

Distribution of Longidoridae in the Viticultural Regions of the Cape Province*

Antoinette P. Malan¹ and A.J. Meyer²

1) Plant and Quality Control, Private Bag X5015, 7599 Stellenbosch, Republic of South Africa

2) Department of Entomology and Nematology, University of Stellenbosch, 7600 Stellenbosch, Republic of South Africa

Submitted for publication: January 1994

Accepted for publication: May 1994

Key words: Distribution, grapevine, Longidoridae, South Africa, survey, grapevine, *Xiphinema*

Soil samples from five viticultural regions in the Cape Province were analysed for the presence of longidorid nematodes. Sixteen species of *Xiphinema* were found, the most common species being *X. elongatum*, *X. americanum* and *X. brevicolle*. *X. index* was recorded from three of the five regions. A survey in the Theewaterskloof area was conducted and nine *Xiphinema* species were recorded but *X. index* was absent.

Since nematodes of the family Longidoridae were found to be vectors of plant viruses (Taylor & Robertson, 1975), it became important to ascertain their occurrence and distribution. Grapevine fanleaf virus (GFLV) is the only soil-borne virus of grapevine reported in South Africa (Gorter, 1977). The South African Vine Improvement Board (VIB) has been initiated to furnish plant material of a high phytosanitary standard for use in the grapevine industry. In developing phytosanitary regulations with regard to nematodes, the occurrence and distribution of virus vectors in the viticultural regions of the Cape Province needed to be established in order to ensure the prevention of reinfestation of plant material with GFLV. One of the conditions for participation in the plant improvement scheme is the absence of vectors of GFLV in soil samples (Cohn *et al.*, 1970; Hewitt *et al.*, 1958).

Concern of the VIB regarding the possible spread of *X. index* by irrigation water from the Theewaterskloof dam (34° 01', 19° 54') to the uninfected Berg River and Eerste River valley prompted a survey of the Theewaterskloof dam catchment area. The Theewaterskloof dam is situated in the Riviersonderend valley near Villiersdorp. Apart from runoff from its own catchment, inflow is supplemented by runoff from neighbouring catchment areas and is transferred via intake works, shafts and tunnels (Fig. 2). Construction on the Theewaterskloof dam started in 1968 and since 1980 water has been distributed through the tunnel system to the Berg River and Eerste River valleys. It was demonstrated that plant parasitic nematodes could be spread through treated municipal water (Smith & van Miegheem, 1983b) as well as irrigation water (Smith & van Miegheem, 1983a). This was confirmed by Barbercheck *et al.* (1985) in a survey of the distribution of *X. index* along the Breede River and the distribution of *X. italiae* along the Berg River (Van Reenen & Heynes, 1988).

The present survey was launched to determine the presence of *X. index* in vineyards in the Theewaterskloof area since it is situated close to the Worcester and Robertson areas, where *X. index* was found to be one of the most common longidorid species (Barbercheck *et al.*, 1985). *X.*

index has a limited host range with fig as the most important host (Bleve-Zacheo & Zacheo, 1983), followed by grapevine (Kunde *et al.*, 1986). Alternative hosts do exist (Cohn & Mordechai, 1969), but *X. index* does not reproduce well on these.

The present paper reports on the occurrence and distribution of longidorid species identified in samples from so-called mother units, nurseries and established vineyards in the Cape Province, and a survey of the Theewaterskloof catchment area.

MATERIALS AND METHODS

Soil samples were analysed during September and October of each year for a period of six years. Samples were collected from viticultural regions in the Cape Province, which include the Southwest Cape Coastal, Breede River Valley, Klein Karoo, Olifants River and Orange River regions (Fig. 1), including the Ceres, Hermanus and Piketberg areas.

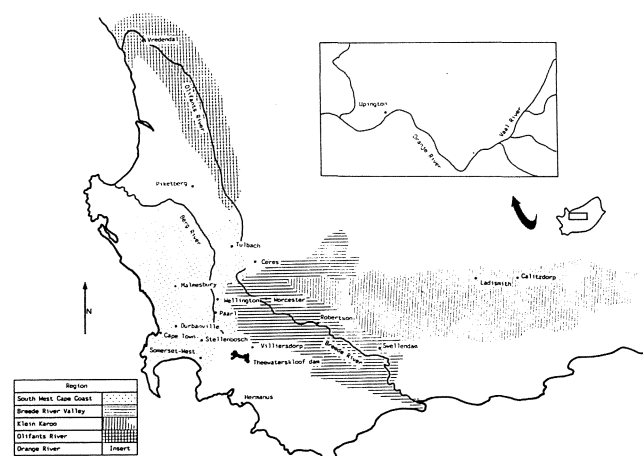


FIGURE 1
Viticultural regions of the Cape Province.

*Part of a Ph.D. (Agric.) dissertation to be submitted by the senior author to the University of Stellenbosch.

Acknowledgements: The authors wish to express their appreciation to Sharon Roos and H.C. Gouws for technical assistance; D. Conradie and Plant Inspectors of Quality Control for assistance in collecting the samples.

The survey in the Theewaterskloof region was conducted during September. Soil samples were taken from established vineyards generally situated close to rivers feeding the dam. A total of 44 soil samples were taken from vineyards in the region, including the Rooihooft (86%), Vyeboom (9%) and Elandskloof areas (5%) (Fig. 2). Three samples were taken at fig trees, two in the Rooihooft area and one in the Vyeboom area.

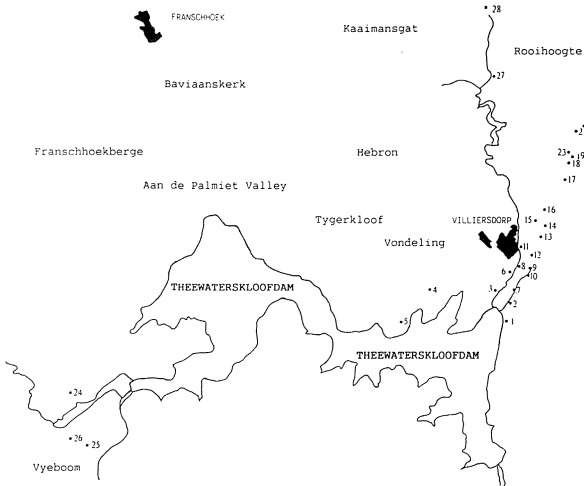


FIGURE 2

Sampling sites for the presence of Longidoridae in the Theewaterskloof catchment area.

Soil samples at the different localities were taken with a spade or a soil auger, depending on soil type, to a depth of 30 cm. Nematodes were extracted by suspending 500 cm³ soil in water which was subsequently sieved twice through three stacked 150 µm sieves (Flegg, 1967). Residues on sieves were washed into a 500 cm³ beaker and cleared for 24 h on a modified Baermann funnel fitted with a 142 µm aperture nylon sieve. All longidorid specimens were hand picked, killed and fixed in hot (80-85°C) FAA fixative (Hooper, 1970). After two days in FAA the nematodes were dehydrated, processed in pure glycerine and mounted on permanent microscope slides (Seinhorst, 1962).

RESULTS

The following *Xiphinema* species were found in samples from the five viticultural regions of the Cape Province in order of decreasing frequency, *X. elongatum* Schuurmans Stekhoven & Theunissen, 1983, *X. americanum* Cobb, 1913 sensu Heyns 1974, *X. brevicolle* Lordello & Da Costa, 1961 sensu Heyns, 1974, *X. italiae* Meyl, 1953, *X. vanderlinde* Heyns, 1962, *X. pachtaicum* (Tulaganov, 1938), *X. index* Thorne & Allen, 1950, *X. meridianum* Heyns, 1979, *X. vitis* Heyns, 1974, *X. krugi* Lordello, 1955, *X. parvistilus* Heyns, 1985, *X. barbercheckae* Coomans & Heyns, 1985, *X. capense* Coomans & Heyns, 1985, *X. bolandium* Coomans & Heyns, 1985, *X. mampara*, Heyns 1979 forma major sensu Hutsebaut, Heyns & Coomans, 1988 and some unknown *Xiphinema* spp. (Table 1). The only species in the genus *Longidorus* found was *L. pisi* Edward, Misra & Singh, 1964.

TABLE 1
Occurrence of longidorid species at sampling sites in the Cape Province.

P o c e s t i t i v s c e m s s p p l l e s s	N o t a t i v s c e m s s	T o t a l S a m p l e s	REGION/AREA	Longidorid species identified in samples																S p p. U n k n o w n l o c a l i t y						
				X.	X.	X.	X.	X.	X.	X.	X.	X.	X.	X.	X.	X.	X.	X.	L.		S					
1	0	1	CAPE COASTAL:	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1
0	2	2	Cape Town	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15	27	42	Durbanville	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30	24	54	Malmesbury	3	-	-	11	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	4
8	8	16	Paarl	5	-	-	16	-	9	2	1	2	-	3	1	-	-	-	-	-	-	-	1	1	-	10
8	8	16	Somerset West	-	-	-	2	-	8	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3
19	9	28	Stellenbosch	5	-	1	7	1	-	-	-	-	-	6	2	2	-	-	-	-	-	-	1	1	9	
5	1	6	Tulbagh	1	-	-	-	-	2	-	-	1	-	-	-	-	-	-	-	-	-	-	3	-	-	4
94	415	509	Wellington	60	1	-	17	1	24	-	12	-	-	2	4	1	4	4	17	-	-	-	-	-	-	12
15	2	17	BREEDE RIVER:	-	-	-	2	-	6	6	-	1	-	-	1	-	2	1	3	-	-	-	-	-	-	8
40	33	73	Robertson	4	-	-	6	-	6	9	-	-	-	-	1	2	13	1	10	4	-	-	-	-	10	
66	7	73	Swellendam	14	1	-	16	-	41	1	2	6	1	1	8	1	3	3	5	1	-	-	-	-	-	15
2	2	4	Worcester	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	2	4	KLEIN KAROO:	-	-	-	1	-	-	1	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	3
2	1	3	Calitzdorp	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
4	0	4	Ladismith	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4	0	4	OLIFANTS RIVER:	-	-	-	2	-	1	-	3	-	-	-	-	-	-	-	1	-	2	-	-	-	-	5
4	0	4	Vredendal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	4	6	ORANGE RIVER:	-	-	-	-	-	1	-	-	-	-	-	-	-	-	2	1	-	-	-	-	-	-	4
2	4	6	Upington	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1	0	1	Ceres	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1
0	2	2	Hermanus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8	3	11	Piketberg	2	-	-	1	-	6	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	5	
37%	63%	852	Localities per spp.	94	2	1	81	2	105	21	20	10	1	13	18	6	25	16	38	9	-	-	-	-	-	-

Nine species of *Xiphinema* were identified from vineyards in the Theewaterskloof catchment area. *Xiphinema* spp. present in order of decreasing frequency were *X. brevicolle*, *X. elongatum*, *X. americanum*, *X. meridianum*, *X. krugi*, *X. bolandium*, *X. judex* Hutsebaut, Heyns &

Coomans, 1989, *X. mampara* and *X. vanderlinde* (Table 2). A single species of *Longidorus*, viz. *L. pisi*, was found in six samples. From the samples taken at fig trees only *X. brevicolle* was present in one sample from the Rooihogte area.

TABLE 2
Occurrence of longidorid species at sampling sites in the Theewaterskloof catchment area.

P o s s i v e s a m p l e s	N e g a t i v e s a m p l e s	T o t a l s a m p l e s	S a m p l e n u m b e r	LOCALITY	Longidorid species identified in samples										S p p. p e r l o c a l i t y		
					X. a m e r i c a n u m	X. b o l a n d i u m	X. b r e v i c o l l e	X. e l o n g a t u m	X. j u d e x	X. k r u g i	X. m a m p a r a	X. m e r i d i a n u m	X. v a n d e r l i n d e	L. p i s i			
				ROOIHOOGTE:													
2	0	2	1	Welgelegen	-	-	2	-	-	-	-	-	-	-	-	-	1
3	0	3	2	Goedehoop	3	-	1	3	-	-	-	1	-	3	-	-	5
1	1	2	3	Waternal	1	-	-	-	-	-	-	-	1	-	-	-	2
2	0	2	4	Wonderfontein	1	-	1	2	1	1	-	-	-	-	-	-	5
1	0	1	5	Tweefontein	-	-	1	-	-	1	-	-	-	-	-	-	2
2	0	2	6	Maranda	1	-	1	1	-	-	-	-	-	-	-	-	3
1	0	1	7	Goedehoop	1	-	-	-	-	-	-	-	-	-	-	-	1
1	1	2	8	Rivierspruit	-	-	-	1	-	-	-	-	-	-	-	-	1
2	0	2	9	Bloemendal	1	-	2	1	-	-	-	-	-	-	-	-	3
2	0	2	10	Skoongezicht	-	-	1	2	-	-	-	-	-	-	-	-	2
1	0	1	11	Elandia	1	-	1	1	-	-	-	-	-	-	-	-	3
3	0	3	12	Skoongesig	-	-	2	2	-	1	-	-	-	2	-	-	4
2	0	2	13	Skoongesig Boerdery	-	-	-	2	-	-	-	-	-	-	-	-	1
1	0	1	14	Green Oaks of Valley	-	-	-	1	-	1	-	1	-	-	-	-	3
2	0	2	15	Radyn	1	-	1	2	-	-	-	-	-	-	-	-	3
2	0	2	16	Goedemoed	2	-	-	2	-	-	-	1	-	-	-	-	3
1	0	1	17	Erfkamp	-	-	1	-	-	-	1	-	-	-	-	-	2
1	0	1	18	Oude Non Pareil	-	-	1	-	-	-	-	-	-	-	-	-	1
1	0	1	19	Enon	1	-	-	-	-	-	-	-	-	-	-	-	1
1	0	1	20	Kyk Uit	-	-	1	-	-	-	-	-	-	-	-	-	1
1	1	2	21	Driefontein	1	1	-	-	-	-	-	1	-	-	-	-	3
1	0	1	22	Non Pareil	-	-	1	-	-	-	-	-	-	-	-	-	1
1	0	1	23	Driefontein	1	-	1	-	-	-	-	-	-	-	-	-	2
				VYEBOOM:													
1	0	1	24	Versoek	-	-	1	1	-	-	-	-	-	-	-	-	2
1	0	1	25	Ebenhaezer	-	-	1	-	-	-	-	-	-	-	-	-	1
2	0	2	26	Outol	-	-	1	-	-	-	-	-	-	-	-	-	1
				ELANDSKLOOF:													
1	0	1	27	Kaaimansgat Boerdery	-	-	-	-	-	-	-	1	-	-	-	-	1
0	1	1	28	Kaaimansgat Boerdery	-	-	-	-	-	-	-	1	-	1	-	-	2
91%	9%	44		Localities per species	15	1	21	21	0	4	1	6	1	6			

DISCUSSION

Xiphinema spp. occurred in only 37% of the samples, which include samples from mother units and nurseries (Table 1). This low incidence should be viewed against the backdrop of 91% incidence in established vineyards in the Theewaterskloof catchment area (Table 2). The low incidence can possibly be attributed to several cultural practices such as regular soil fumigation, extended fallowing, use of virgin land and crop rotation in mother units and nurseries.

In the survey of established vineyards in the Theewaterskloof area, two or more species often occurred together in a single sample. Single species occurred in 34% of the samples while 21%, 27%, 7% and 11% contained two, three, four and five longidorid species respectively. The Worcester area (Table 1) yielded up to 15 different species.

X. americanum occurred in the Coastal and Breede River regions (Table 1). This nematode is also a vector of nepoviruses, such as peach rosette mosaic virus, the grapevine yellow vein virus strain of tomato ringspot virus (Bovey *et al.*, 1980) and tobacco ringspot virus (McGuire, 1964) in the U.S.A. According to Lamberti & Blevet-Zacheo (1979) *X. americanum sensu lato* is a complex containing many different species and clarification of the vector potential of the component species is required.

X. italiae is more widely distributed in the viticultural regions of the Cape Province than was initially indicated (Van Miegheem & Pieterse, 1989; Van Reenen & Heyns, 1986). It occurred in all regions except the Orange River and Klein Karoo regions where the number of samples taken was very low. According to Trudgill *et al.*, (1983) the experimental proof supplied by Cohn *et al.*, (1970) is sufficient to regard *X. italiae* as a vector of GFLV. Catalano *et al.*, (1992) found no GFLV associated with *X. italiae* in ELISA tests and in transmission studies, but indicated that no feeding had taken place.

X. index was first recorded in Robertson and Swellendam (Heyns, 1971). A survey of the Breede River valley indicated that *X. index* occurred only in the Robertson district (Barbercheck *et al.*, 1985). *X. index* was reported in samples from the Plant Improvement vineyards (Barbercheck & Heyns, 1986) in the Worcester district. Van Reenen & Heyns (1986) reported a single *X. index* specimen during a survey of the Berg River system on the farm La Sharnell in the Paarl district in 1986, but subsequent sampling yielded no more specimens of *X. index*. During this survey *X. index* was again found in the Breede River region and in two samples in the Paarl area, but in a different locality. It was also found in Calitzdorp and Ladismith in the Klein Karoo region.

Six *Longidorus* spp. are known to transmit nepoviruses associated with a grapevine disease (Lamberti & Roca, 1989). None of these species was found in vineyards in the Cape Province. *L. pisi* was found in 38 localities, but has not been reported to be a virus vector as yet.

The Theewaterskloof survey provided the first record of *X. judex* on grapevine in the Cape Province. The species was originally recorded from wet soil under ferns in Venda, from indigenous grassland at Leisure Bay in Natal (Hutsebaut *et al.*, 1989) and from Transvaal (Hutsebaut & Heyns, 1989.)

Heyns (1977) described *X. krugi* from two vineyards in Brandvlei and Stellenbosch respectively. Barbercheck *et al.* (1985) reported *X. krugi* from Robertson, while Van Reenen & Heyns, 1986 reported *X. krugi* from Franschhoek and Wellington. In this survey *X. krugi* was found in Robertson, Tulbagh, Worcester, Paarl and in Rooihogte during the Theewaterskloof survey.

X. barbercheckae occurred in Wellington and Worcester, *X. bolandium* in Stellenbosch and Rooihogte, *X. capense* in Wellington and Stellenbosch and *X. mampara* in the Rooihogte and Worcester areas. These four endemic species are seldom found in vineyards (Heyns, 1979; Coomans & Heyns, 1985). *X. vitis*, *X. meridianum*, *X. parvistilus*, *X. vanderlinde* and *X. pachtaicum* occurred more frequently; with the exception of *X. pachtaicum*; all these species are endemic. The present survey as well as similar studies (Barbercheck & Heyns, 1986; Van Miegheem & Pieterse, 1989; Van Reenen & Heyns, 1986) indicated that *X. elongatum*, *X. americanum* and *X. brevicolle* are the most common *Xiphinema* species occurring on grapevine in the Cape Province.

The Theewaterskloof catchment area survey indicated longidorid species in 91% of the samples taken, but no *X. index* was found. No water is actively transported via pipelines or tunnels from the Robertson or Worcester areas infested with *X. index*. The elevation of Rooihogte prevents runoff water from infested areas entering the dam. From these results it can be concluded that the possibility of dissemination of *X. index* through irrigation water from the Theewaterskloof area seems to be slight.

The presence of *X. index* in the Cape Coastal region is discouraging since most of the mother units and nurseries participating in the plant improvement scheme are situated in this region. Once soil is infested with *X. index* it cannot be used for the production of GFLV-free grapevine material, since fumigation can only temporarily reduce nematode numbers and the nematodes may survive for up to ten years on root fragments in the soil (Raski *et al.*, 1965). The local populations of *X. index* is a good vector of GFLV (Malan & Meyer, 1992), but also a potent pathogen on certain grapevine rootstocks such as Jacquez and SO4 (Malan & Meyer, 1993).

LITERATURE CITED

- BARBERCHECK, M. & HEYNS, J., 1986. Occurrence of *Xiphinema* in South African Plant Improvement vineyards. *Phytophylactica* **18**, 59-61.
- BARBERCHECK, M., SMITH, P.C. & HEYNS, J., 1985. Occurrence and distribution of *Xiphinema* in vineyards of the Breë River valley. *Phytophylactica* **17**, 27-30.
- BLEVE-ZACHEO, T. & ZACHEO, G., 1983. Early stage of disease in fig roots induced by *Xiphinema index*. *Nematol. medit.* **11**, 175-187.
- BOVEY, R., GÄRTEL, W., HEWITT, W.B., MARTELLI, G.P., VUITTENEZ, A., 1980. Virus and virus-like diseases of grapevine, Editions Payor Lausanne, La Mainson Rustique Paris, Verlag Eugen Ulmer Stuttgart. pp. 46-56.
- CATALANO, L., SAVINO, V. & LAMBERTI, F., 1992. Presence of grapevine fanleaf nepovirus in populations of longidorid nematodes and their vectoring capacity. *Nematol. medit.* **20**, 67-70.
- COHN, E. & MORDECHAI, M., 1969. Investigations on the lifecycles and host preference of some species of *Xiphinema* and *Longidorus* under controlled conditions. *Nematologica* **15**, 295-302.
- COHN, E., TANNE, E. & NITZANY, F.E., 1970. *Xiphinema italiae*, a new vector of grapevine fanleaf virus. *Phytopathology* **60**, 181-182.
- COOMANS, A. & HEYNS, J., 1985. The genus *Xiphinema* in South Africa. X. Species of the *X. meridianum* group (Nematoda: Dorylaimida). *Phytophylactica* **17**, 183-194.
- FLEGG, J.J.M., 1967. Extraction of *Xiphinema* and *Longidorus* species from soil by a modification of Cobb's decanting and sieving technique. *Ann. appl. Biol.* **60**, 429-437.
- GORTER, G.J.M.A., 1977. Index of plant pathogens and the diseases they cause in cultivated plants in South Africa. Department of Agricultural Technical Services. Science Bulletin 392.
- HEWITT, W.B., RASKI, D.J. & GOHEEN, A.C., 1958. Nematode vector of soil-borne fanleaf virus of grapevines. *Phytopathology* **48**, 586-595.
- HEYNS, J., 1971. Three *Xiphinema* species from the South Western Cape Province (Nematoda: Longidoridae). *Phytophylactica* **3**, 107-114.
- HEYNS, J., 1977. The genus *Xiphinema* in South Africa. IV. *X. krugi* Lordello, 1955, *X. mediterraneum* Martelli & Lamberti, 1967, and a new species of the *X. hallei* group (Nematoda: Dorylaimida). *Phytophylactica* **9**, 109-114.
- HEYNS, J., 1979. The genus *Xiphinema* in South Africa. V. *X. zulu* Heyns, 1965 and related species in the *X. hallei* group (Nematoda: Dorylaimida). *Phytophylactica* **11**, 13-22.
- HUTSEBAUT, M. & HEYNS, J., 1989. A key to the *Xiphinema* species of Southern Africa, with notes on their distribution (Nematoda: Longidoridae). *Phytophylactica* **21**, 353-366.
- HUTSEBAUT, M., HEYNS, J. & COOMANS, A., 1989. The genus *Xiphinema* in Southern Africa. XX. Two species related to *X. flagellicaudatum* Luc, 1961 (Nematoda: Dorylaimida). *Phytophylactica* **21**, 113-120.
- HOOPER, D.J., 1970. Handling, fixing, staining and mounting nematodes. In: Southey, J.F. (ed.). Laboratory methods for work with plant and soil nematodes. Technical Bulletin 2, H.M.S.O., London, pp. 39-54.
- KUNDE, R.M., LIDER, L.A. & SCHMITT, R.V., 1986. A test of *Vitis* resistance to *Xiphinema index*. *Am. J. of Enol. and Vitic.* **19**, 30-36.
- LAMBERTI, F. & BLEVE-ZACHEO, T., 1979. Studies on *Xiphinema americanum sensu lato* with description of fifteen new species (Nematoda: Longidoridae). *Nematol. medit.* **7**, 51-106.
- LAMBERTI, F. & ROCA, F., 1989. Present status of nematodes as vectors of plant viruses. In: VEECH, J.A. & DICKSON, D.W. (eds.). Vistas on Nematology. Printing Co., De Leon Springs, Florida. pp. 321-353.
- MALAN, A.P. & MEYER, A.J., 1992. Transmission of grapevine fanleaf virus by a South African population of *Xiphinema index*. *Phytophylactica* **24**, 217-219.
- MALAN, A.P. & MEYER, A.J., 1993. Interaction between a South African population of *Xiphinema index* and different grapevine rootstocks. *S. Afr. J. Enol. Vitic.* **14**, 11-15.
- McGUIRE, J.M., 1964. Efficiency of *Xiphinema americanum* as a vector of tobacco ringspot virus. *Phytopathology* **54**, 799-108.
- RASKI, D.J., HEWITT, W.B., GOHEEN, A.C., TAYLOR, C.E. & TAYLOR, R.H., 1965. Survival of *Xiphinema index* and reservoirs of fanleaf in fallowed vineyard soil. *Nematologica* **11**, 349-352.
- SEINHORST, J.W., 1962. On the killing, fixation and transferring to glycerin of nematodes. *Nematologica* **8**, 71-74.
- SMITH, P.C. & VAN MIEGHEM, A.P., 1983a. The occurrence and distribution of nematodes in irrigation water in the Western Cape Province. *Phytophylactica* **15**, 71-74.
- SMITH, P.C. & VAN MIEGHEM, A.P., 1983b. First report on the occurrence of nematodes in municipal water in South Africa. *Phytophylactica* **15**, 79.
- TAYLOR, C.E. & ROBERTSON, W.M., 1975. Acquisition, retention and transmission of viruses by nematodes. In: LAMBERTI, F., TAYLOR, C.A. & SEINHORST, J.W. (eds.). Nematode vectors of plant viruses. London & New York: Plenum Press. pp. 253-276.
- TRUDGILL, D.L., BROWN, J.F. & McNAMARA, K.G., 1983. Methods and criteria for assessing the transmission of plant viruses by longidorid nematodes. *Revue de Nématologie* **6**, 133-141.
- VAN MIEGHEM, A.P. & PIETERSE, W., 1989. The distribution of Longidoridae in vineyards of the Western Cape. *Phytophylactica* **21**, 17-19.
- VAN REENEN, E. & HEYNS, J., 1986. A survey of Longidoridae in vineyards along the Berg River system. *Phytophylactica* **18**, 203-207.