

## A LITERATURE REVIEW ON THE OCCURRENCE OF NEMATODES OF THE FAMILY LONGIDORIDAE IN GREECE

E.A. Tzortzakakis<sup>1</sup>, V. Peneva<sup>2</sup>, D.J.F. Brown<sup>2</sup> and A.D. Avgelis<sup>3</sup>

<sup>1</sup> Nematology Laboratory, Plant Protection Institute, N.AG.RE.F., P.O. Box 2228, 71003, Heraklion, Crete, Greece

<sup>2</sup> Central Laboratory of General Ecology, 2 Garagrin Street, 1113 Sofia, Bulgaria

<sup>3</sup> Plant Virus Lab., N.AG.RE.F., 71003, Heraklion, Crete, Greece

**Summary.** Information on the occurrence of longidorid nematodes in Greece is compiled from literature and unpublished data of the authors. Five species of *Xiphinema* (*X. americanum*, *X. diversicaudatum*, *X. index*, *X. italiae*, *X. pachtaicum*), nine of *Longidorus* (*L. africanus*, *L. closelongatus*, *L. cretensis*, *L. elongatus*, *L. euonymus*, *L. fasciatus*, *L. intermedius*, *L. pisi*, *L. proximus*) and one of *Paralongidorus* (*P. maximus*) have been reported to occur in Greece. Their association with two nepoviruses has also been reported. Comments are provided on records of doubtful validity.

**Key words:** *Xiphinema*, *Longidorus*, nepoviruses.

The occurrence of longidorid nematodes in Greece has been variously described in several publications, including reviews by Lamberti (1981) and Brown and Taylor (1987) for the Mediterranean region.

Here we provide a comprehensive review of the distribution and host associations of the five *Xiphinema*, nine *Longidorus*, and one *Paralongidorus* species that are reported to occur in Greece. The data have been obtained from published information referred to in Helminthological Abstracts, series B, Plant Nematology, Nematological Abstracts from 1992, other accessible/available publications, and unpublished information from surveys and experiments conducted by the authors. Publications referring to genus without species determination have been omitted.

### XIPHINEMA SPECIES

*Xiphinema index* Thorne et Allen, 1950 has been reported from vineyards in Thassos, Attica, Thessaloniki, Korinthos, Amaliada, Arta, Crete, Samos, Rhodes, Paros, Limnos and Tyrnavos (Kyrou, 1964; Hirschman et al., 1966; Terlidou, 1967; Vovlas and Avgelis, 1988; Avgelis et al., 1993; Lamberti et al., 1996; Avgelis and Tzortzakakis, 1997, 2001; Tzortzakakis et al., 2006). The nematode's ability to reproduce on American grapevine rootstocks used for grafting in Greece has been reported (Goumas and Tzortzakakis, 1998). The nematode has been also found in association with olive in Crete (Lamberti et al., 1996; Tzortzakakis, unpublished), hop in Arta (Koliopanos and Vovlas, 1977) and in olive nurseries (Vlachopoulos, 1991). A terminal digi-

tate mucro (peg) is one of the characteristics used in the diagnosis of *X. index*. However, females without tail mucro have been found at low frequencies in some populations. Females without terminal mucro reproduced in potted grapevines and figs and their progeny had tail mucro, confirming that its absence is not an inherited characteristic (Tzortzakakis and Brown, 1996; Tzortzakakis, 2004).

*Xiphinema italiae* Meyl, 1953 has been found in vineyards and grapevine nurseries in Thessaloniki, Attica, Amaliada, Korinthos, Thiva and Argos (Terlidou, 1967; Kalyviotis-Gazelas, 1981; Vlachopoulos, 1991). Extensive surveys of vineyards in Samos, Rhodes, Crete, Paros, Limnos and Tyrnavos (Vovlas and Avgelis, 1988; Avgelis et al., 1993; Avgelis and Tzortzakakis, 1997, 2001; Tzortzakakis et al., 2006) also revealed the presence of the species. The nematode has also been recorded from olive in Crete (Lamberti et al., 1996; Tzortzakakis, unpublished), and is mainly recovered from light sandy soils (Tzortzakakis et al., 2006).

*Xiphinema americanum sensu lato* Cobb, 1913 has been recorded in association with grapevine (Kyrou, 1964; Hirschman et al., 1966; Terlidou, 1967), citrus (Kalyviotis-Gazelas, 1971), grapevine and citrus nurseries (Vlachopoulos, 1991, 1992), maize, tobacco and oregano (Kalyviotis-Gazelas, 1981), and spinach and strawberry (Kyrou, 1965).

It is unlikely that any of these records are of *X. americanum sensu stricto*, and the correct identification of the species belonging to the *X. americanum* group reported in these publications remains unknown.

*Xiphinema pachtaicum* (Tulaganov, 1938) Kirjanova, 1951 and its host associations have been reported several times from various areas of Greece: grapevine (Lam-

---

<sup>1</sup> Contact author e-mail: [etzortza@her.forthnet.gr](mailto:etzortza@her.forthnet.gr)

berti and Bleve-Zacheo, 1979; Kalyviotis-Gazelas, 1981; Vovlas and Avgelis, 1988; Vlachopoulos, 1991; Avgelis *et al.*, 1993; Avgelis and Tzortzakakis, 1997, 2001; Tzortzakakis *et al.*, 2006), citrus (Koliopanos and Kalyviotis-Gazelas, 1979), artichoke (Roca *et al.*, 1986), olive (Lamberti *et al.*, 1996; Tzortzakakis, unpublished), cherry, fig and cypress (Koliopanos and Vovlas, 1977), and weeds and natural vegetation (Tzortzakakis, unpublished).

*Xiphinema diversicaudatum* (Micoletzky, 1927) Thorne, 1939 has been reported once from a vineyard on the Island of Kos (Terlidou, 1967), but the morphometric data provided in the report are insufficient to confirm the species identification.

### LONGIDORUS SPECIES

Three species of *Longidorus*, *L. fasciatus* Roca *et al.* Lamberti, 1981, *L. proximus* Sturhan *et al.* Argo, 1983 and *L. euonymus* Mali *et al.* Hooper, 1974 have been found in association with artichoke in areas of Argos (Roca and Lamberti, 1981) and Marathon (Roca, 1986; Roca *et al.*, 1982, 1986). The authors of this review found *L. proximus* in vineyards in Paros and Limnos, and Roca (1986) described the male of that species from specimens found in Greece.

*Longidorus africanus* Merny, 1966 was reported associated with Jerusalem sage in Louros Preveza (Koliopanos and Vovlas, 1977).

*Longidorus closelongatus* Stoyanov, 1964 was found associated with olive in Crete (Lamberti *et al.*, 1996) and the male was described for the first time. In a subsequent paper (Lamberti *et al.*, 1997) the population from Kolibari was re-examined and only three juvenile stages were detected.

*Longidorus maximus* Bütschli, 1874 and *L. elongatus* (de Man, 1876) Micoletzky, 1922 were reported from Rhodes, Korinthos (Terlidou, 1967) and Thassos (Kyrou, 1964), but the morphometric data provided in these reports are insufficient to confirm the species identifications. The record of *L. maximus* was referred to as *Paralongidorus maximus* (Bütschli, 1874) Siddiqi, 1964 by Brown and Taylor (1987), and the occurrence of *L. elongatus* in Greece, but not the area or host, was referred to by Hooper (1973).

*Longidorus pisi* Edward, Misra *et al.* Singh, 1964 was reported associated with tobacco in Greece, but a specific locality was not mentioned (Robbins *et al.*, 1995). Lamberti *et al.* (1997) reported *L. latocephalus* (a junior synonym of *L. pisi* according to Choleva *et al.*, 1991) from the same host at Katerini and provided morphometric data.

*Longidorus cretensis* Tzortzakakis, Peneva, Terzakis, Neilson *et al.* Brown, 2001 was described originally from a vineyard in Crete. The nematode was also found associated with olive but attempts to multiply it on potted olives in a four-month period failed. Furthermore, in preliminary studies the nematode population was found not to be a virus vector (Tzortzakakis *et al.*, 2001).

*Longidorus intermedius* Kozłowska *et al.* Seinhorst, 1979 was found in association with *Quercus coccifera* L. near Kavala (Peneva, unpublished).

### VIRUS ASSOCIATION AND TRANSMISSION

The presence of grapevine fanleaf nepovirus (GFLV) was detected in plant tissues and associated specimens of *X. index* in samples collected from vineyards on Rhodes (Avgelis *et al.*, 1993). Also, the virus has been detected in plant tissues coming from infected grapevines from Samos, Paros and Crete, where the vector nematode was present. In most cases the presence of *X. index* was associated with a progressive spreading of diseased plant patches over time, but the vectoring ability of the nematode at these sites was not verified (Avgelis and Tzortzakakis, 1997, 2001).

*Xiphinema italiae* was found in a vineyard in Crete in which grapevines had symptoms of GFLV. The virus was subsequently confirmed from infected grapevine leaves, and further soil sampling failed to reveal the presence of *X. index*. A pot test was conducted using virus-free grapevines to examine the ability of the *X. italiae* population to transmit GFLV (Tzortzakakis and Avgelis, unpublished data). Grapevine plantlets or rooted mature plants, originating from virus-free mother plants and produced *in vitro*, were planted in 100 ml pots filled with a steam-sterilized mixture of soil and sand. An inoculum level of 14-80 nematodes per pot (females and juveniles) collected from the rhizosphere of the GFLV infected vines was used. Ten plants of two local varieties (Mandilaria and Monembasia) and ten American rootstocks R110 were tested. After a period of 4-6 months in a climatic room with 20-25 °C air temperature and 16 h photoperiod the plants were checked for the presence of GFLV, and the soil was processed for nematode extraction with wet sieving. From twelve out of the twenty pots nematodes were not recovered, while in the remaining pots 1-2 specimens (females and juveniles) were found, which were sluggish in movement having a transparent intestine without granules. Furthermore, there were no galled root tips, indicating the absence of nematode feeding, and GFLV was not detected in the plant roots and leaves. In four control pots inoculated with *X. index*, the roots had abundant tip galls, indicating nematode feeding, and juveniles and females were recovered from the soil proving successful reproduction (10-fold population increase within four months). Due to the failure of the *X. italiae* population

to reproduce on the potted vines the study was discontinued (Tzortzakakis and Avgelis, unpublished data).

The inability of *X. italiae* to reproduce in pots and transmit GFLV has also been shown with several Italian populations (Catalano *et al.*, 1992).

Roca *et al.* (1986) obtained negative results in transmission tests of raspberry ringspot nepovirus (RRSV) undertaken with *L. euonymus* and *L. proximus* recovered from the rhizosphere of infected artichokes. However, individuals of *L. fasciatus* collected from artichoke fields infected with artichoke Italian latent nepovirus (AILV) did transmit the virus (Roca *et al.*, 1982; Brown *et al.*, 1997).

These are the only reports on the association of Longidoridae nematodes from Greece with their respective Nepoviruses.

## GENERAL REMARKS

The longidorid species *X. index*, *X. italiae* and *X. pachtaicum* are widespread in the Mediterranean area (Lamberti, 1981). *Xiphinema diversicaudatum*, *L. africanus*, *L. closelongatus*, *L. euonymus*, *L. pisi*, *L. proximus* and *P. maximus* have been also found in central and/or southern Europe (Lamberti, 1981; Brown and Taylor, 1987). *Longidorus elongatus* is frequently found in northern Europe, and isolated populations in southern Europe, including Greece, probably are other species (Brown and Taylor, 1987). However, the occurrence of *L. elongatus* in Serbia was confirmed on the basis of morphological and molecular characteristics of the populations originating from poplar and the invasive plant species *Amorpha fruticosa* L. (Barsi and De Luca, 2006). *Longidorus fasciatus* was first described with specimens obtained from artichoke fields in Greece and Sicily (Roca and Lamberti, 1981). Furthermore, *L. cretensis* was originally described from a vineyard in Crete, but its host range has not been determined (Tzortzakakis *et al.*, 2001) and it has never been reported outside Greece. The records of *X. americanum* refer to *X. pachtaicum* or to other species of the *X. americanum sensu lato* group (Lamberti and Bleve Zacheo, 1979). Further studies are required to elucidate the status of the species belonging to the *X. americanum* group and the presence of *L. elongatus*, *P. maximus* and *X. diversicaudatum* in Greece.

## ACKNOWLEDGMENTS

This study was partly supported by: Union of Wine Producing Cooperatives of Samos, Greece; DEMETRA 95 project of the National Agricultural Research Foundation, Greece; Organization of Agricultural Insurance, ELGA (project ANAPTYR), Greece; Grant No 1405/04 of the National Science Fund, Bulgaria.

## LITERATURE CITED

- Avgelis A.D. and Tzortzakakis E.A., 1997. Occurrence and distribution of *Xiphinema* species and grape fanleaf nepovirus in vineyards of the Greek island of Samos. *Nematologia Mediterranea*, 25: 177-182.
- Avgelis A.D. and Tzortzakakis E.A., 2001. Occurrence of viruses and *Xiphinema* spp. in vineyards of the Greek islands of Paros and Limnos. *Phytopathologia Mediterranea*, 40: 284-288.
- Avgelis A., Catalano L. and Vovlas, N., 1993. Occurrence of virus vector nematodes and their associated nepovirus in vineyards of the Greek island of Rhodes. *Nematologia Mediterranea*, 21: 93-95.
- Barsi L. and De Luca F., 2006. Morphological and molecular characterization of *Longidorus elongatus* (Nematoda: Dorylaimida) from Serbia and first record of *L. raskii* from Bosnia and Herzegovina. *Russian Journal of Nematology*, 14: 31-41.
- Brown D.J.F. and Taylor C.E., 1987. Comments on the occurrence and geographical distribution of longidorid nematodes in Europe and the Mediterranean region. *Nematologia Mediterranea*, 15: 333-373.
- Brown D.J.F., Kyriakopoulou P.E. and Robertson W.M., 1997. Frequency of transmission of artichoke Italian latent nepovirus by *Longidorus fasciatus* (Nematoda: Longidoridae) from artichoke fields in the Iria and Kandia areas of Argolis in northeast Peloponnesus, Greece. *European Journal of Plant Pathology*, 103: 501-506.
- Catalano L., Savino V. and Lamberti F., 1992. Presence of *Grapevine fanleaf nepovirus* in populations of longidorid nematodes and their vectoring capacity. *Nematologia Mediterranea*, 20: 67-70.
- Choleva B., Peneva V. and Brown D.J.F., 1991. *Longidorus latocephalus* Lamberti, Choleva *et* Agostinelli, 1983, a junior synonym of *L. pisi* Edward, Misra *et* Singh, 1964 (Nematoda: Dorylaimida). *Revue de Nématologie*, 14: 505-509.
- Goumas D.E. and Tzortzakakis E.A., 1998. Reproduction of *Xiphinema index* and *Meloidogyne* species and infection of *Agrobacterium vitis* on grapevine rootstocks. *Phytopathologia Mediterranea*, 37: 22-27.
- Hirschmann H., Paschalaki-Kourtzi N. and Triantaphyllou A.C., 1966. A survey of plant parasitic nematodes in Greece. *Annales de l'Institut Phytopathologique Benaki, New Series*, 7: 144-156.
- Hooper D.J., 1973. *Longidorus elongatus*. C.I.H. *Descriptions of Plant Parasitic Nematodes. Set 2, No 30*, 4 pp.
- Kalyviotis-Gazelas C., 1971. List of nematodes and their host-plants as identified in Greece during 1969. *Annales de l'Institut Phytopathologique Benaki, New Series*, 10: 138-140.
- Kalyviotis-Gazelas C., 1981. Nematodes and host plants reported for the first time in Greece. *Annales de l'Institut Phytopathologique Benaki, New Series*, 13: 30-35.
- Koliopanos C.N. and Kalyviotis-Gazelas C., 1979. Nematodes and host plants identified for the first time in Greece. *Annales de l'Institut Phytopathologique Benaki*, 12: 50-58.
- Koliopanos C.N. and Vovlas N., 1977. Records of some plant parasitic nematodes in Greece with morphometrical descriptions. *Nematologia Mediterranea*, 5: 207-215.
- Kyrou N.C., 1964. [Phytoparasitic nematodes found in vineyards on the island of Thassos]. *Geoponika*, 114-115: 3-4.
- Kyrou N.C., 1965. [Stylet-bearing nematodes obtained from soil roots and above grown on various plant hosts in C. Macedonia]. *Geoponika*, 140-141: 60-63.

- Lamberti F., 1981. Plant nematode problems in the Mediterranean region. *Helminthological Abstracts, series B, Plant Nematology*, 50(4): 145-166.
- Lamberti F. and Bleve-Zacheo T., 1979. Studies on *Xiphinema americanum* sensu lato with description of fifteen new species (Nematoda, Longidoridae). *Nematologia Mediterranea*, 7: 51-106.
- Lamberti F., Iovev T., Choleva B., Brown D.J.F., Agostinelli A. and Radicci V., 1997. Morphometric variation and juvenile stages of some longidorid nematodes from Bulgaria with comments on the number of juvenile stages of *Longidorus africanus*, *L. closelongatus* and *Xiphinema* species. *Nematologia Mediterranea*, 25: 213-237.
- Lamberti F., Vouyoukalou E. and Agostinelli A., 1996. Longidorids (Nematoda: Dorylaimoidea) occurring in the rhizosphere of olive trees in western Crete, Greece. *Nematologia Mediterranea*, 24: 79-85.
- Robbins R.T., Brown D.J.F., Halbrecht J.M. and Vrain T.C., 1995. Compendium of *Longidorus* juvenile stages with observations on *L. pisi*, *L. taniwha* and *L. diadecturus* (Nematoda: Longidoridae). *Systematic Parasitology*, 32: 33-52.
- Roca F., 1986. A bisexual population of *Longidorus proximus* Sturhan *et* Argo, (Nematoda, Dorylaimida) from Greece. *Nematologia Mediterranea*, 14: 155-158.
- Roca F. and Lamberti F., 1981. *Longidorus fasciatus* sp. n. from Greece and Italy. *Nematologia Mediterranea*, 9: 175-179.
- Roca F., Rana G.L. and Kyriakopoulou P.E., 1982. *Longidorus fasciatus* Roca *et* Lamberti vector of a serologically distinct strain of artichoke Italian latent virus in Greece. *Nematologia Mediterranea*, 10: 65-69.
- Roca F., Rana G.L. and Kyriakopoulou P.E., 1986. Studies on Longidoridae (Nematoda, Dorylaimida) and raspberry ringspot virus spread in some artichoke fields in Greece. *Nematologia Mediterranea*, 14: 251-256.
- Terlidou M.C., 1967. [Nematodes attacking grapevines and their control]. Vine Institute Lykovryssi Kiffisia, Greece, 106 pp.
- Tzortzakakis E.A., 2004. Observations on the absence of a tail mucro in three populations of *Xiphinema index* Thorne *et* Allen, 1950 (Nematoda: Dorylaimida). *Nematologia Mediterranea*, 32: 243-244.
- Tzortzakakis E.A. and Brown D.J.F., 1996. The absence of a tail mucro in *Xiphinema index* (Nematoda: Longidoridae) appears not to be an inherited characteristic. *Russian Journal of Nematology*, 4: 187-189.
- Tzortzakakis E.A., Peneva V., Terzakis M., Neilson R., and Brown D.J.F., 2001. *Longidorus cretensis* n. sp. (Nematoda: Longidoridae) from a vineyard infected with a foliar 'yellow mosaic' on Crete, Greece. *Systematic Parasitology*, 48: 131-139.
- Tzortzakakis E.A., Pateras D. and Charoulis A., 2006. Occurrence of *Xiphinema* species in grapevine areas of Tyrnavos with comments on the distribution of *X. italiae* in Greece. *Helminthologia*, 43: 186-187.
- Vlachopoulos E.G., 1991. Nematode species in nurseries of Greece. *Annales de l'Institut Phytopathologique Benaki*, 16: 115-122.
- Vlachopoulos E.G., 1992. *Xiphinema americanum* present in Greece. *FAO plant Protection Bulletin*, 40: 110.
- Vovlas N. and Avgelis A., 1988. Occurrence and distribution of *Xiphinema* species in vineyards of the Heraklion province Crete (Greece). *Nematologia Mediterranea*, 16: 197-200.