Occurrence and ecology of longidorid nematodes in Belgium

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SUMMARY

The frequency of occurrence and ecology of longidorids in Belgium was investigated by examining two thousand and fifteen soil samples. About 23 % of these soil samples contained longidorid nematodes with *Longidorus elongatus* being the most common species followed by *Xiphinema diversicaudatum, L. caespiticola, L. macrosoma, L. goodeyi, L. leptocephalus, L. intermedius, L. cylindricaudatus, X. pseudocoxi, L. attenuatus, L. profundorum* and *L. vineacola.* Two unidentified *Longidorus* species and one *Paralongidorus* species were also found. Numerous significant relationships were present between species and the biotopic factors primary vegetation, percent of sand, percent of silt and pH. Several differences in habitat preferences between Belgian and British populations of the same species were identified.

RÉSUMÉ

Fréquence et écologie des nématodes Longidorides en Belgique

En vue de l'étude de la fréquence et de l'écologie des nématodes Longidorides de Belgique, 2 015 échantillons de sol ont été analysés dont 23 % étaient positifs. Quinze espèces de Longidorides ont été identifiées, la plus fréquente étant *Longidorus elongatus* suivi de *Xiphinema diversicaudatum, L. caespiticola, L. macrosoma, L. goodeyi, L. leptocephalus, L. intermedius, L. cylindricaudatus, X. pseudocoxi, L. attenuatus, L. profundorum* et *L. vineacola.* Deux espèces non identifiées de *Longidorus* et une de *Paralongidorus* ont également été observées. La répartition des espèces de Longidorides en fonction de la végétation primaire, du type de sol et du pH a été analysée. De nombreuses corrélations significatives entre espèces et facteurs du milieu ont été caractérisées. Une comparaison de l'écologie des espèces communes à la Belgique et à la Grande-Bretagne révèle des différences importantes dans les préférences de la même espèce selon le pays.

A survey of the Trichodoridae and Longidoridae of Belgium was initiated in 1977 as part of the European Plant Parasitic Nematode Survey and financed by a National Foundation for Scientific Research (Belgium) grant (no. 32.0024.77). An objective of the national and the European survey was the establishment of a data bank for trichodorid *(Trichodorus, Paratrichodorus)* and longidorid *(Longidorus, Paralongidorus, Xiphinema)* nematodes which could be used to produce geographical distribution maps and for analysing the physical and biotic factors influencing the distribution and abundance of the nematode species (De Waele, 1980; Alphey & Taylor, 1986). Such information would be useful for developing nematode management strategies, including quarantaine regulations.

Although trichodorid and longidorid nematodes can cause damage to many economically important crops by direct feeding on their roots, interest in these nematodes stems largely from the discovery that some species transmit plant viruses (Hewitt, Raski & Goheen, 1958; Sol & Seinhorst, 1961; Lamberti & Roca, 1987). In Belgium, two viruses transmitted by nematodes are of economic importance : tobacco rattle tobravirus on potatoes and arabis mosaic nepovirus on hops and strawberries (De Pelsmaeker & Coomans, 1985). The former virus is transmitted by trichodorid nematodes, the latter virus by *Xiphinema diversicaudatum.*

Geographical distribution maps of trichodorid and longidorid nematodes in Belgium have been published by De Waele and Coomans (1983). In the present paper, the distribution of longidorid nematodes with respect to primary vegetation, soil texture, and pH is reported and discussed.

Material and methods

Data were obtained during a national survey of virus-vector nematodes (Trichodoridae and Longidoridae) in Belgium between 1977 and 1982 (De Waele, 1980, 1983). Sampling was based on the 10 km grid system of the Universal Transverse Mercator (UTM) maps. The land-area of Belgium, about 30 500 km², consists of some 300 of these 10 km squares. At least five

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soil samples were taken within each 10 km square, with a standard core sampler (5 cm diam.), from five different vegetation types : arable crops, pastures, grass vegetation at road sides, deciduous and coniferous woodland. Each soil sample consisted of about 2 kg of soil collected within an area of about 20 cm diameter and to a depth of 20-40 cm, according to the vegetation type.

Nematodes were extracted from 100 ml subsamples by the decanting and sieving method (Flegg, 1967) followed by the Ludox centrifugal-flotation method (Coolen & D'Herde, 1977). The extracted nematodes were killed and fixed in hot 4 % formalin. Samples were examined for trichodorids and longidorids with the aid of a stereoscopic microscope and species identification confirmed with nematodes mounted in anhydrous glycerin (De Grisse, 1969).

The following biotopic data were collected for each sample : primary vegetation type, soil texture (percent of sand, percent of silt) and pH. Soil texture was determined by a rapid hydrometer method based on Day's (1965) modification of Bouyoucos' (1951) technique. The pH of the soil was measured electrometrically using a Philips PW 9408 digital pH meter.

Data were added to the databank of the European Plant Parasitic Nematode Survey at the Scottish Crop Research Institute, Dundee, Scotland, and held at the Edinburgh Regional Computer Centre, Scotland. Chi-squared contingency tests were used to analyse the relationships between the frequency of occurrence of the virus-vector nematodes and the biotopic data recorded. Quantitative data were transformed to qualitative data by prescribing class limits, thus percent of sand, percent of silt and pH were grouped into three, five and four classes, respectively.

Results and discussion

Two thousand and fifteen soil samples from 908 sampling sites were examined for longidorids. About 23 % of all samples contained at least one species. Fifteen species were identified, among them the five species previously reported from Belgium (Table 1). The *X. pseudocoxi* populations found during the national survey were initially identified as *X. coxi* (De Waele, 1983; De Waele & Coomans, 1983). As the Belgian survey was organized in the same way as the survey undertaken in Britain (Taylor & Brown, 1976) it was possible to compare the frequency of occurrence and ecology of longidorid species common to both countries.

Longidorus elongatus and *X. diversicaudatum* are the most frequently recorded species in most western European countries, including Britain (Alphey & Taylor, 1986; Brown & Taylor, 1987). Also, *L. caespiticola*, *L. goodeyi*, *L. leptocephalus* and *L. macrosoma* occur relatively frequently in Britain (Taylor & Brown, 1976) but are less common on the continent except *L. macrosoma* which is widely distributed to the west of the Rhine, in W. Germany, France and Switzerland (Rau, 1975; Alphey & Taylor, 1986; Klingler & Valloton, 1985; Scotto la Massèse, 1985; Brown & Taylor, 1987). The geographical distribution of *L. intermedius* is discontinuous : apart from the more than 40 and 20 localities in Belgium and Italy (Roca & Lamberti, 1985), respectively, this nematode was found at only a few localities in The Netherlands (Seinhorst & Van Hoof, 1982), and Poland (Szczygiel & Brzeski, 1985). The species which are less common in Belgium also occur less frequently elsewhere in Europe except *L. attenuatus* which is the second most common longidorid species in Poland (Szczygiel & Brzeski, 1985). Outside Belgium, *L. cylindricaudatus* is known from only four other areas in The Netherlands and W. Germany (Rau, 1975; Kozlowska & Seinhorst, 1979; Seinhorst & Van Hoof, 1982). Two *Xiphinema* species, *X. vuittenezi* and *X. pachtaicum* which have been found in Britain (Taylor & Brown, 1976; Alphey & Taylor, 1986) and France (Scotto la Massèse, 1985) were not recorded in Belgium.

In general, relatively more populations were associated with pastures and deciduous woodland than with any of the other vegetation types (Tab. 2). Almost 30 % of

Table 1

Longidorid nematodes found in Belgium during the national survey (1977-1982)

Species	*No. of positive samples*	*% of total samples (n = 2015)*
*Longidorus elongatus** (de Man) Thorne & Swanger	163	8.1
*Xiphinema diversicaudatum** (Micoletzky) Thorne	118	5.9
*Longidorus caespiticola** Hooper	65	3.2
*Longidorus macrosoma** Hooper	57	2.8
Longidorus goodeyi Hooper	52	2.6
Longidorus leptocephalus Hooper	43	2.1
Longidorus intermedius Kozłowska & Seinhorst	41	2.0
Longidorus cylindricaudatus Kozłowska & Seinhorst	15	0.7
Xiphinema pseudocoxi Sturhan	14	0.7
Longidorus attenuatus Hooper	8	0.4
Longidorus profundorum Hooper	7	0.3
*Longidorus vineacola** Sturhan & Weischer	3	0.1
Longidorus sp. 2	3	0.1
Longidorus sp. 1	1	0.05
Paralongidorus sp.	1	0.05
All longidorid nematodes	461	22.9

* Species previously reported from Belgium.

Table 2

Association of *Longidorus* and *Xiphinema* species with vegetation type in Belgium

Species	*No. of samples with nematodes*					*Statistical significance**
	Vegetation type					
	Arable crops (n = 341)	*Pastures (n = 521)*	*Grasses at road sides (n = 390)*	*Deciduous woodland (n = 539)*	*Coniferous woodland (n = 89)*	
L. attenuatus	1	1	4	2	0	—
L. caespiticola	11	28	11	15	0	NS
L. cylindricaudatus	0	0	1	9	5	S
L. elongatus	12	87	26	33	0	S
L. goodeyi	3	31	14	4	0	S
L. intermedius	0	1	3	36	1	S
L. leptocephalus	5	29	5	4	0	S
L. macrosoma	9	3	14	31	0	S
L. profundorum	0	2	1	4	0	NS
L. vineacola	0	2	0	1	0	—
X. pseudocoxi	1	4	4	3	2	NS
X. diversicaudatum	4	34	16	62	2	S
All longidorid nematodes	42	154	84	156	7	S
% of positive samples	12.3	29.6	21.5	28.9	9.0	

* Statistical significances of chi-squared contingency tests applied to the associations :
S = significant ($P < 0.001$); NS = not significant.

all samples from pastures and deciduous woodland contained at least one longidorid species. More than 50 % of the *L. elongatus, L. goodeyi* and *L. leptocephalus* populations were recovered from pastures while more than half of the *L. cylindricaudatus, L. intermedius, L. macrosoma* and *X. diversicaudatum* populations were associated with deciduous woodland. Only about 10 % of the samples from arable crops and coniferous woodland contained longidorids. Half the number of populations recovered from arable crops were either *L. elongatus* or *L. caespiticola* and half from coniferous woodland were *L. cylindricaudatus. L. caespiticola, L. profundorum* and *X. pseudocoxi* were not significantly associated with any particular vegetation type. In contrast with Belgium arable crops in Britain supported as many populations as grassland and relatively more populations than deciduous woodland : between 25 and 100 % of the populations of each longidorid species were recovered from arable crops, among them more than 50 % of all *L. caespiticola* and *L. profundorum* populations and all *L. attenuatus* populations (Taylor & Brown, 1976). Also, in Britain 5 to 10 % of all *L. goodeyi, X. diversicaudatum* and *L. elongatus* populations were associated with coniferous woodland (Taylor & Brown, 1976) whereas in Belgium these species were rare or absent in this vegetation type.

The association of longidorids with some arable crops, deciduous tree species and hedgerows is shown in Table 4. Fifteen samples were collected from rye but no longidorids were found. Among the deciduous tree species, *Fagus* spp., *Acer* spp., *Salix* spp. and *Populus* spp. were frequently infested with longidorids. More than 50 % of all *L. cylindricaudatus* and *L. intermedius* populations recovered from deciduous woodland were associated with *Fagus* spp., and *Quercus* spp., respectively. Almost 80 % of all samples collected from hedgerows contained longidorids with *L. macrosoma, X. diversicaudatum, L. caespiticola* and *L. elongatus* being most frequently recorded.

In general, longidorid populations were equally frequent in all percent of sand and percent of silt classes (Tab. 3). Two species, *L. profundorum* and *L. leptocephalus,* showed no preference for a particular soil type and were not significantly associated with either a percent of sand or percent of silt class. Fifty percent or more of *L. elongatus, L. attenuatus* and *X. pseudocoxi* populations were associated with soils with a sand fraction > 90 % and most populations of *L. goodeyi* and *L. cylindricau-*

Table 3

Association of *Longidorus* and *Xiphinema* species with soil texture and pH in Belgium

Species	*No. of samples with nematodes*			*Statistical significance**	*No. of samples with nematodes*					*Statistical significance**	*No. of samples with nematodes*				*Statistical significance**
	% sand				*% silt*						*pH*				
	0-79 (n = 587)	*80-89 (n = 762)*	*90-100 (n = 639)*		*0-4 (n = 304)*	*5-9 (n = 519)*	*10-14 (n = 466)*	*15-19 (n = 303)*	*20- (n = 396)*		*0.5-5.4 (n = 497)*	*5.5-6.4 (n = 543)*	*6.5-6.9 (n = 408)*	*7.0-8.5 (n = 564)*	
L. attenuatus	1	3	5	–	4	1	2	1	0	–	0	0	1	7	–
L. caespiticola	34	23	8	***	4	5	18	13	24	***	9	24	19	13	*
L. cylindricaudatus	0	13	2	***	0	4	9	2	0	**	6	7	0	2	*
L. elongatus	31	49	83	***	42	50	32	19	20	***	25	46	51	41	***
L. goodeyi	8	33	11	**	1	19	19	7	5	**	1	13	21	17	***
L. intermedius	14	21	6	*	2	12	13	7	7	NS	14	19	3	5	**
L. leptocephalus	10	16	17	NS	6	14	13	2	8	NS	3	19	14	7	**
L. macrosoma	31	21	5	***	3	7	8	11	28	***	0	9	13	35	***
L. profundorum	2	5	0	NS	0	3	2	1	1	NS	0	0	1	6	**
L. vineacola	1	2	0	–	0	0	1	1	1	–	1	2	0	0	–
X. pseudocoxi	0	5	9	*	2	8	4	0	0	**	3	6	4	1	NS
X. diversicaudatum	39	49	29	NS	12	24	34	13	34	*	27	41	27	23	NS
All longidorid nematodes	136	192	133	NS	61	115	122	63	100	NS	74	142	118	127	***
% of positive samples	22.8	24.9	20.7		19.7	22.0	26.0	20.5	25.0		14.9	26	28.9	22.5	

* Statistical significances of chi-squared contingency tests applied to the association; *, **, *** : $P < 0.05$, $P < 0.01$, $P < 0.001$, respectively; NS = not significant.

Table 4

Association of *Longidorus* and *Xiphinema* species with some arable crops, deciduous tree species and hedgerows in Belgium

Nematode species	*Arable crops*				*Deciduous tree species*							*Hedgerows*
	Barley (n = 43)	*Wheat (n = 53)*	*Maize (n = 101)*	*Feeder crops (n = 76)*	Acer *spp. (n = 19)*	Alnus *spp. (n = 35)*	Betula *spp. (n = 16)*	Fagus *spp. (n = 104)*	Quercus *spp. (n = 159)*	Populus *spp. (n = 87)*	Salix *spp. (n = 17)*	Crataegus *(n = 61)*
L. attenuatus	0	1	0	0	0	0	0	0	0	1	0	0
L. caespiticola	2	2	3	4	0	0	0	2	1	3	0	8
L. cylindricaudatus	0	0	0	0	0	0	0	6	0	0	0	0
L. elongatus	2	3	4	2	2	1	1	1	3	11	2	8
L. goodeyi	0	1	1	1	0	0	0	1	1	1	0	1
L. intermedius	0	0	0	0	1	2	0	8	22	0	0	1
L. leptocephalus	2	0	1	1	0	0	0	0	1	1	1	1
L. macrosoma	0	2	2	1	3	2	0	5	2	4	1	13
L. profundorum	0	0	0	0	0	0	0	0	0	0	0	3
L. vineacola	0	0	0	0	0	0	0	0	0	1	0	0
X. pseudocoxi	0	0	0	0	0	0	0	3	0	0	0	0
X. diversicaudatum	0	0	1	1	1	0	0	9	11	21	2	13
All longidorid nematodes	7	9	11	10	7	5	1	35	42	42	6	48
% of positive samples	16.3	17.0	10.9	13.2	36.8	14.3	6.3	33.7	26.4	48.3	42.9	78.7

datus were associated with soils with a sand fraction between 80 and 89 % and 5 to 14 % silt. *L. macrosoma, L. caespiticola* and *L. intermedius* were recovered from soils with a sand fraction of 79 % or lower. *L. macrosoma* was associated with soils with a higher silt fraction than *L. caespiticola* and *L. intermedius*. In Britain, longidorids were associated with sandy loam to loam soils : more than 50 % of all sandy loam to silty loam samples contained longidorids (Taylor & Brown, 1976) and approximately 70 % of *L. elongatus, L. goodeyi* and *L. leptocephalus* and 80 % of *X. diversicaudatum* populations were recovered from sandy loam to loam soils.

In general, relatively more populations occurred in soils with a pH ranging from 5.5 to 6.9 (Table 3). In soils with a pH lower than 5.5 and higher than 6.9, the observed frequency was lower than expected (14.9 % *vs* 24.7 %, respectively in the former soils and 22.5 % *vs* 28 % in the latter soils). No discernable effects of pH were observed on the occurrence of *X. diversicaudatum* and *X. pseudocoxi. L. cylindricaudatus* and *L. intermedius* preferred soils with a pH lower than 6.5 whereas *L. elongatus, L. caespiticola* and *L. leptocephalus* occurred mostly in soils with a pH between 5.5 and 6.9. Most populations of *L. macrosoma* and almost all populations of *L. attenuatus* and *L. profundorum* were found in soil with a pH higher than 7. In Britain, the pH of the soil samples infested with longidorids ranged from 3.6 to 8 with 60 % of the samples within the range 4.6-6.5 (Taylor & Brown, 1976).

The frequency of occurrence of longidorids in Belgium and Britain show that both countries have a similar longidorid nematofauna. Prior to the Quarternary period Belgium and Britain formed part of the same land mass. However, a comparison of the ecology of longidorid species common to both countries reveals important differences in habitat preferences between the Belgian and British populations of the same species. Differences between Belgium and Great Britain in species associations of longidorids have been reported previously (Topham *et al.*, 1986). *X. diversicaudatum, L. leptocephalus* and *L. caespiticola* are frequently found in association in Britain whereas in Belgium *X. diversicaudatum* is most frequently associated with *L. leptocephalus* and *L. elongatus*. Since the physical separation of Belgium and Britain, soil and vegetation in Belgium and Britain underwent different natural and man-made changes. The observed ecological differences indicate different adaptations to changing habitats by geographically separated populations of the same longidorid species.

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