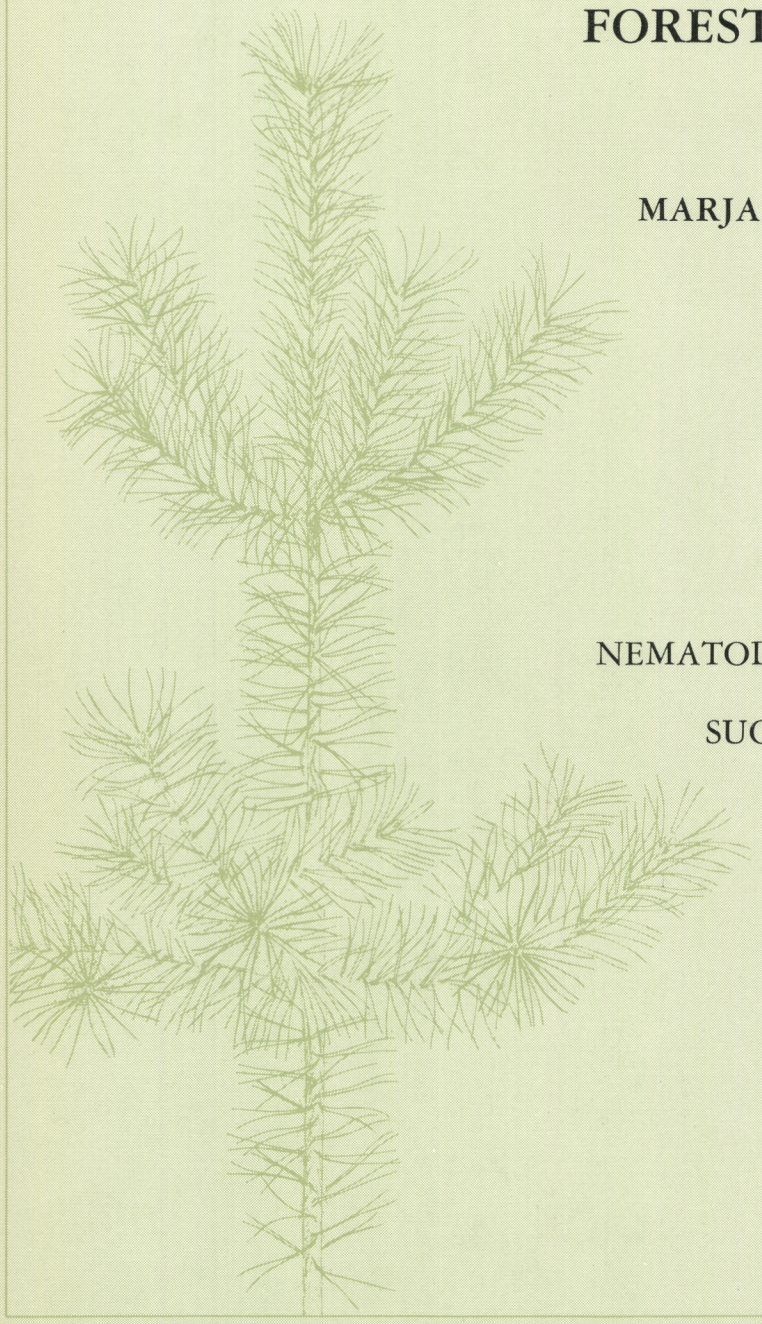
COMMUNICATIONES INSTITUTI FORESTALIS FENNIAE 103

NEMATODES IN SOME CONIFEROUS FORESTS IN FINLAND

MARJA LEENA MAGNUSSON



SELOSTE

NEMATODIEN ESIINTYMISESTÄ SUOMEN HAVUMETSISSÄ

HELSINKI 1982

COMMUNICATIONES INSTITUTI FORESTALIS FENNIAE

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Cover (front & back): Scots pine (*Pinus sylvestris* L.) is the most important tree species in Finland. Pine dominated forest covers about 60 per cent of forest land and its total volume is nearly 700 mill. cu.m. The front cover shows a young Scots pine and the back cover a 30-metre-high, 140-year-old tree.

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MAGNUSSON, M. L. 1982. Nematodes in some coniferous forests in Finland. Seloste: Nematodien esiintymisestä Suomen havumetsissä. Commun. Inst. For. Fenn. 103:1–12.

The nematode fauna of five coniferous forests were studied in northern and southern Finland. The total numbers were higher in the southern forests than in the northern one. The stylet-bearing nematodes were dominated by potential mycophages e.g. *Aphelenchoides, Tylenchus, Malenchus, Tylencholaimus mirabilis* and *T. stecki*. The obligate root feeding nematodes usually occurred in low numbers and contained the genera *Geocenamus, Tylenchorhynchus, Pratylenchus, Paratylenchus* and *Gracilacus*, as well as subfamily Criconematinae. Due to their low numbers, the root feeding nematodes could not be expected to damage the mature forest trees. Nitrogen fertilization did not drastically effect nematode numbers.

Viiden etelä- ja pohjoissuomalaisen havumetsän nematodipopulaatiot tutkittiin vuosina 1977–78. Nematodien kokonaismäärät olivat korkeammat Etelä-Suomessa kuin pohjoisessa. Juuria ja/tai sienihyyfejä ravinnokseen käyttävistä nematodeista olivat vallitsevia potentiaaliset mykofagit, kuten *Aphelenchoides, Tylenchus, Malenchus, Tylencholaimus mirabilis* ja *T. stecki*. Korkeampien kasvien juuria ravinnokseen käyttäviä nematodeja, *Geocenamus, Tylenchorhynchus, Pratylenchus, Paratylenchus, Gracilacus* ja Criconematinae, tavattiin yleensä vain pieniä määriä. Näiden nematodien ei epäillä vioittavan taimivaiheen ohittaneita havupuita.

ODC 459
ISBN 951-40-0552-X
ISSN 0358-9609

Helsinki 1982. Valtion painatuskeskus

CONTENTS

1. INTRODUCTION

Nematoda, the most common group of multicellular animals in soil, consistently contains species equipped with a mouth spear, or stylet, by which root cells and fungal hyphae are pierced and withdrawn of their contents. Many exclusively root feeding nematodes are known, but many species certainly also feed on both roots and fungi. Due to the incomplete knowledge of the feeding habits, the stylet-bearing nematodes may be broadly recognized as root/fungal feeders.

The occurrence of such nematodes in Finnish coniferous forests is poorly known. In previous works the nematodes have only been recognized at the group level (e. g. Huhta et al. 1967, Huhta and Koskenniemi 1975). Löyttyniemi and Sarakoski (1978) found the genera *Cephalenchus, Pratylenchus, Tylechorhynchus, Paratylenchus* and *Trichodorus* in Finnish forest tree nurseries. Species in all these genera have been observed to feed on or damage conifers (Ruehle and Sasser 1962, Sutherland 1967, Ruehle 1969, 1973, Gowen 1971, Riffle 1972). Magnusson and Sohlenius (1980) and Magnusson (1982 a) found the following root/fungal feeders in two Swedish pine forests: *Tylenchus, Malenchus, Ditylenchus, Rotylenchus, Paratylenchus, Geocenamus, Aphelenchoides, Deladenus, Tylencholaimus mirabilis, T. stecki* and *Diphtherophora.* The genus *Rotylenchus* have been reported to damage spruce seedlings (Goodey 1965, Boag 1978). The most dangerous nematode pest of pine, *Bursaphelenchus lignicolus,* which has caused severe damage in Japan (Mamiya 1976), has been reported also from USA (Dropkin and Foundin 1979) and France (Baujard 1979). So far this species has not been recorded in the Nordic countries.

The aim of this work was to study the occurrence of root/fungal feeding nematodes in some common Finnish forest types. Due to the restricted number of localities examined, this study is rather preliminary. I am grateful to Mr. C. Magnusson and professor P. Juutinen for their valuable comments on the manuscript.

2. MATERIAL AND METHODS

Soil samples were taken in 1977–78 from four forest types in Ruotsinkylä experimental forest in Tuusula, about 30 km north of Helsinki, and from a pine forest at Kaamanen in Inari, about 300 km north of the Arctic Circle. The forest types were: *Calluna*-type *Pinus sylvestris* L. forest (CT), *Myrtillus*-type *P. sylvestris* forest (MT), *Oxalis-Myrtillus* -type *Picea abies* (L.) Karst. forest (OMT) and *Vaccinium*-type *P. sylvestris* forest (VT) at Ruotsinkylä, and *Cladonia*-type *P. sylvestris* forest (ClT) at Kaamanen. The forest types are distinguished according to the dominating ground vegetation. At Ruotsinkylä samples were also taken from fertilized trial plots in the MT- and VT-forests. These plots had received 90–120 kg nitrogen/ha in form of urea 3 times during the last 20 years, last time in 1970.

Soil samples were taken with a corer, diameter 2,5 cm, down to a depth of about 20 cm. Each sample consisted of about 50 subsamples taken along a sampling line of 50 meters, with 10 sampling lines in the MT- and VT-forests, 8 in the CT- and OMT-forests and 5 in the ClT-forests. From the fertilized and corresponding unfertilized areas samples were taken from 8 lines. The FH-layer and the mineral soils were separated. 3 x 8 g soil from each sample were extracted with a Baermann funnel. From the fertilized and corresponding unfertilized plots 3 x 9 ml soil were extracted with a Mistifier. The nematodes were killed with heat, fixed in 4 % formalin, and the fixed nematodes were counted under the compound microscope. The material was partly processed to glycerol for more detailed analysis of the generic identity. The data were analysed with the Student's t-test.

Table 1. Total numbers and numbers of root/fungal feeding nematodes per 100 g soil (wet weight) in some coniferous forests in Finland. Numbers are means ($\bar{x}$) of 10 (MT and VT), 8 (CT and OMT) and 5 (ClT) replicates. SD = standard deviation.

Taulukko 1. Nematodien kokonaismäärät sekä juuria/sieniä ravinnokseen käyttävien nematodien määrät/100 g maata tutkituissa havumetsissä Suomessa. Luvut 10 (MT ja VT), 8 (CT ja OMT) sekä 5 (ClT) kerranteen keskiarvoja ($\bar{x}$). SD = keskihajonta.

Location and forest type		FH-layer – *Humus*				Mineral layer – *Mineraalimaa*			
Paikka ja metsätyyppi		Total *Kokonaismäärä*		Root/fungal feeders *Juuria/sieniä syövät*		Total *Kokonaismäärä*		Root/fungal feeders *Juuria/sieniä syövät*	
		$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
Ruotsinkylä	CT	3 379	1 186	1 275	453	1 008	977	240	151
Kaamanen	ClT	1 157	356	462	49	165	55	24	10
Ruotsinkylä	MT	1 706	655	734	271	212	99	97	50
Ruotsinkylä	OMT	3 151	1 530	1 260	394	378	210	173	108
Ruotsinkylä	VT	2 538	1 076	1 155	461	310	145	135	70

3. RESULTS

The highest total number of nematodes was observed in the FH-layer of the CT-forest, which did not, however, differ significantly from the OMT- and VT-humus (Tables 1−2). The lowest values were recorded in the northern ClT-forest. The highest total numbers in the mineral soil were found in the CT-forest, and were significantly higher than in the MT- and VT-forests. The total nematode population of the CT-forest tended to be higher than the total population in the ClT- and OMT-forests (Tables 1−2).

The numbers of root/fungal feeders in the FH-layer of the CT-, OMT- and VT-forests did not differ significantly. Root/fungal feeders occurred in significantly higher numbers in these forests than in the MT- and ClT-forests. Also the MT-forest contained significantly more root/fungal feeders than the ClT-forest. A similar pattern was observed in the mineral soil (Tables 1−2).

The dominating genera and species of root/fungal feeders in the FH-layer were *Aphelenchoides* Fischer, *Tylenchus* (Bastian) Golden, *Malenchus* Andrássy, *Tylencholaimus mirabilis* (Bütschlii) de Man and *T. stecki* Steiner (Fig. 1 a−d). The only exception was the northern ClT-forest, where only *Aphelenchoides, Tylenchus* and *T. stecki* were rather common (Fig. 1 e). These genera and species were also frequent in the mineral layers, with the exception of the ClT-forest (Fig. 1). The main food source of these nematodes was probably the fungal mycelia.

The genus *Aphelenchoides* occurred in significantly higher numbers in the CT-humus than in humus of any other forest type. In the mineral soil, the only significant difference pertained to the higher population of *Aphelenchoides* in the OMT-forest compared to the ClT-forest (Table 2, Fig. 1). The genus *Tylenchus* was common in the OMT- and VT-humus, which differed clearly from the ClT- and MT-humus. This genus occurred in significantly higher numbers in the CT-mineral than in the ClT- and MT-minerals, and tended to reach higher numbers in the CT-mineral than in the OMT- and VT-minerals (Table 2, Fig. 1). There was also a tendency of higher numbers of *Tylenchus* in the MT- and VT-minerals compared with the ClT-mineral (Table 2). The genus *Malenchus* was rather common in the FH-layers in the Ruotsinkylä-forests, but was observed only in low numbers in the ClT-humus at Kaamanen (Fig. 1). Significantly higher numbers of this genus was found in the OMT- and VT-humus compared with the ClT-humus (Table 2). The numbers of *Malenchus* was typically low in the mineral soils, with the highest numbers occurring in the VT- and CT-minerals (Fig. 1).

The two species of *Tylencholaimus, T. mirabilis* and *T. stecki,* were present in all forests. While *T. stecki* was observed in higher numbers in the FH-layer than in the mineral soil, *T. mirabilis* was equally abundant in both layers (Fig. 1). The highest densities of *T. mirabilis* were recorded in the OMT- and VT-forests, significantly more such nematodes were found in both OMT-humus and mineral compared to the corresponding layers in the CT- and MT-forests (Table 2). While the numbers of *T. mirabilis* were significantly higher in the VT-humus than in the OMT-humus, the reverse was noted in the mineral soils (Table 2, Fig. 1). In the ClT-forest this nematode was observed only occasionally. *T. stecki* was least abundant in the CT-humus, which differed significantly from all other forests (Table 2, Fig. 1). The population of this nematode was also significantly higher in the OMT-humus than in the MT-humus (Fig. 1 b−c). No significant differences in abundance were observed in the mineral soils for *T. stecki* (Table 2).

Table 2. Differences in the nematode numbers between different forest types at Ruotsinkylä and Kaamanen. Forest types in the left column are compared with the forest types above. *T. mirabilis* was observed only occasionally in the CIT-humus, but not in the CIT-mineral.

Taulukko 2. Nematodimäärien erot tutkituilla metsätyypeillä Ruotsinkylässä ja Kaamasessa. Vasemmalla olevien metsätyyppien vertailu taulukon yläreunassa oleviin. T. mirabilis havaittiin satunnaisena CIT-humuksessa, mutta ei ollenkaan CIT-mineraalimaassa.

	Nematodes total *Kokonaismäärä*				Root/fungal feeders *Juuria/sieniä syövät*				*Aphelenchoides*				*Tylenchus*				*Malenchus*				*T. mirabilis*				*T. stecki*			
	CT	CIT	MT	OMT	CT	CIT	MT	OMT	CT	CIT	MT	OMT	CT	CIT	MT	OMT	CT	CIT	MT	OMT	CT	CIT	MT	OMT	CT	CIT	MT	OMT
FH-layer – *Humus*																												
CIT	--				--				--				0				0								++			
MT	--	0			--	+			--	0			(+)	0			0	(+)			0				+	0		
OMT	0	+	+		0	+++	++		--	0	0		0	++	++		0	+	0		+		++		++	0	+	
VT	0	+	+	0	0	++	+	0	-	0	0	0	0	+	(+)	0	(+)	++	0	0	0		0	+	++	0	0	0
Mineral layer – *Mineraalimaa*																												
CIT	(-)				--				(-)				-				(-)								0			
MT	-	0			-	++			0	(+)			-	(+)			(-)	0			-				0	0		
OMT	(-)	+	+		0	+	(+)		0	+	0		(-)	0	0		-	0	0		+		++		0	0	0	
VT	-	(+)	(+)	0	(-)	++	0	0	0	0	0	0	(-)	(+)	0	0	0	(+)	0	+	0		0	--	0	0	0	0

0 = no significant differences
(-), (+) the population tends to be lower or higher respectively, $0{,}1 \geq P > 0{,}05$
- , + the population is significantly lower or higher respectively, $0{,}05 \geq P > 0{,}01$
-- , ++ the population is significantly lower or higher respectively, $0{,}01 \geq P > 0{,}001$
--- ,+++ the population is significantly lower or higher respectively, $P \leq 0{,}001$

0 = ei merkittäviä eroja
(-), (+) suuntaus pienempään tai suurempaan populaatioon, $0{,}1 \geq P > 0{,}05$
- , + populaatio merkittävästi pienempi tai suurempi, $0{,}05 \geq P > 0{,}01$
-- , ++ populaatio merkittävästi pienempi tai suurempi, $0{,}01 \geq P > 0{,}001$
--- ,+++ populaatio merkittävästi pienempi tai suurempi, $P \leq 0{,}001$

Table 3. The effect of fertilization on the nematode populations in two Scots pine forests at Ruotsinkylä. Means ($\bar{x}$) of 8 replicates and standard deviations (SD). Nematode numbers per 100 ml soil.
Taulukko 3. Lannoituksen vaikutus kahden mäntymetsän nematodipopulaatioihin Ruotsinkylässä. Luvut 8 kerranteen keskiarvoja ($\bar{x}$), SD = keskihajonta. Nematodimäärät/100 ml maata.

Sampling site *Koeala*	FH-layer – *Humus*				Mineral layer – *Mineraalimaa*			
	Total *Kokonaismäärä*		Root/fungal feeders *Juuria/sieniä syövät*		Total *Kokonaismäärä*		Root/fungal feeders *Juuria/sieniä syövät*	
	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
MT-forest – *MT-metsä*								
Unfertilized *Lannoittamaton*	2 336	1 506	559	285	325	194	82	62
Fertilized *Lannoitettu*	3 834	2 880	435	196	475	256	101	79
VT-forest – *VT-metsä*								
Unfertilized *Lannoittamaton*	2 890	2 110	345	235	574	303	110	36
Fertilized *Lannoitettu*	2 524	1 493	250	92	863	538	153	73

The abundance of obligate root feeders was usually low. The genus *Geocenamus* Thorne and Malek was the only obligate root feeding genus found in the arctic ClT-forest, where it occurred in small numbers in the mineral layer (Fig. 1 e). *Tylenchorhynchus* Cobb was occasionally observed in all forests in Ruotsinkylä (Fig. 1 a–d), while *Pratylenchus* Filipjev was only present in the OMT-forest (Fig. 1 c). The genus *Paratylenchus* (Micoletzky) Raski was rather common in the latter forest (Fig. 1 c), where its maximal abundance in one sampling line was 116 ind./100 g humus soil and 50 ind./100 g mineral soil. This genus was also observed in the CT- and MT-forests (Fig. 1 a–b). The abundance of *Gracilacus* (Micoletzky) Raski was 72 ind./100 g humus in one sampling line in the MT-forest (Fig. 1 b). The subfamily Criconematinae Golden occurred in the CT-, OMT- and VT-forests (Fig. 1 a, c–d).

The nitrogen fertilization had only a slight effect on the nematode abundance in the studied MT- and VT-forests (Table 3). The only significant difference was the higher numbers of *Tylencholaimus* in the mineral soil of the fertilized plots in the VT-forest.

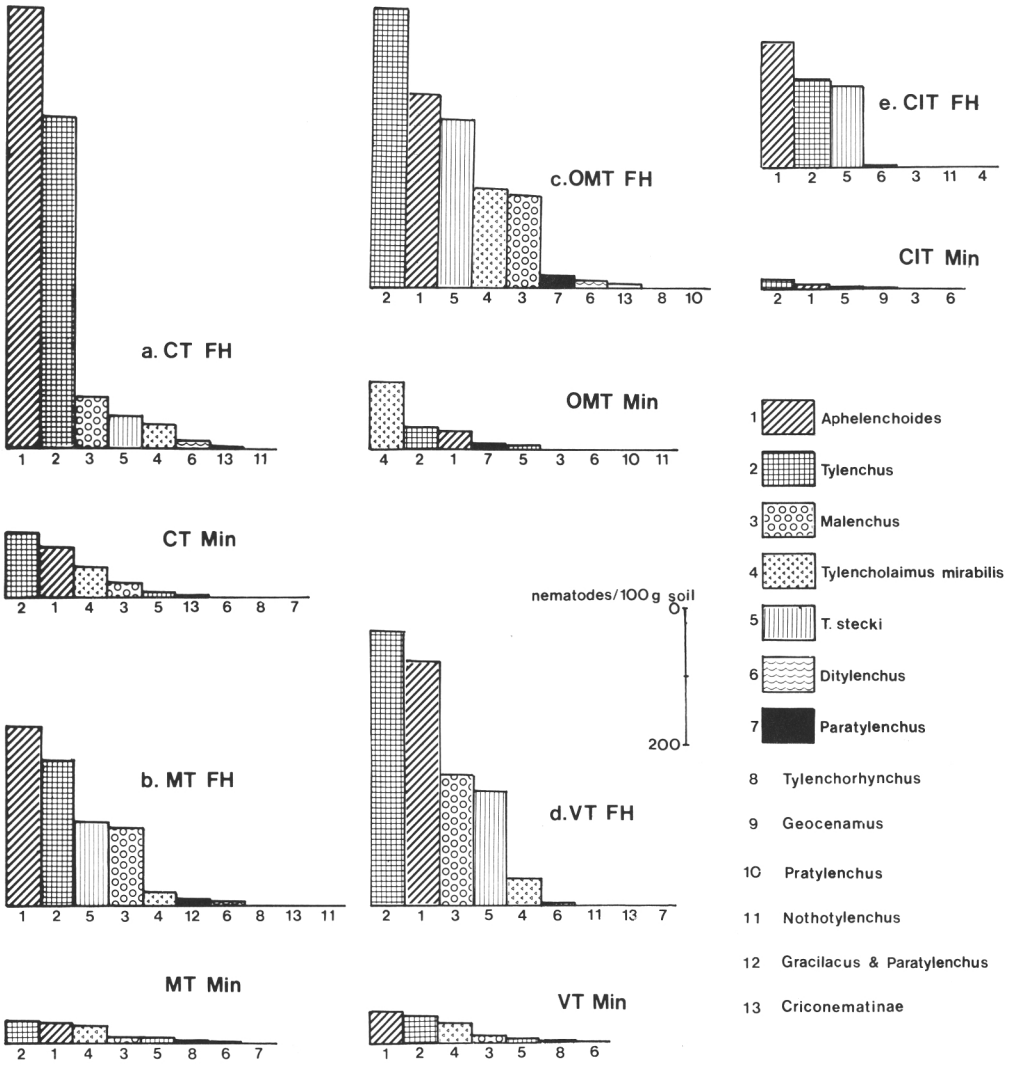

Fig. 1. Root/fungal feeding nematodes per 100 g soil (wet weight) in some coniferous forests in Finland. a. *Calluna*-type pine forest (CT), Ruotsinkylä. b. *Myrtillus*-type pine forest (MT), Ruotsinkylä. c. *Oxalis-Myrtillus* -type spruce forest (OMT), Ruotsinkylä. d. *Vaccinium*-type pine forest (VT), Ruotsinkylä. e. *Cladonia*-type pine forest (CIT), Kaamanen. FH = humus layer. Min. = mineral soil.

Kuva 1. Juuria/sieniä syövät nematodit/100 g maata. a. Calluna-tyypin (CT) mäntymetsä, Ruotsinkylä. b. Myrtillus-tyypin (MT) mäntymetsä, Ruotsinkylä. c. Oxalis-Myrtillus-tyypin (OMT) kuusimetsä, Ruotsinkylä. d. Vaccinium-tyypin (VT) mäntymetsä, Ruotsinkylä. e. Cladonia-tyypin (CIT) mäntymetsä, Kaamanen. FH = humus. Min. = mineraalimaa.

4. DISCUSSION

The total number of nematodes and the number of root/fungal feeders were higher in the FH-layer than in the mineral soil. The highest populations were observed in the CT-, OMT- and VT-forests. The numbers were low in the arctic ClT-forest, and low numbers were, rather unexpectedly, observed also in the MT-forest in southern Finland. Fertilization did not drastically effect nematode abundance. This may depend on the space of time between fertilization and this study.

It was obvious that the genera *Aphelenchoides* and *Tylenchus* formed the major part of the root/fungal feeding nematodes in the FH-layers. These genera were also dominating in the mineral soil often together with *T. mirabilis*. This is in line with observations in a pine forest soil in central Sweden (Sohlenius et al. 1977, Magnusson pers. comm.). As was noted in the Swedish pine forests (Magnusson and Sohlenius 1980, Magnusson 1982 a) the clear majority of the root/fungal feeding nematodes was potential mycophages.

The root feeding nematodes e.g. *Geocenamus, Tylenchorhynchus, Pratylenchus* and the subfamily Criconematinae have previously been reported from coniferous forests and forest tree nurseries in Scandinavia (Thuvesson 1977, Löyttyniemi and Sarakoski 1978, Zethraeus 1978, Magnusson and Sohlenius 1980). Species in the genera *Tylenchorhynchus, Pratylenchus* and the subfamily Criconematinae have also been reported to feed on and damage conifers (Riffle 1972, Ruehle 1973). This is the first report on the genus *Gracilacus* from Scandinavian coniferous forests. Both *Geocenamus* and *Gracilacus* were also observed in alpine soil in the western Finnish Lapland (Magnusson pers. commun.). As *Geocenamus* also occurs in Sweden (Magnusson and Sohlenius 1980), this genus is probably well distributed in Scandinavia. Similarly, *Gracilacus* may be well distributed, at least in Finland.

The small population of obligate root feeders observed in the studied forests is in agreement with reports from some coniferous forests in DDR and Sweden (Bassus 1962, Sohlenius 1977, Magnusson and Sohlenius 1980). In the studied mature forests, the ground vegetation had reached a stabile stage typically dominated by moss, lichens and dwarf-shrubs, with grasses occurring only occasionally. In contrast to this, the field layer vegetation of clearings and young conifer stands often is dominated by grass. Grasses have a higher root production and their fibrous root systems are far more suitable for nematode consumption than the more suberized roots of conifers and dwarf-shrubs. Because of this, such grass dominated stages can be expected to support higher numbers of root feeding nematodes than mature forests. In a Swedish pine forest the forest grass was demonstrated to be a key-factor for the abundance of obligate root feeding nematodes (Magnusson 1982 b). Boag (1978) reported young conifer seedlings to be more easily damaged by nematodes than older plants. Therefore, reduction in the growth of small seedlings in newly established stands can be expected if root pathogenic nematodes occur in higher levels. There is, however, no evidence that the root feeders observed in this study cause any reduction in the growth of mature forest trees.

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SELOSTE

Nematodien esiintymisestä Suomen havumetsissä

Nematodipopulaatioita tutkittiin Ruotsinkylässä (Tuusula) *Calluna-* (CT), *Myrtillus-* (MT), *Oxalis-Myrtillus-* (OMT) ja *Vaccinium*-tyypin (VT) havumetsissä sekä Kaamasessa (Inari) *Cladonia*-tyypin (ClT) mäntymetsässä vuosina 1977–78. Suurimmat kokonaistiheydet sekä humuksessa että mineraalimaassa havaittiin CT-mäntymetsässä. Juuria ja/tai sienihyyfejä ravinnokseen käyttäviä nematodeja tavattiin eniten CT-, OMT- ja VT-metsien humuksesta verrattuna MT- ja ClT-humukseen. Mineraalimaassa oli havaittavissa sama suuntaus (taulukot 1–2).

Juuria/sienihyyfejä käyttävistä nematodeista esiintyivät runsaslukuisimpina suvut *Aphelenchoides* Fischer, *Tylenchus* (Bastian) Golden, *Malenchus* Andrássy sekä lajit *Tylencholaimus mirabilis* (Bütschlii) de Man ja *T. stecki* Steiner. Kaamasen ClT-metsässä tavattiin vain *Aphelenchoides-* ja *Tylenchus*-sukujen sekä *T. stecki-* lajin nematodeja suhteellisen yleisinä. Näiden sukujen ja lajien esiintyminen ja runsaus on esitetty taulukossa 2 ja kuvassa 1.

Yksinomaan korkeampien kasvien juurista ravintonsa ottavia nematodeja tavattiin yleensä vain pieniä määriä. Seuraavat suvut esiintyivät tutkituissa metsissä: *Geocenamus* Thorne ja Malek ClT-metsässä, *Tylenchorhynchus* Cobb kaikissa tutkituissa Ruotsinkylän metsissä, *Pratylenchus* Filipjev OMT-metsässä, *Paratylenchus* (Micoletzky) Raski CT-, MT- ja OMT-metsissä, *Gracilacus* (Micoletzky) Raski MT-metsässä sekä Criconematinae Golden CT-, OMT- ja VT-metsissä (kuva 1). Sukuihin *Tylenchorhynchus* ja *Pratylenchus* kuuluvien nematodien on todettu vioittavan havupuun taimia (Riffle 1972, Ruehle 1973), ja niiden voidaankin olettaa aiheuttavan vioitusta nuorissa taimikoissa runsaina esiintyessään. Hakkuukypsissä metsissä tutkimuksessa tavatut nematodit tuskin aiheuttavat minkään asteista vioitusta.

Tutkimuksessa laskettiin myös nematoditiheydet metsänlannoitusaloilta Ruotsinkylässä (taulukko 3). Lannoituksella ei näyttänyt olevan merkittävää vaikutusta nematodipopulaatioon, mikä saattaa johtua siitä, että viimeisestä lannoituksesta oli kulunut jo useita vuosia.

MAGNUSSON, M. L. 1982. Nematodes in some coniferous forests in Finland. Seloste: Nematodien esiintymisestä Suomen havumetsissä. Commun. Inst. For. Fenn. 103: 1–12.

ODC 459
ISBN951-40-0552-X
ISSN 0358-9609

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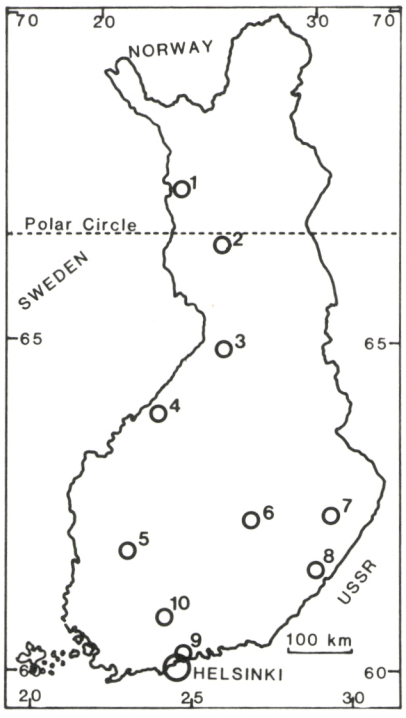

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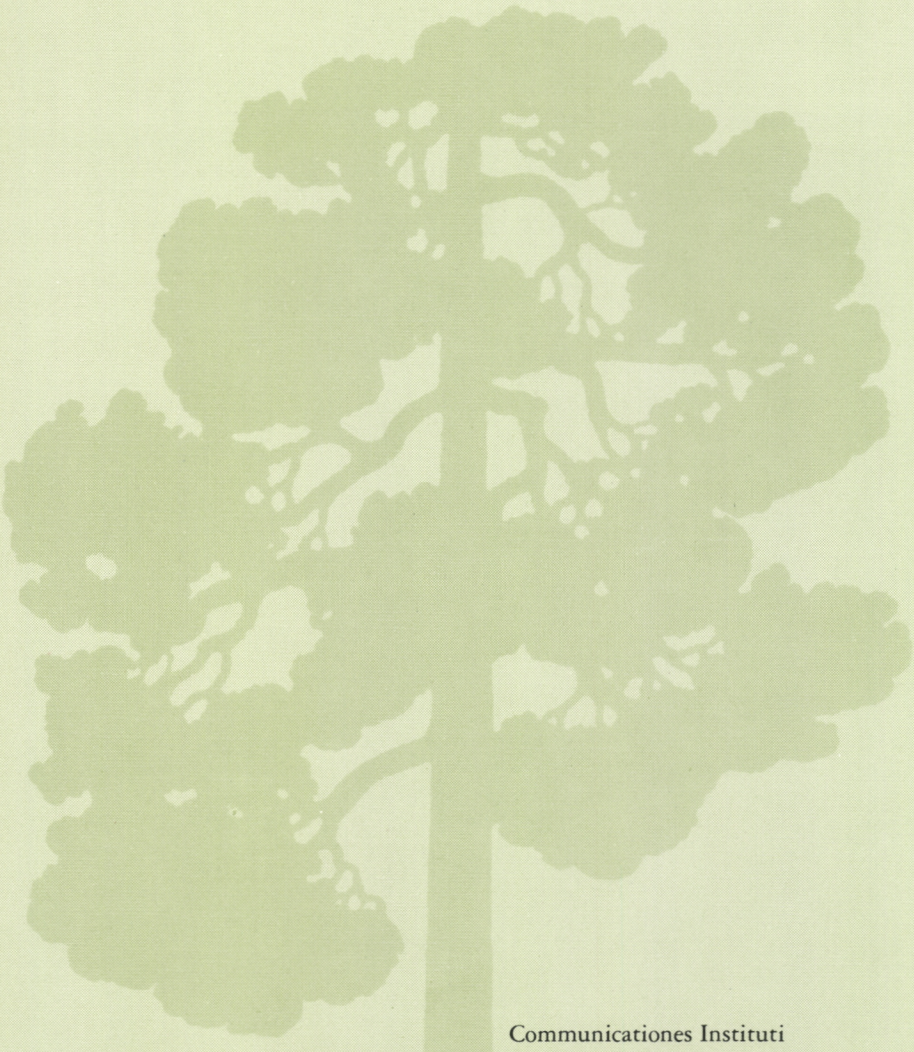
FACTS ABOUT FINLAND

Total land area: 304 642 km² of which 60–70 per cent is forest land.

Mean temperature, °C:	Helsinki	Joensuu	Rovaniemi
January	-6,8	-10,2	-11,0
July	17,1	17,1	15,3
annual	4,4	2,9	0,8

Thermal winter (*mean temp.* < 0°C):	20.11.–4.4.	5.11.–10.4.	18.10.–21.4.

Most common tree species: Pinus sylvestris, Picea abies, Betula pendula, Betula pubescens



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