south, Portugal in the west and as far east as Czechoslavakia. The species has been most frequently identified from Israel, Spain and Italy. In laboratory experiments *X. brevicolle* was implicated as a vector of tomato ringspot virus (Fritzsche and Kegler, 1968). Trudgill *et al.* (1983) established a set of criteria and methods for assessing the transmission of plant viruses by longidorids and suggest that there is insufficient evidence to support two thirds of the published claims of virus and vector associations, including *X. brevicolle* and tomato ringspot virus.

6. *X. conurum* Siddiqi, 1964 was originally described from a single female from the rhizosphere of *Prunus amygdalus* Batsch, located about 70 km from Tunis, Tunisia. Siddiqi (1964) considered the species «very similar»

to *X. arenarium* Luc *et* Dalmasso 1963 (Siddiqi, 1964) which is now a junior synonym of *X. italiae* Meyl, 1953. Subsequently, *X. conurum* was considered a *species inquirenda* (Martelli *et al.*, 1966) and Cohn and Sher (1972) considered it a junior synonym of *X. italiae.* More recently Luc and Aubert (1985a) identified specimens from vineyard soil from Soukra, a small town 80 km from the original location of *X. conurum*, as a mixed population comprising *X. italiae* and *X. conurum*, thus confirming *X. conurum* as a valid species.

7. *X. coxi* Tarjan, 1964b has for some years been considered as a species complex comprising at least three distinguishable forms. Dalmasso (1970) recognised the occurrence of two forms in Europe which were distinct from the type population described from Florida, USA (Tarjan, 1964b). The European populations could also be further differentiated because specimens from Brittany, France were smaller than the type species; Taylor and Brown (1976) also found that English populations were smaller than the type species and had more apophyses in the Z organ. Sturhan (1984) concluded that populations from Germany and other European countries, previously identified as *X. coxi*, comprise two species. One of the species agrees in most characters with *X. coxi* from Florida but with sufficient deviations for Sturhan to consider it as a sub-species, *X. coxi europaeum* (with the Florida populations as *X. coxi* sub sp. *coxi*). The second species differs in the structure of the Z organ, the shorter stylet and other characters which distinguish it from the two sub-species and it has been named *X. pseudocoxi.*

The erection of sub-species is taxonomically questionable but European populations previously identified as *X. coxi* must now be recognised as including *X. pseudocoxi*. Populations are sporadically distributed in north and west Europe where they usually occur in relatively undisturbed biotopes (Taylor and Brown, 1981). In laboratory experiments *X. coxi*/*X. pseudocoxi* transmitted brome mosaic virus (Schmidt *et al.*, 1963), arabis mosaic virus (Fritzsche, 1964), cherry leaf roll virus (Fritzsche and Kegler, 1964), strawberry latent ringspot virus (Putz and Stocky, 1970) and tobacco ringspot virus (van Hoof, 1971) but Trudgill *et al.* (1983) consider that the evidence for specific transmission is inconclusive.

8. *X. dentatum* Sturhan, 1978 was originally described from soil samples from central Germany F.G.R. and has not been reported subsequently from any other locality in Europe.

9. *X. diversicaudatum* (Micoletzky, 1927) Thorne, 1939 (Fig. 1) has been recorded from most European countries except Finland, Romania and

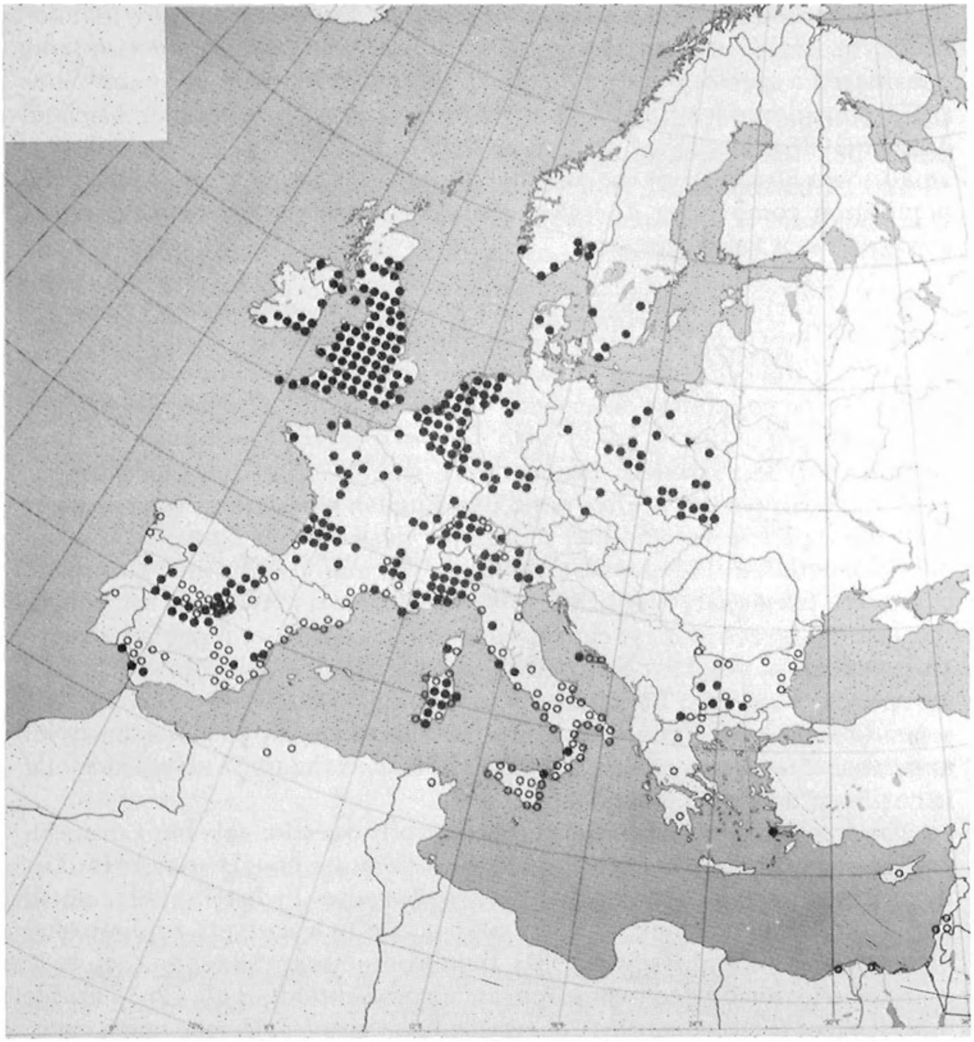

Fig. 1 - Distribution in European and Mediterranean countries of ●, *Xiphinema diversicaudatum* and ○, *X. italiae.*

some of the southern Mediterranean countries. Populations collected from several biotopes in Israel and identified as *X. diversicaudatum* were subsequently identified as a new species, *X. israeliae* (Luc *et al.*, 1982) because of their smaller size and absence of a Z differentiation in the female genital tract. *X. paraelongatum* Altherr, 1958 is a junior synonym of *X. diversicaudatum* (Luc and Tarjan, 1963).

X. diversicaudatum was the first European longidorid to be reported as a virus vector, of arabis mosaic virus (Jha and Posnette, 1959; Harrison and Cadman, 1959). It is also a vector of strawberry latent ringspot virus (Lister, 1964). Populations of *X. diversicaudatum* from various countries have been shown to differ in their ability to transmit the two viruses (Brown and Taylor, 1981; Brown and Trudgill, 1983; Brown, 1983, 1985, 1986a). Literature on virus transmission and general biology is extensive (Taylor and Robertson, 1970, 1978; Taylor and Brown, 1981; Brown, 1983, 1986b). In the Palatinate region of Germany F.G.R the grapevine cultivar Kerner is affected by a graft union necrosis disease which results in the death of the fruiting scion in the first or second fruiting years. This «Kerner disease» is associated with a virus, possibly arabis mosaic, and *X. diversicaudatum* (M. Rudel, personal communication).

10. *X. elongatum* Schuurmans Stekhoven *et* Teunissen, 1938 occurs in several tropical and sub-tropical countries throughout the world. In Europe it has been recorded from the southern Mediterranean countries, Algeria, Egypt and Israel and in Spain.

11. *X. ensiculiferum* (Cobb, 1893) Thorne, 1937 is mainly a tropical species and the only report of its occurrence in Europe is a population from Israel which was identified by Cohn and Sher (1972).

12. *X. globosum* Sturhan, 1978 was described from several biotopes in Bavaria, Germany F.G.R. and it has also been recorded from a few locations in Italy, mainly in the north (Roca and Lamberti, 1985).

The record of *X. clavatum* Heyns, 1965 from central Italy (Roca and Lamberti, 1978) was a misidentification and has since been re-identified as *X. globosum* (F. Lamberti, personal communication).

13. *X. incertum* Lamberti, Choleva *et* Agostinelli, 1983 was described from a single female specimen from the rhizosphere of grapevine (*Vitis* sp.) at Varna, Bulgaria. It was found in low numbers at four other localities and Lamberti *et al.* consider that it may be more widespread than indicated by present records.

14. *X. index* Thorne *et* Allen, 1950 (Fig. 2) was described from populations in California, USA but it is now generally accepted that it originated in the Middle East where it has been found in association with natural woodlands and wild grapevines (Southey, 1973; Sturhan *in* Weischer, 1975;

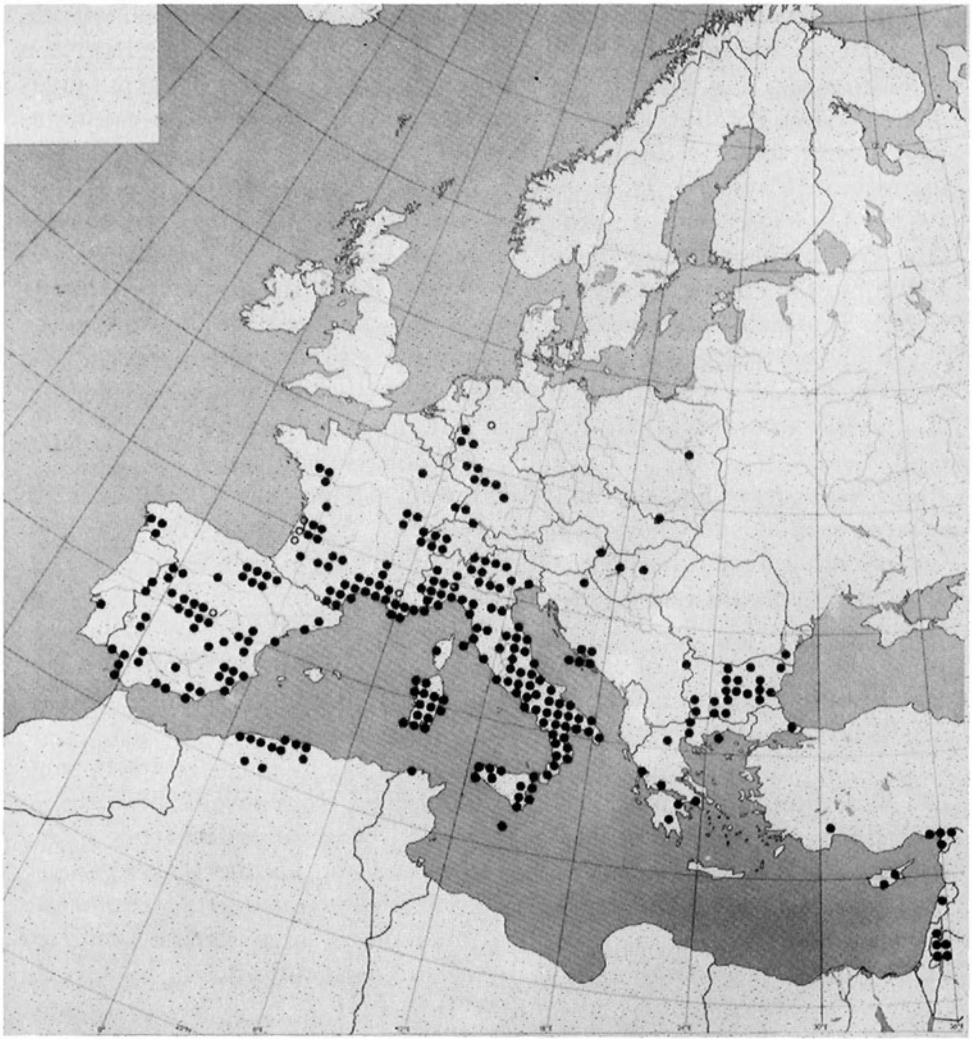

Fig. 2 - Distribution in European and Mediterranean countries of ●, *Xiphinema index* and ○, *X. riversi.*

Mojtahedi *et al.*, 1980) and from where it has been distributed to most of the grapevine growing regions of the world in soil accompanying propagation material. *X. index* has been reported from most regions of Europe where grapevines are grown but in central Europe it appears to be replaced by *X. vuittenezi* which is more frequently found in the rhizosphere of grapevines. It is reported to be rare in the vineyards of

Corsica (Dalmasso, 1970) and has not been found in Great Britain (Taylor and Brown, 1976) where the Romans established many vineyards in the past and where about 1000 hectares of commercial grapevines are currently grown.

In natural conditions *X. index* is associated almost exclusively with grapevine and fig (*Ficus carica* L.) and only occasionally has it been identified from the rhizosphere of other plant species. Siddiqi (1974) recorded more than 30 plant species as hosts and Coiro and Brown (1984) found that cultivars of tomato (*Lycopersicon esculentum* Mill.) could be used to differentiate between European and USA populations. Differences in the length of the life cycle have also been reported between populations from Israel, Italy, France and the USA (Brown and Coiro, 1985).

X. index was the first nematode to be conclusively identified as a vector of a plant virus, grapevine fanleaf (Hewitt *et al.*, 1958) which occurs in most of the grapevine growing regions of the world, including Europe (Martelli, 1975). It has also been reported to transmit grapevine chrome mosaic virus (Mali *et al.*, 1975) but Trudgill *et al.*, (1983) consider that the evidence for specific transmission is inconclusive.

15. *X. ingens* Luc *et* Dalmasso, 1963 has been recorded in five countries. In Israel and Spain it has been found in several localities but in Jordan and Turkey it is relatively rare. It has been recorded in Italy but identification was difficult because the populations may comprise a species complex (F. Lamberti, personal communication).

16. *X. insigne* Loos, 1949 has been reported from several locations in Egypt, Israel and Jordan where it was found in association with a wide range of host plants.

17. *X. israeliae* Luc, Brown *et* Cohn, 1982 was identified in soil samples taken from the rhizosphere of *Citrus* sp. at Nes-Ziona and lemon trees at Tel-Mond, and from a golf green at Caesarea, Israel. It had previously been found associated with *Citrus* sp., avocado, grapevine and occasionally from *Rosa* sp. and these populations had been referred to *X. diversicaudatum* (Luc *et al.*, 1982). So far the species has been recorded only in Israel.

18. *X. italiae* Meyl, 1953 (Fig. 1) was designated as a *species inquirenda* by Luc and Tarjan (1963) because of the loss of the type material but Martelli *et al.* (1966) resurrected the species, designated a neotype from the original type location and made *X. arenarium* Luc *et* Dalmasso, 1963 a

junior synonym. Meanwhile, Stoyanov (1964) had described *X. bulgariense* as a new species but Cohn and Sher (1972) made it a junior synonym of *X. italiae*. Therefore all *X. arenarium* and *X. bulgariense* records have been referred to *X. italiae*.

X. italiae has been reported from thirteen European countries particularly those of the Mediterranean region. Luc and Aubert (1985b) whilst acknowledging the natural distribution of *X. italiae* to be circum-Mediterranean also consider the species to be indigenous to northern Natal and Eastern Transvaal Lowenveld, South Africa. *X. italiae* has been shown to be a vector of grapevine fanleaf virus in Israel (Cohn *et al.*, 1970) but in Italy it does not appear to transmit the virus in the field and the experimental evidence for transmission was slight (Martelli, 1975).

19. *X. krugi* Lordello, 1955 has been recorded from Spain as *X. denoudeni* Loof *et* Maas 1972 [a junior synonym of *X. krugi* (Lamberti and Tarjan, 1974)] but morphological and biological data were not given (Alphey and Taylor, 1986).

20. *X. lusitanicum* Sturhan, 1983 was described from a population obtained from cultivated soil at Quinta de Laranjeiras, north Portugal which is the only record of its occurrence.

21. *X. melitense* Lamberti, Bleve Zacheo *et* Arias, 1982 has been recorded from several localities in Malta and once each from the other Maltese islands of Gozo and Comino, and also from Italy (Roca *et al.*, 1987).

22. *X. neovuittenezi* Dalmasso, 1969 has been identified from a few soil samples from Bulgaria, Spain, Yugoslavia and from France, from where it was originally described (Dalmasso, 1969). Stegarescu (1977) considered that although *X. neovuittenezi* is bisexual and *X. vuittenezi* is parthenogenetic, the species differ only in minor morphological details and therefore *X. neovuittenezi* should become a junior synonym. The proposal was, however, published only as an abstract and therefore is not implemented in this paper.

23. *X. opisthohysterum* Siddiqi, 1961 has been recorded only once in Europe, from Quinta de Laranjeiras, Torre de Moncorvo, Portugal in association with *X. lusitanicum* and *X. pachydermum* (Sturhan, 1983).

24. *X. pachtaicum* (Tulaganov, 1938) Kirjanova, 1951 (Fig. 3) is probably the most widespread and frequently occurring of the *Xiphinema* species

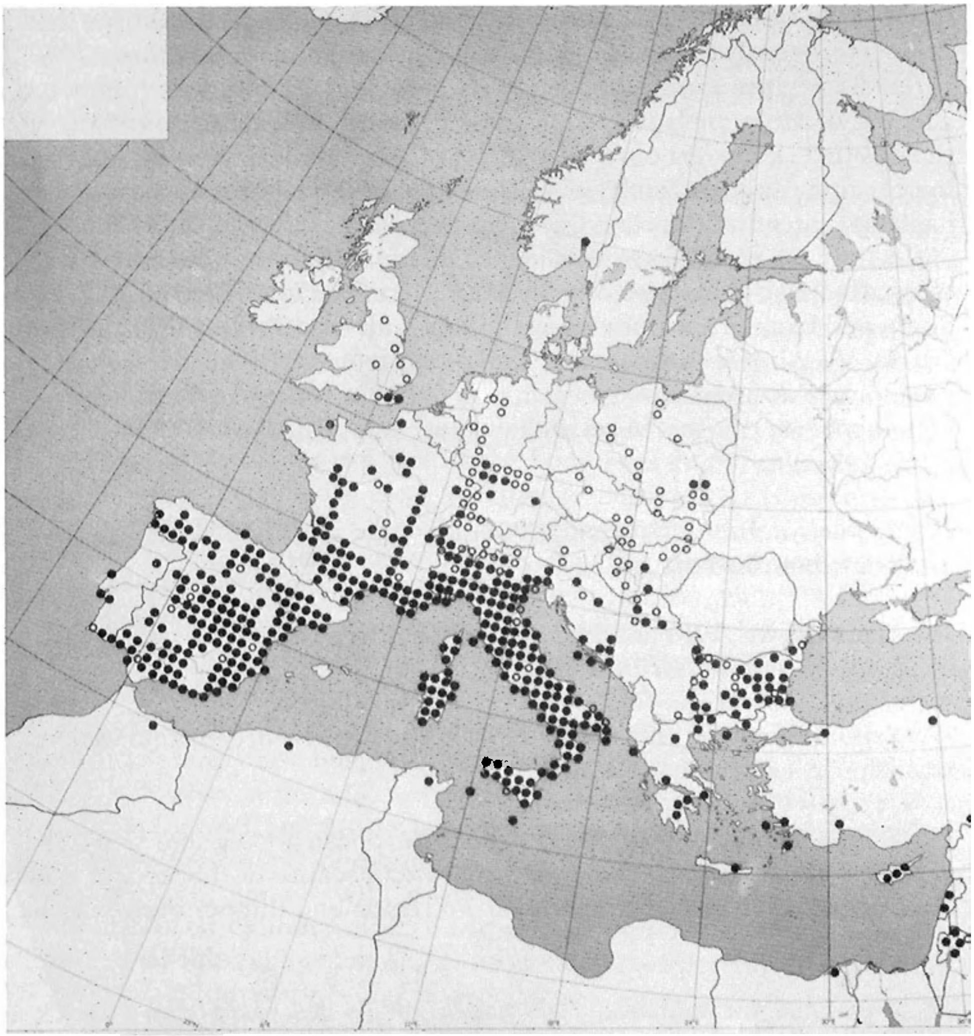

Fig. 3 - Distribution in European and Mediterranean countries of ●, *Xiphinema pachtaicum* and ○, *X. vuittenezi.*

in the Mediterranean region. It has also been reported from southern England, central Germany F.G.R., Portugal, Switzerland, Hungary and Bulgaria. *X. pachtaicum* has also been found in soil in a glasshouse near Oslo, Norway where it was probably introduced with propagating material (M. Stoen, personal communication) and this is considered to be the way it was introduced into countries outside Europe such as the USA, where it occurs in California. *X. pachtaicum* tolerates drought conditions and is most frequently found in soils with a high clay content. Dalmasso (1970) rarely found it in sandy, wet or poorly aerated soils whereas in Israel it was prevalent in such soils (Cohn, 1969). Apart from these observations there is little known about the biology or the pathogenicity of the species, mainly due to the difficulty of culturing it in the laboratory because of bacterial infection (Morone De Lucia and Grimaldi De Zio, 1973).

In Italy, *X. pachtaicum* was identified from the rhizosphere of peach trees affected by «stem pitting» disease (Giunchedi and Tacconi, 1974) in Spain and from grapevines infected with grapevine fanleaf virus (Alfaro Garcia, 1971) but so far there has been no experimental evidence of it being a vector of the viruses. In Greece it was found in artichoke fields infected with raspberry ringspot virus but it was not implicated as the vector (Roca *et al.*, 1986c).

25. *X. pachydermum* Sturhan, 1983 has been recorded from only two localities, both in Portugal.

26. *X. pini* Heyns, 1965 has been reported only from southern Israel where it has a restricted distribution (Cohn, 1969).

27. *X. porosum* Roca *et* Agostinelli, 1986 has been recorded from various localities in central Italy (Roca *et al.*, 1987).

28. *X. pseudocoxi* Sturhan, 1984 includes European populations that were previously included in *X. coxi* but separated because of the structure of the Z organ, shorter stylet, narrower lip region and thinner body cuticle at the tail.

29. *X. pyrenaicum* Dalmasso, 1969 was originally described from west and southwest France and subsequently Arias (1979) has recorded its occurrence in northwest Spain.

30. *X. radicicola* Goodey, 1936 has been recorded from several localities in central Spain but morphological and biological data were not given (Alphey and Taylor, 1986).

31. *X. rivesi* Dalmasso, 1969 (Fig. 2) was described from populations in several localities in western France and subsequently it has been recorded from central Spain and Germany F.G.R. (Arias and Navacerrada, 1973; D.

Sturhan, personal communication). It has also been found in Guadeloupe where it appears to be endemic and this may be the origin of the populations in France when ships sailed between Brittany and the French West Indian colonies (A. Dalmasso, personal communication). Lamberti and Bleve-Zacheo (1979) reported the first occurrence of *X. rivesi* in the USA, in Nebraska and Kansas, and it has since been recorded from many localities in the eastern States, particularly Pennsylvania (Forer, 1981). It is a vector of tomato ringspot virus in Pennsylvania (Forer *et al.*, 1981; Forer and Stouffer, 1981) but it has not been associated with a virus in Europe.

32. *X. rotundatum* Schuurmans Stekhoven *et* Teunissen, 1938 is one of several *Xiphinema* species, mainly reported from tropical Africa, which have true Z organs containing a few refrigent «teeth» (Luc and Dalmasso, 1975). In Europe it has been recorded from Hungary and Yugoslavia (Andrassy, 1973; Hrzic, 1978) but these identifications require to be confirmed.

33. *X. sahelense* Dalmasso, 1969 was originally described from specimens extracted from the rhizosphere of grapevines in Algeria. *X. amarantum* (Macara, 1970) was described from Portugal but was subsequently made a junior synonym of *X. sahelense* (Macara, 1972).

34. *X. simile* Lamberti, Choleva *et* Agostinelli, 1983 was described from specimens from the rhizosphere of apricot and quince at Kovachitsa, Bulgaria and was also found in association with blackcurrants, grapevine and apple at three other locations.

35. *X. surinamense* Loof *et* Maas, 1972 has been recorded from central Spain but morphological and biological data were not given (Alphey and Taylor, 1986).

36. *X. turcicum* Luc *et* Dalmasso, 1963 has been recorded in Europe as discrete and widely separated populations, except for central Spain where several populations have been reported from a relatively small area. A population from Algeria differed in various morphological features from the type specimens (Dalmasso, 1969) and D. Sturhan (personal communication) stated that differences between three populations examined by him may be sufficient to warrant the erection of new species. In Algeria, *X. turcicum* was found in a vineyard in which grapevine fanleaf

virus was spreading (C. Scotto La Massese, personal communication) but possibly small numbers of *X. index*, the vector of the virus, may not have been extracted from the soil (see *X. vuittenezi*, below).

37. *X. vuittenezi* Luc, Lima, Weischer *et* Flegg, 1964 (Fig. 3) is relatively widespread in central Europe, particularly in vineyards where it replaces *X. index* and *X. italiae* as the most frequently identified species. It has also been identified from northern England, southwest Portugal, the Jordan Valley and is the most frequently recorded *Xiphinema* species in Poland (M.W. Brzeski, personal communication). In Czechoslovakia, Germany F.G.R. and France, *X. vuittenezi* has been associated with the occurrence and spread of grapevine fanleaf virus but there is a lack of unequivocal evidence to suggest that it is a vector (Trudgill *et al.*, 1983). *X. vuittenezi* was associated with the spread of the virus in vineyards in Switzerland but after persistent soil sampling small numbers of *X. index* were detected (J. Klingler, personal communication). In Germany F.G.R., *X. vuittenezi* has been found in association with a virus which was spreading in grapevine plantations (Rudel, 1980) and which is considered to be a distinct strain of grapevine fanleaf (M. Rudel, personal communication).

38. *X. vulgare* Tarjan, 1964b has been recorded from four areas in central Spain but morphological and biological data were not given (Alphey and Taylor, 1986).

There are two *Xiphinema species inquirendae* reported from biotopes in Europe.

X. grande Steiner, 1914, was originally described from specimens in Switzerland and was subsequently reported from Germany and Poland (Schneider, 1953; Witkowska, 1958). Specimens from Spain identified as *X. grande* by Gadea (1955) refer to another *Xiphinema* species (Sturhan, 1963b) and therefore the record of *X. grande* in northern Spain given in Alphey and Taylor (1986) requires to be confirmed. Thorne (1939) and Sturhan (1963b) consider that *X. grande* was an *Enchodelus* species but that insufficient information was available to describe it. *X. grande* is recognised as a *species inquirenda* by Luc and Tarjan (1963), Cohn and Sher (1972) and Luc and Dalmasso (1975).

X. makrodorum Vanha, 1893 was described from specimens from Czechoslovakia and placed in the *Xiphinema* genus by Thorne (1939). However, on the basis of Vanha's drawing of the neck region Thorne considered «the species represents an unknown genus». Luc and Tarjan

(1963) considered that *X. makrodorum* was distinct from other *Xiphinema* species and Cohn and Sher (1972) included it as a *species inquirenda* in their list of *Xiphinema* species. Luc and Dalmasso (1975) include *X. dolichodorum* (de Man, 1907; Thorne and Swanger, 1936) as a *species inquirenda* in their list of *Xiphinema* species but Thorne (1939) had synonymised this with *X. macrodorum*, which takes precedence.

Longidorus

Up to mid-1987, 80 species of *Longidorus* had been described and 44 of these have been reported from European and Mediterranean countries. Nine species have been reported to be virus vectors (Taylor and Brown, 1981; Lamberti and Roca, 1987).

1. *L. aetnaeus* Roca, Lamberti, Agostinelli *et* Vinciguerra, 1986b was described from specimens obtained from the rhizosphere of *Quercus ilex* L. at Monte Minardo, Sicily, Italy on the slopes of Mount Etna. Previously it had been found in the rhizosphere of *Juniperus* sp., in the National Park of Circeo, Latina during a survey of Longidoridae undertaken during 1971-73 but was then merely noted as an undescribed species and was not reported in the Atlas of Plant Parasitic Nematodes of Italy (Roca and Lamberti, 1985).

2. *L. africanus* Merny, 1966 is considered to refer to all populations of *L. elongatus* from North Africa. Thus there are records from the Nile Delta, Egypt; from Preveza county, Greece; from the central and coastal regions of Israel; and from the central valley, Jordan.

3. *L. apulus* Lamberti *et* Bleve-Zacheo, 1977 (Fig. 4) was described from populations from the rhizosphere of artichoke plants in Apulia, Italy. It had earlier been identified as *L. attenuatus* (Roca *et al.*, 1975a) and this specific name was used in describing its association with artichoke Italian latent virus (Vovlas and Roca, 1975; Roca *et al.*, 1975b; Taylor *et al.*, 1976). *L. apulus* is quite common in the sandy soils of the north coastal area of Apulia and has probably been widely spread in soil adhering to artichoke (*Cynara scolymus* L.) sprouts used for propagation (Roca *et al.*, 1975a,b). A report of *L. attenuatus* in Yugoslavia is also referred to *L. apulus* (Lamberti *et al.*, 1973).

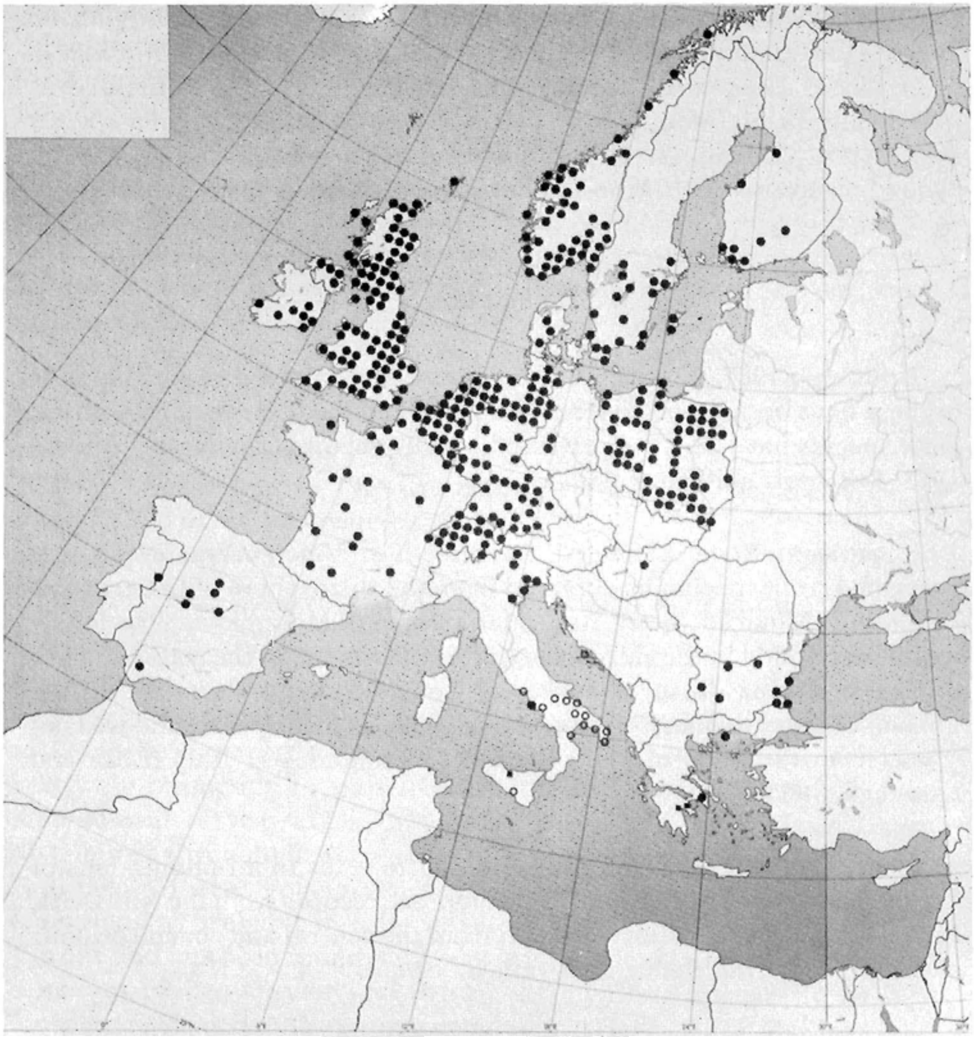

Fig. 4 - Distribution in European and Mediterranean countries of ●, *Longidorus elongatus*; ○, *L. apulus* and ■, *L. fasciatus*.

4. *L. attenuatus* Hooper, 1961 (Fig. 5) appears to have a localized distribution in those countries where it occurs, which are mainly in northern Europe. Several identifications of *L. attenuatus* are now referred to other species (see *L. apulus*, *L. protae*) and it is suggested that reports of the species in Bulgaria, southern France, Spain and Portugal should be re-examined as these are outwith the area of its distribution. Lamberti *et al.*

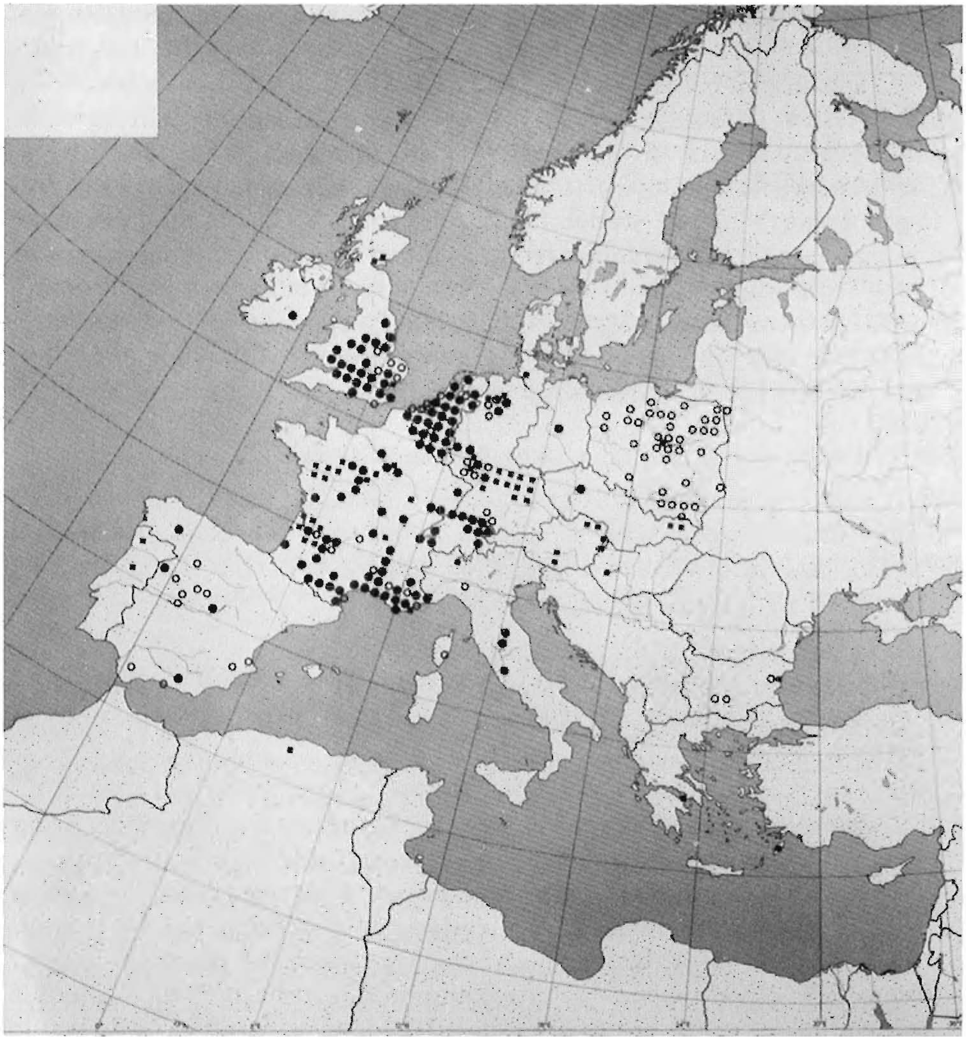

Fig. 5 - Distribution in European and Mediterranean countries of ●, *Longidorus macrosoma*; ○, *L. attenuatus* and ■, *Paralongidorus maximus*.

(1983) suggest that the populations from Bulgaria (Choleva, 1975) were probably *L. moesicus*. Thorne (1939) identified *Longidorus* specimens with expanded head regions from Syrna, Turkey as *L. elongatus* but subsequently Sturhan (1963a) suggested that the specimens might be *L. attenuatus*. The morphometrics and drawings given by Thorne (1939) correspond with those of *L. apulus*, *L. attenuatus*, *L. protae* and *L. vineacola* therefore the identification of the specimens should be confirmed (Brown, 1983).

L. attenuatus is the vector of the English strain of tomato blackring virus (TBRV) (Harrison *et al.*, 1961). A strain of tomato blackring virus serologically similar to the English strain has been transmitted by *L. attenuatus* to field pumpkin (*Cucurbita pepo* L.) (Forghani *et al.*, 1965) and to grapevine (*Vitis* sp.) (Rudel, 1977) in Germany F.G.R. In the laboratory a population of *L. attenuatus* from England transmitted five isolates of TBRV from England more frequently than three isolates from Germany F.G.R. (Brown and Trudgill, 1986). The proportion of individual *L. attenuatus* that transmitted the English isolates varied from 20 to 70% whereas only 3 to 5% transmitted the German isolate (Brown and Trudgill, 1986).

5. *L. caespiticola* Hooper, 1961 is widely distributed in Europe and often occurs in association with *X. diversicaudatum*. It has been reported as a vector of several viruses (Flegg, 1969; Valdez, 1972) but it has not been associated with virus infections in the field.

6. *L. carpetanensis* Arias, Andres *et* Navas, 1986 has been recorded only from its type location in soil from around *Cytisus purgans* L. roots in Ávila Province, Spain.

7. *L. closelongatus* Stoyanov, 1964 was originally described from specimens from the rhizosphere of diseased grapevines in Bulgaria. Choleva (1975) reported its wide occurrence in Bulgaria but in an erratum expressed doubt about the identification of the species; Lamberti *et al.* (1983) did not find it during their extensive survey of plant habitats in Bulgaria. *L. closelongatus* is quite common in southern France where it replaces *L. elongatus*, but Dalmasso (1970) included it in the *L. elongatus* complex in his survey of the Longidoridae in France.

8. *L. cohni* Heyns, 1969 has been reported only from the Sharon region of central Israel where it caused damage to oats (*Avena sativa* L.) (Cohn and Ausher, 1973).

9. *L. congoensis* Aboul-Eid, 1970 has been recorded from four date palm (*Phoenix dactylifera* L.) oases in Algeria but was not found in many other soil samples from that country (Lamberti *et al.*, 1975a).

10. *L. cylindricaudatus* Kozlowska *et* Seinhorst, 1979 has been recorded from four areas in Europe — near Wolfhezen and at Vortum in the Netherlands, in Lower Saxony, Germany F.G.R. and at several sites in Belgium (D. De Waele, personal communication; Kozlowska and Seinhorst, 1979; Rau, 1975). It is morphologically similar to *L. elongatus* but is distinguished from it by the longer odontostyle, and shape of the lip region and tail.

11. *L. distinctus* Lamberti, Choleva *et* Agostinelli, 1983 was described from specimens obtained from the rhizosphere of walnut (*Juglans regia* L.) and quince (*Cydonia oblonga* Mill.) at Kovachitsa, Bulgaria and at many other localities in the country, usually in association with woody hots.

12. *L. edmundsi* Hunt *et* Siddiqi, 1977 was described from specimens from the rhizosphere of *Coccoloba uvifera* L. growing on a beach at St. Lucia, West Indies but it has since been found at three localities in Italy (Lamberti *et al.*, 1985; Roca *et al.*, 1986a). Morphometrics of the Italian populations are similar to those of the type population (but see p. 363).

13. *L. elongatus* (de Man, 1876) Thorne *et* Swanger, 1936 (Fig. 4) is the earliest recorded longidorid species in Europe. Consequently many early records of *L. elongatus* are referred to other species, although conversely other species have been synonymised with *L. elongatus*. Populations vary morphometrically and at least nine authors have redescribed the species (Jacobs and Heyns, 1987). As a result of the uncertainty of the identity of this species many taxonomists regard *L. elongatus* as a species complex. Sturhan (1963a) reported that some German F.G.R. populations of *L. elongatus* had shorter bodies and odontostyles than the type British population and Dalmasso (1970) found differences among French populations in body size and the form of the labial contour. Because of these variations the French populations of *L. elongatus* can be grouped with those from Britain and The Netherlands whereas those from southern France form an easily recognisable separate group.

In Britain the earliest records of *L. elongatus* are from northeast Scotland where it was found in pastureland (Robertson, 1928, 1929). It is now known to be widespread and commonly occurring in eastern Scotland (Taylor and Brown, 1976) and it has frequently been identified from northern European countries but it has not been reported from central Europe or the mediterranean coastal areas, except for isolated population outliers in Italy and Greece. The populations from Italy and

Greece possibly refer to another species, as do populations reported from Bulgaria. Reports of *L. elongatus* in Spain and Portugal must also be regarded as of doubtful validity. At present the European distribution of *L. elongatus* as a species complex includes the British Isles, Scandinavian countries, Germany D.G.R. and F.G.R., The Netherlands, Belgium, northern France and northern Italy (Alphey and Taylor, 1986).

L. elongatus has been associated with damage to a wide range of crops and is economically important as a vector of the Scottish strains of raspberry ringspot and tomato black ring viruses (Taylor and Brown, 1981). It is reported to transmit carnation ringspot virus (Fritzsche *et al.*, 1979) but this association of virus and vector has not been found in the field and Brown and Trudgill (1985) have demonstrated that the results obtained by Fritzsche *et al.* (1979) could be due to contamination.

L. elongatus mainly is a parthenogenic species but several populations in Germany F.G.R. and The Netherlands are bisexual. However, differences in mode of reproduction are not related to differences in the nematodes morphology (Kozlowska and Seinhorst, 1979) or their ability to transmit viruses (C.E. Taylor, unpublished results).

14. *L. eridanicus* Roca, Lamberti *et* Agostinelli, 1984 was described from a population in a woodland in the Province of Torino, Italy and was also found in the rhizosphere of grapevines in the Province of Reggio Emilia and woodland soil in the Provinces of Piacenza and Belluno, Italy.

15. *L. euonymus* Mali *et* Hooper, 1974 was described from populations from several locations in eastern Czechoslovakia and was also erroneously reported as the vector of euonymus mosaic virus. It occurs in Italy (Basile *et al.*, 1982), southern Poland (Szczygiel, personal communication) and in several locations in Bulgaria where it was found in association with herbaceous and woody hosts (Lamberti *et al.*, 1983). It has also been found in Greece in artichoke fields infested with raspberry ringspot virus but experiments demonstrated that it was not a vector (Roca *et al.*, 1986c).

16. *L. fasciatus* Roca *et* Lamberti, 1981 (Fig. 4) was described from populations found in artichoke fields in Greece and Sicily. It was associated with outbreaks of artichoke Italian latent virus and its ability to vector the virus was confirmed in laboratory tests (Roca *et al.*, 1982).

17. *L. globulicauda* Dalmasso, 1969 has been found at several locations in Brittany, France but so far has not been recorded elsewhere.

18. *L. goodeyi* Hooper, 1961 is probably restricted in its distribution to the British Isles, The Netherlands, southeastern France and with sporadic occurrence in Germany F.G.R. It has been reported from Spain, Bulgaria and Malta but these appear to be discrete populations. Populations from The Netherlands differed from the type description in some morphological characters (Seinhorst and van Hoof, 1981) and those from France were smaller (Dalmasso, 1969).

19. *L. intermedius* Kozlowska *et* Seinhorst, 1979 resembles *L. elongatus* but may be distinguished by the longer odontostyle, rounded lip region, increased number of lateral, dorsal and ventral pores, slightly bilobed amphids and the absence of thickening of the body in the anal region. So far, the species has been recorded from several localities in The Netherlands, in the Ems Valley and Lower Saxony, Germany F.G.R. and from several sites in Belgium.

20. *L. iuglandis* Roca, Lamberti *et* Agostinelli, 1984 has been recorded only from its type locality in soil from the rhizosphere of *Juglans regia* L. in the province of Bari, Italy.

21. *L. juvenilis* Dalmasso, 1969 is limited in its European distribution to southeastern France and northern and central Italy, where it was found in association with grapevine, citrus and *Pinus strobus* L. This species has also been recorded from several localities in South Africa (Van Reenen and Heyns, 1986; Jacobs and Heyns, 1987).

22. *L. laevicapitatus* Williams, 1959 is relatively host specific and has been most frequently reported from sugarcane (*Saccharum officinarum* L.) plantations in tropical and sub-tropical countries (Lamberti, 1975). In Europe it has been found in five Mediterranean countries, France, Spain and Jordan and in association with citrus in Egypt and Israel (Oteifa and Tarjan, 1965; Cohn, 1969). Dalmasso (1970) speculates that the species may have been introduced into southern France during an abortive attempt to establish a sugarcane industry there in the 16th century.

23. *L. latocephalus* Lamberti, Choleva *et* Agostinelli, 1983 was described from specimens found in the rhizosphere of grapevine at Petrich, Bulgaria and from other locations in the country. This species has several characteristics in common with *L. pisi*, namely the basal swellings on the odontophore and a more posteriorly located guide ring than in other *Longidorus* species.

The morphometrics of 58 females and one male *L. pisi* from South Africa were described by Jacobs and Heyns (1983) and these data extend the ranges in the measurements reported for other populations (Brown *et al.*, 1982). Morphometrics of the South African specimens of *L. pisi* overlap with those of *L. latocephalus* and as the two species cannot be differentiated *L. latocephalus* is thus considered to be a junior synonym of *L. pisi*. Although the morphometric ranges overlap F. Lamberti (personal communication) considers that the mean values consistently distinguish two groups and are thus considered to support the validity of two species.

24. *L. leptocephalus* Hooper, 1961 exists as a large and small form, the latter being described as the type; the large form (Flegg, 1967; Hooper, 1973) is the more commonly occurring and intermediate populations have been found. *L. leptocephalus* is restricted in its distribution to the Scandinavian countries (where only the large form has been found), northern Germany F.G.R., Belgium, The Netherlands and the British Isles. In Britain it frequently occurs with *L. elongatus* and *L. goodeyi*. *L. leptocephalus* has also been recorded from southern Poland and southern Germany F.G.R., but these populations lie outwith what appears to be the distribution range of the species and their identification should be queried.

L. leptocephalus has been reported as a vector of the English strain of raspberry ringspot virus (Valdez, 1972) but Trudgill *et al.*, (1983) questioned this. Flegg (1969) found *L. leptocephalus* in the rhizosphere of cherry trees infected with cherry leaf roll virus but did not do any laboratory tests of vector transmission.

25. *L. lusitanicus* Macara, 1986 has been recorded only from its type locality in a forest of poplar trees [*Populus* × *euroamericana* (Dode) Guinier] near Golegã, in the Province of Ribatejo, Portugal.

26. *L. macrosoma* Hooper, 1961 (Fig. 5) has been recorded in thirteen European countries and is fairly common in five of them (England, France, Belgium, The Netherlands and Germany F.G.R.). It has been infrequently identified in Czechoslovakia, Germany D.G.R., Eire, Italy, Spain and Yugoslavia. In Germany F.G.R. its occurrence and distribution (and also that of *X. diversicaudatum*) was associated with shallow soils overlying carboniferous limestone (Rau, 1975) and Taylor *et al.*, (1978) noted a similar association in southern England. The distribution in southern England also was associated with pre-historic oak (*Quercus robur* L.) and beech (*Fagus sylvatica* L.) forests (Taylor and Brown, 1976; McNamara and Flegg, 1981).

L. macrosoma is the vector of the English strain of raspberry ringspot virus (Harrison, 1962) and in laboratory experiments it has been associated with the transmission of brome mosaic, carnation ringspot and *Prunus* necrotic ringspot viruses (Fritzsche, 1968). Kegler *et al.* (1976) found *L. macrosoma* in the rhizosphere of pear trees infected with pear stony pit virus. Trudgill *et al.* (1983) suggest that published evidence is valid only for the transmission of raspberry ringspot virus.

27. *L. macroteromucronatus* Altherr, 1974 was described from a single female specimen from Germany D.G.R. but D. Sturhan (personal communication) considers that it is probably correctly identified as *L. macrosoma*. This species has not been recorded elsewhere.

28. *L. magnus* Lamberti, Bleve Zacheo *et* Arias, 1982 has been recorded from Malta where it is widely distributed in association with various herbaceous and woody plants and from the Aprutium region of Italy (see *L.major*).

29. *L. major* Roca *et* D'Errico, 1987 was described from a population collected in 1986 from the rhizosphere of *Vitis* sp. at Colonna, near Rome, Italy. It was previously found in material collected in a survey of Longidoridae in central Italy (Roca and Lamberti, 1985) but identified as *L. magnus*. Re-examination of the specimens revealed differences in the first juvenile stage and adult females and further material was obtained from the type locality on which the description of the new species is based.

30. *L. moesicus* Lamberti, Choleva *et* Agostinelli, 1983 has been recorded from nine locations in Bulgaria in association with grapevine, apple, rose, plum and blackcurrant. It is widespread in central and southern Italy (Roca and Lamberti, 1985).

31. *L. nevesi* Macara, 1986 has been recorded only from its type locality in mixed woodland at Guincho, Cascais, Portugal.

32. *L. paraelongatus* Altherr, 1974 was described from specimens from Germany D.G.R. and was subsequently found in forest nursery soils near Munster, Germany F.G.R. (D. Sturhan, personal communication) and from St. Emilian, Bordeaux, France (Brown and Boag, 1986).

33. *L. picenus* Roca, Lamberti *et* Agostinelli, 1984 was described from a

population found in the rhizosphere of apple (*Malus communis* L.) at Pedaso, Province of Ascoli Piceno, Italy.

34. *L. pisi* Edward, Misra *et* Singh, 1964 has been reported from the southern mediterranean countries of Cyprus, Egypt, Israel and Jordan and from several biotopes in Bulgaria (Choleva-Abadzhieva, 1975). It is mainly a tropical to sub-tropical species occurring in India, South Africa, east and west Africa and thus in Europe it is likely to remain restricted to the warmer Mediterranean countries. All records of *L. siddiqii* Aboul-Eid, 1970 and *X. brevicaudatum* Schuurmans Stekhoven, 1951 in Europe are referred to *L. pisi*. (See *L. latocephalus* for proposed synonymy).

35. *L. poessneckensis* Altherr, 1974 is described from specimens from Germany D.G.R. which constitute the only report of its occurrence.

36. *L. profundorum* Hooper, 1966 has been recorded most frequently from Belgium, southern England, France and Spain, and occasionally from Wales, The Netherlands, Germany F.G.R., Germany D.G.R. and Northern Ireland. In southern England *L. profundorum* has a distribution similar to that of *L. macrosoma* and in France it most frequently occurs in soils in natural habitats. Morphometric differences between populations from different countries suggest that *L. profundorum* is a species complex (F. Lamberti, personal communication). *L. profundorum* has been implicated as a vector of a strain of raspberry ringspot virus (Fritzsche and Kegler, 1968) but Trudgill *et al.* (1983) suggest that this association requires confirmation.

37. *L. protae* Lamberti *et* Bleve-Zacheo, 1977 has been found only in northwest Sardinia in association with grapevine and was first recorded as *L. attenuatus* (Prota *et al.*, 1977).

38. *L. proximus*, Sturhan *et* Argo, 1983 was described from specimens obtained from arable soil at Friedelsheim, Rheinland-Pflaz, Germany F.G.R. Most recently it has been recorded in Greece, in artichoke fields infected with raspberry ringspot virus but experiments indicated that it was not the vector (Roca, 1986; Roca *et al.*, 1986c).

39. *L. pseudoelongatus* Altherr, 1976 was originally described from Germany F.G.R. and according to D. Sturhan (personal communication) the type specimen, which is in poor condition, is similar to *L. closelongatus*. During their study of morphometric variability within *L. vineacola* Brown

and Boag (1986) identified a population from Vortum Bosje, The Netherlands supplied by Dr. J.W. Seinhorst, as *L. pseudoelongatus*. The thirteen female and four male *L. pseudoelongatus* specimens were most similar morphometrically to *L. proximus* specimens collected in Greece.

40. *L. sylphus* Thorne, 1939 was originally described as a rare species from forest soil in the Wasatch Mountains, Utah, USA. Choleva *et al.* (1980) reported its occurrence in orchards and rose (*Rosa damascena* Mill.) nursery soils in several districts in Bulgaria.

41. *L. taniwha* Clark, 1963 was described from New Zealand but has subsequently been recorded in southern France, Egypt and Israel. It is a relatively rare species in Europe and the Mediterranean region, where it has been most frequently found in Egypt (Tarjan, 1964a; Oteifa and Tarjan, 1965).

42. *L. tarjani*, Siddiqi, 1962 has been identified from only two locations near d'Adge, southern France.

43. *L. unedoi* Arias, Andres *et* Navas, 1986 has been recorded only from Spain at Tora, Lerida and Romanya de la Selva, Gerona.

44. *L. vineacola* Sturhan *et* Weischer, 1964 was described from a population on grapevine at Trier, Germany F.G.R. It is sporadically distributed in Europe but in northern Germany F.G.R., southern Netherlands and southern Israel, it appears to be locally abundant. Differences have been noted in morphological characters and in morphometrics between populations from different countries which indicate that *L. vineacola* is a species complex (F. Lamberti, personal communication). Belgium specimens were smaller than the type (Aboul-Eid, 1970), those from The Netherlands had longer odontostyles and other differences (J. Seinhorst, personal communication), whereas those from northwest England had longer odontophores than the type. Also, those from three Scottish islands differed from other European populations in having a shorter body, odontostyle and tail length (Boag and Brown, 1987). From their study of morphometrical variability between *L. vineacola* populations Brown and Boag (1986) concluded that several populations had been incorrectly identified including one from France which was *L. paraelongatus* and one from The Netherlands which was *L. pseudoelongatus*. Other morphometric differences were within an acceptable range for the species.

Terlidou (1967) reported a *Longidorus* sp. from Greece and from the drawings and photomicrographs it would appear to be *L. vineacola*.

A report of *Paralongidorus maximus* Meyl (1954) was based on one female and one fourth stage juvenile and Sturhan (1963a) later described these as *L. meyli*. Subsequently Siddiqi (1965) noted that *L. meyli* was similar to *L. vineacola* but Aboul-Eid (1970) could not support this and left *L. meyli* as a *species inquirenda*. However, acknowledging the variation between populations of *L. vineacola* it is possible that *L. meyli* represents an aberrant population within the *L. vineacola* species complex.

Paralongidorus

1. *P. epimikis* Dalmasso, 1969 was described from Algeria and constitutes the only record of its occurrence.

2. *P. georgiensis* Tulaganov, 1937 has been reported in Europe from only the Nile Delta, Egypt.

3. *P. maximus* Butschli, 1874 (Fig. 5) has a distribution somewhat similar to *L. vineacola* according to Dalmasso (1970) but it has been identified relatively frequently in soils from southern Germany F.G.R. and from alluvial soil in two areas in western France. It probably is widely distributed throughout Europe as it also has been recorded in Algeria, Bulgaria, Greece, Poland, Portugal, Spain and eastern Scotland. *P. maximus* was probably introduced into Britain in planting material from Europe and has been found only in private gardens, a forest nursery and a market garden (Taylor and Brown, 1976). There appears to be little morphometric variability among populations (Heyns, 1975; McElroy *et al.*, 1977; Lamberti *et al.*, 1983). *P. maximus* transmitted three nepoviruses, including raspberry ringspot, under experimental conditions (McElroy *et al.*, 1977), but these «transmissions» could have been caused by contamination (Trudgill *et al.*, 1983); it has been associated with a mild strain of raspberry ringspot virus spreading in vineyards in Germany F.G.R. (Rudel, 1985).

4. *P. remeyi* Altherr, 1963 was described from specimens collected in northeastern France and has not been found elsewhere.

Discussion

Some tentative views have been expressed on the distribution of longidorid nematodes in relation to palaeoecology (Dalmasso, 1970; Rau, 1975; Taylor and Brown, 1976; McNamara and Flegg, 1981). Coomans (1985) considers that *Xiphinema* originated in Gondwana during the Permian period and before the break-up of Pangaea the genus spread to Laurasia. He deduces from the present distribution that the *Longidorus-Longidoroides-Paralongidorus* complex originated in South-East Africa and India, when these areas were still united and that a later spread to Laurasia was accompanied, and followed, by a main speciation of *Longidorus* in the holartic region, especially Europe.

In their analysis of the European longidorid fauna, Topham and Alphey (1985) relate the distribution of species to geological changes. They point to the gradual faunal change that is apparent in western Europe compared with the wide divergences among the eastern Mediterranean countries of Israel, Malta and Italy which is considered from the perspective of the complex Mediterranean plate tectonics in the Miocene (MacKenzie, 1970) while they associate the marked impoverishment of the fauna in northern Europe with the influence of quarternary glaciation.

Much of the dispersal of soil-inhabiting nematodes is thought to be recent and the present occurrence and maintenance of species populations is related to edaphic factors such as soil type, soil porosity, host plants, precipitation and temperature, which in combination comprise the biotope. Hashim (1979) observed that the nematode fauna of the rain-fed, elevated areas of Jordan resembles that of Europe but that in the Jordan Valley and the Southern Ghors the nematode fauna is more similar to sub-tropical Africa. Also, Dalmasso (1970) reported that in France several members of the Longidoridae appear to be dependent on the local climate e.g. *X. neovuittenezi* is found only in very warm regions with an annual rainfall of less than 500 mm, *X. vuittenezi* is found in areas with an annual rainfall between 500 and 700 mm but the species is absent in surrounding areas with larger annual rainfall. Thus, in some European countries the occurrence of particular nematode species appears to be correlated with the local climate. However, differences in the microclimate presumably also affect the local vegetation including arable crops, and plant hosts can be a major factor limiting the distribution of some nematode species e.g. in field situations *X. index* is usually found only associated with grapevine and fig (Cohn, 1975; Siddiqi, 1974). The complex inter-relationships between microclimate, soil factors, plant species and nematode species are probably many and varied. It is unlikely therefore that an examination, even at the continental level, of any one factor in isolation from the others will offer any useful explanation of what determines the European distribution of the Longidoridae.

Today man is probably the most important influence on the dissemination and consequent geographical distribution of nematode species (Taylor, 1977; 1986). Examples of longidorids which have been widely disseminated include *X. index* which, with its associated virus grapevine fanleaf, has been disseminated throughout Europe and other grapevine growing areas of the world from ancient Persia, its area of origin (Hewitt, 1968; Mojtahedi *et al.*, 1980). *X. rivesi*, which is a vector of tomato ringspot virus in eastern USA, may have been imported into Europe (see text) where it now occurs in scattered localities, particularly in western France, but so far without association with the virus. Taylor and Brown (1976) reported *L. elongatus* from several of the Scottish islands where it was found only in soils from private gardens or similar sites and thus was probably introduced to these biotopes with planting material. Direct evidence of man's rôle in distributing nematodes is illustrated by the interception and identification of nematodes on imported plants e.g. *X. incognitum* and *X. insigne* associated with coniferous and deciduous «bonsai» species and dwarf conifers respectively, imported into England (Southey and Aitkenhead, 1972); also *X. hygrophilum* was originally described from a tropical aquatic plant *Cryptocoryne* sp., growing at the Royal Botanic Gardens, Kew, England (Southey and Luc, 1973).

Phytosanitary (quarantine) regulations practised by individual countries in recent times have constrained the introduction of nematodes with plant material and soil and hence the likelihood of newly introduced species being found has diminished. However, whilst the occurrence and distribution of the major pathogenic species of Longidoridae may now be considered to be well known, this is not the case for other species that do not reveal their presence by damage to crops. Notwithstanding the considerable amount of information that has accrued on the distribution of the Longidoridae through the auspices of the European Plant Parasitic Nematode Survey (Alphey and Taylor, 1986) it is likely that further soil sampling, particularly in areas of natural vegetation, will reveal further species. Moreover, as more populations of longidorid species are examined it must also be expected that morphometrical and morphological differences will persuade taxonomic nematologists that new species should be differentiated, particularly in those species that are already regarded as species complexes, e.g. *L. elongatus*, *L. profundorum*, *L. vineacola*. The accumulation of information, however, will not only continue to refine our views on factors influencing the geographical distribution of nematodes but also should provide the basis for improved phytosanitary measures, both within and between countries.

We thank the many colleagues who provided unpublished information on various species and who offered their opinions on aspects of nomenclature.

Note added in proof

Three new species of *Xiphinema* are reported from Europe in this issue (*Nematol. medit.*, *15*: 323-332; *15*: 219-223). *X. dissimile* Roca, Pereira *et* Lamberti, 1987 was found in the rhizosphere of *Cupressus* sp. at Escaroupim, Salvaterra de Magos, Portugal and *X. lafoense* Roca, Pereira *et* Lamberti, 1987 in the rhizosphere of grapevine (*Vitis* sp.) at Varzea, S. Pedro do Sul, Portugal. *X. fortuitum* Roca, Lamberti *et* Agostinelli, 1987 is described from a population from the rhizosphere of peach, *Prunus persica* L., at Calizzano (Savona), Italy. Also, two new species of *Longidorus*, namely *L. dunensis* Brinkman, Loof *et* Barbez, 1987 and *L. kuiperi* Brinkman, Loof *et* Barbez, 1987 are reported from the sand dune coastal region of The Netherlands [*Revue Nématol.*, *10*: 299-308 (1987)]. The authors state that the population des ribed by Lamberti, Roca *et* Agostinelli (1985) from Italy as *L. edmundsi* is *L. kuiperi* (see p. 353).

SUMMARY

The species of *Xiphinema*, *Longidorus* and *Paralongidorus* which occur in Europe and the Mediterranean region are listed, with comments on those aspects of the biology of the species that relate to their geographical distribution. Maps of occurrence and distribution are provided for *X. diversicaudatum*, *X index*, *X. italiae*, *L. attenuatus*, *L. elongatus*, *L. fasciatus*, *L. macrosoma*, and *P. maximus*. Factors affecting distributions are discussed.

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