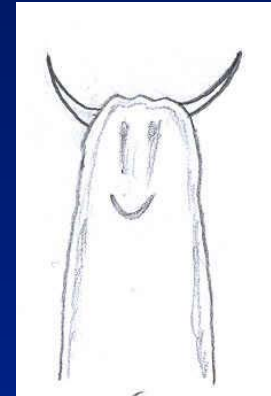


OCCURRENCE of EPN in the NORDIC COUNTRIES



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Nordic countries: Denmark, Iceland, Finland, Norway & Sweden



Country	Land area Latitude	Coast line, terrain	Land use	Climate
Denmark 5,4 mill. Pop. <i>Once the seat of Viking raiders and later a major north European power</i>	42,394 sq km 56 00 N	7,314 km Rather flat, highest point: 173 m	Arable land: 55.74% Permanent crops: 0.19% Other: 44.07%	Temperate; humid & overcast, mild, windy winters and cool summers
Finland 5,2 mill. <i>Grand duchy under Sweden from the 12th to the 19th centuries then autonomous under Russia after 1809. Complete independence in 1917.</i>	305,470 sq km 64 00 N	1,126 km (excluding more than 60,000 lakes) Mostly low, flat to rolling plains	Arable land: 8% (42% cereals, 27% grass). Permanent crops: 0.01% Other: 93.01% (59% forest)	Cold temperate, potentially subarctic, Gulf stream helps. 170 dys growing season in south, 100 in the north.
Iceland 293,966 pop Settled by Norwegian and Celtic immigrants (late 9 th - 10th Century)	103,000 sq km 65 00 N	4, 988 km Mostly plateau interspersed with mountain peaks, glaciers, fjords.	Arable land: 0.7% Permanent crops: 0% Other: 99,93%	Temperate; mild windy winters; damp cool summers
Norway 4,5 mill. <i>Two centuries of Viking raids into Europe until 994. In 1397 in a union with Denmark for more than four centuries. In 1814 in union with Sweden. Independence.in 1905.</i>	307,860 sq km 62 00N	21,925 km glaciated; mostly high plateaus and rugged mountains broken by fertile valleys; small, scattered plains; coastline deeply indented by fjords; arctic tundra in north	Arable land: 2.94% Permanent crops: 0% Other: 97.06%	Temperate along coast, ("Norwegian Riviera"), modified by Gulf stream, colder interior, colder summers; rainy all year on west coast.
Sweden 8,9 mill <i>A military power during the 17th century, Sweden has not participated in any war in almost two centuries</i>	410,934 sq km 62 00 N	3,218 km mostly flat or gently rolling lowlands; mountains in west	Arable land: 6.8% Permanent crops: 0% Other: 93.2% (% forest)	Temperate in south, cold, clody winters, partly cloudy summers; subarctic in north

(CIA the world factbook)

Historic

1931-35 Bovien in Denmark (1937) observed *Steinernema* infections in bibionid flies. He described two new species, and suspected a symbiosis. Re-isolated/re-described (Poinar & Lindhart 1971, Poinar 1988)

1979 –80's Burman & Pye in Sweden (Umeå) Isolation of nematodes from soil, *S. feltiae* & *S. carpocapsae*(?).

1988 - Vanninen, Finland(1989),
Haukeland, Norway (1993)
Isolation of nematodes from soil

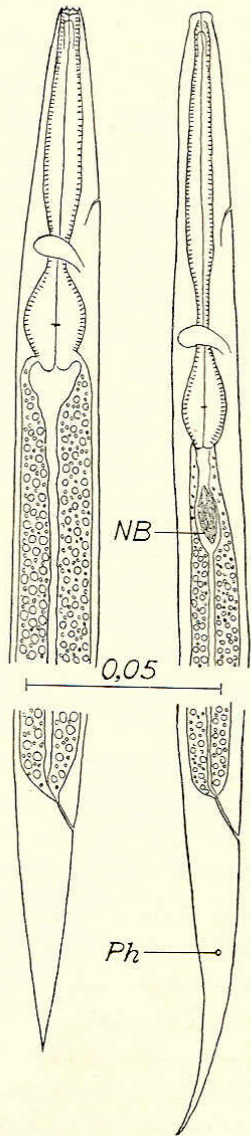


Fig. 24. *Neoplectana bibionis* n. sp. Anterior and posterior portion of young larva and "Dauerlarve" resp. to show differences in shape of oesophagus, head etc. NB. Lemon shaped body apparently consisting of bacteria.

Denmark

Bovien 1937

Nielsen & Philipsen 2000-

Natural infections

Soil samples (bait), mainly
agricultural habitats



Observed species	Samples/ Hosts	How & ID	Ref
<i>S. affine</i> <i>S. feltiae</i>	Approx. 200 Bibionids; <i>Bibio ferrungatus</i> , <i>B. hortulans</i>	Incubation of insects Morph	Bovien 1937
<i>S. affine</i>	Approx. 200 Bibionids, <i>B. hortulans</i>	Incubation of insects Morph	Poinar & Lindhardt 1971, Poinar 1988
<i>H. megidis</i> , <i>H. downesi</i>	85 soil samples from coast line	<i>Galleria</i> bait Molec. & X-breeding	Griffin et al. 1999
<i>S. affine</i> , <i>S. feltiae</i> , C1, (or <i>S. intermedium</i> ?)	5-6000 insects. See table. Mostly <i>Delia radicum</i>	Incubation of insects IJ morph & Molec.	Nielsen & Philipsen, 2003
<i>S. affine</i> , <i>S. bicornotum</i> , <i>S. feltiae</i> , C1 (or <i>S. intermedium</i> ?)	325 soil samples, organic farms	Tenebrio bait IJ morph & Molec.	Nielsen & Philipsen, 2004
<i>S. affine</i> <i>S. feltiae</i>	6-7000 (2-3 yrs) soil samples, experimental sites	Tenebrio bait IJ morph & Molec.	Nielsen & Philipsen, 2004
<i>S. affine</i> <i>S. feltiae</i>	more than 1000 soil samples-(farms golf courses)	Tenebrio bait	unpublished
<i>H. megidis</i> ?		Symbiont Id. only	Nielsen & Lubeck 2003

In many of these studies, *S. feltiae* most common



- NWE type *H. megidis*
- * Irish type *H. downesi*
- ▲ *H. bacteriophora*
- unidentified *Heterorhabditis*
- site where *Heterorhabditis* was not found

"Targeted" survey, north coast.

Griffin et al. 1999

Denmark: Sjælland

Mørdrup	EU85	<i>H.m.</i>	Grass (waste ground)
Hornbæk	EU94	Irish	Open coniferous forest with ground oak, roses and grass
Gilleleje	EU103	<i>Het.</i>	Grassy slope
	EU106	**Irish	Shrubs and long grass
Rågeleje	EU114	Irish	Meadow
W. of Rågeleje	EU116	Irish	Grass
	EU121	Irish	Grassy slope
Liseleje	EU132	Irish	Dunes, some roses
	EU133	<i>Het.</i>	Dunes, some roses
Nyrup	EU140	<i>H.m.</i>	Long grass, scattered conifers
	EU141	<i>Het.</i>	Long grass, scattered conifers
Lumsas	EU143	<i>Het.</i>	Grass (parking place)
Gudmindrup Lyng	EU158	Irish	Grass/rose/heather/ <i>Vaccinium</i>
	EU162	<i>H.m.</i>	Grass verge
Vindekilde	EU166	<i>H.m.</i>	Old dunes, long grass

Natural infections, Nielsen & Philipsen 2003

Table 1. Infections of collected insects by steinernematid nematodes (Denmark, 1997-1999).

Nematode species	Insect order or family	Insect species	Stage(s)
<i>Steinernema feltiae</i>	Curculionidae	Not identified	L
	Diptera	<i>Delia radicum</i>	L*, P
	Diptera	<i>Bibio</i> sp.	L
	Elateridae	<i>Agriotes lineatus</i>	L
	Hepialidae	<i>Hepialus lupulinus</i>	L
	Scarabaeidae	<i>Phyllopertha horticola</i>	L
<i>Steinernema affine</i>	Cantharidae	<i>Cantharis</i> sp.	A
	Scarabaeidae	<i>Phyllopertha horticola</i>	L
		<i>Pterostichus nigrita</i>	L
<i>Steinernema intermedium</i>	Cantharidae	<i>Cantharis</i> sp.	P

**S. feltiae* has been supplied to the plants approximatively three months prior to collection of infected insects

0,08% infected *D. radicum* larvae, 0,13% pupae
 50 out of approx. 370 infected *Phyllopertha horticola*
 (approx. 13%)

Iceland

Soil samples (bait) in relation to other projects have been conducted;

Denmark: unidentified *Steinernema* (unpublished),

Scotland: *S. kraussei* (Spiridonov et al. 2004)

Scope for more sampling!



Finland

Soil samples (bait) have been taken from many parts of the country (Vanninen et al. 1989).

Melita Zec-Vojinovic has conducted more recent sampling. This work is still in process.



Vanninen et al. 1989 collected soil samples from various cultivated fields in 1985 and 1986, (see figure). 243 samples in total from 36 locations.

14 epn isolated (*Tenebrio* bait), 5,8%.

Identified to *Steinernema feltiae* (morph) and *Steinernema* sp.

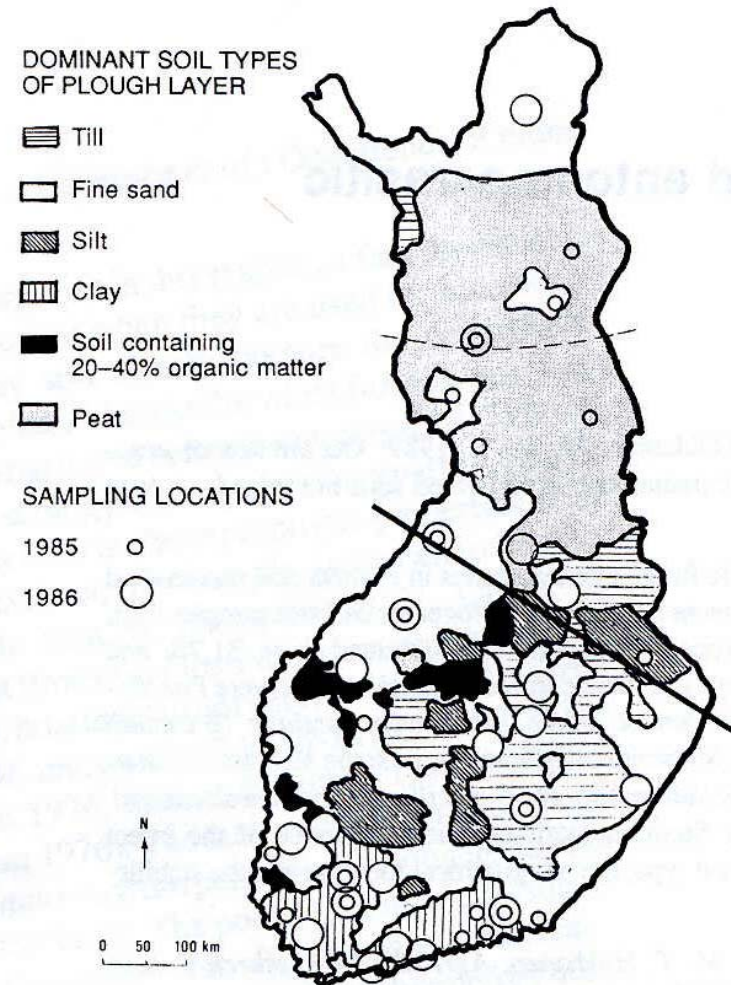


Fig. 1. Sampling locations and a rough presentation of the dominant soil types of plough layer in Finland. The broken line marks the polar circle. The solid line denotes the border between the southern and northern parts of the country used in examining the geographical distribution of the pathogens.

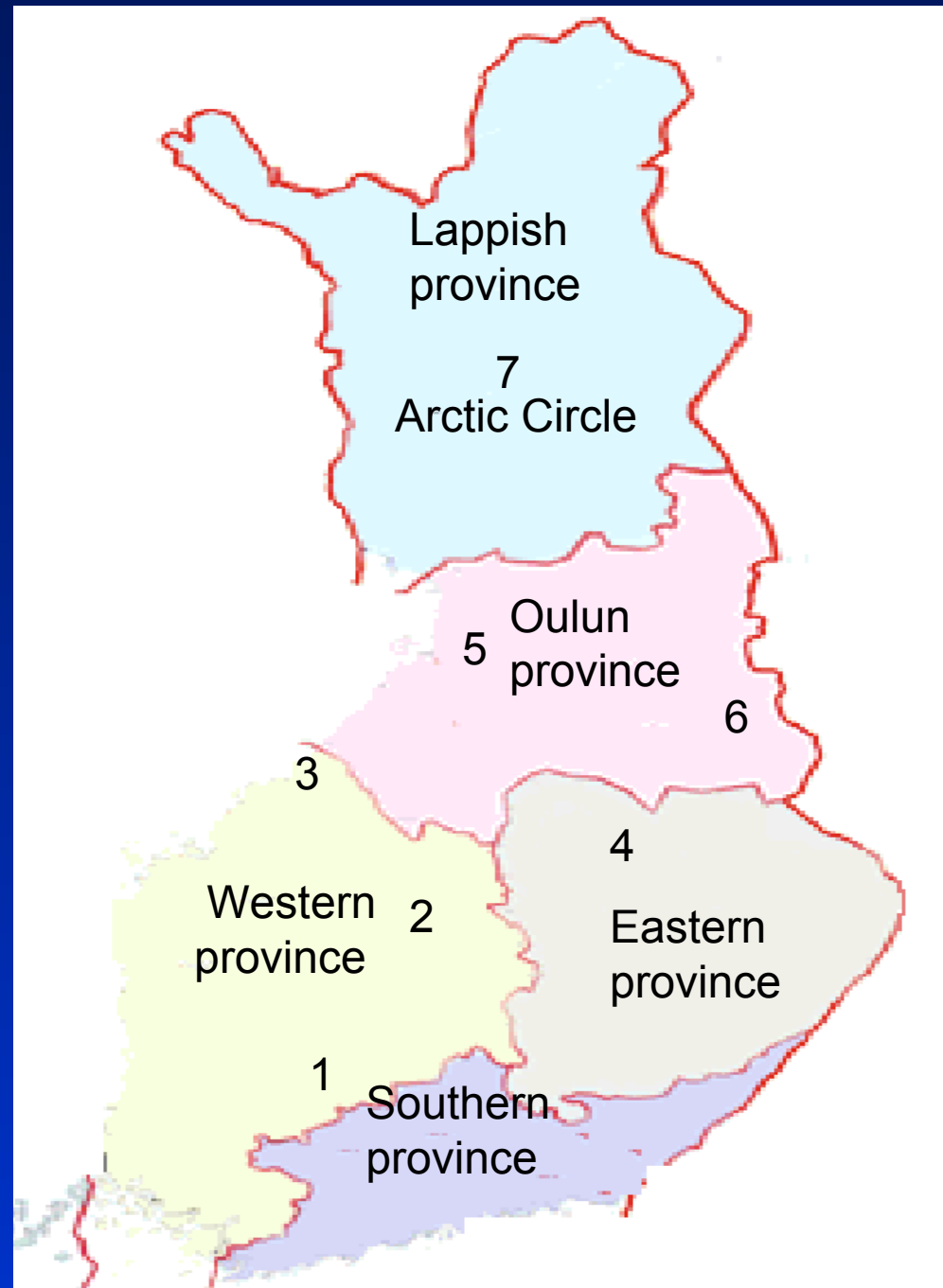
In the Vanninen et al. study, significantly more epn were found in humous soil (37%); 3% in silt and fine sand, and nematodes were absent in clay soil.

2004 -

Soil samples, (currently 50) were taken from 7 regions, map shows numbers that denote the sampled locations.

Preliminary results:

Similar distribution of epn as 1989 survey, but higher incidence (60%), *S. feltiae* not isolated. Identification in process, no *Heterorhabditis* found, IJ measurements of nematodes so far indicate “carpocapsae group” (smaller)



Norway

Haukeland 1993;
Salinas Haukeland 1996

Soil samples (bait), mainly
agricultural and forest habitats



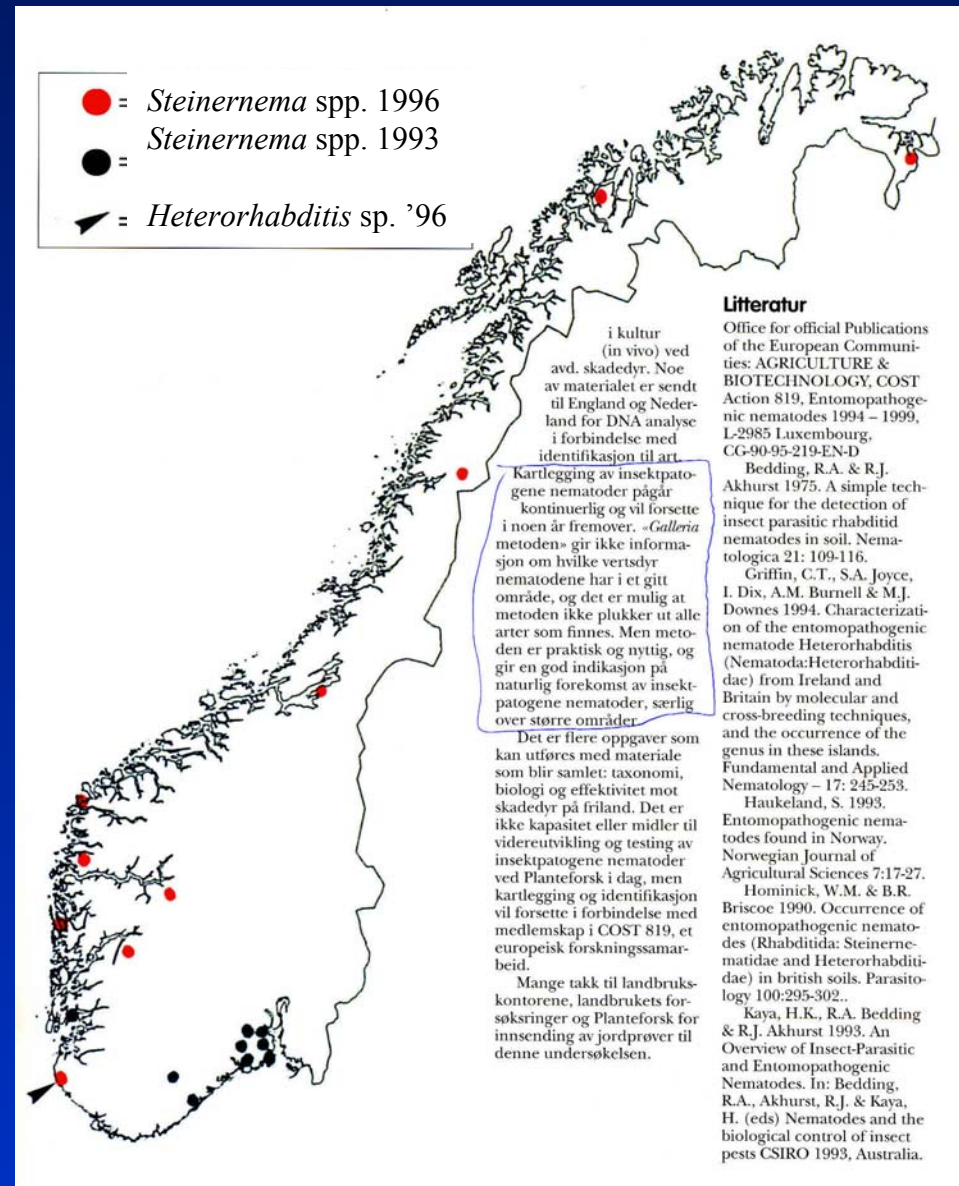
Observed species	Samples/ Hosts	How & ID	Ref
<i>S. affine</i> <i>S. feltiae</i> <i>S. intermedium</i>	710 soil samples,	Southern Norway, cultivated areas <i>Galleria</i> bait. Morph.	Haukeland 1993
<i>Steinernema</i> spp. <i>Heterorhabditis</i> sp	150 soil samples	“Targeted“ sampling along coast, mainly cultiv. areas Morph. to genus	Salinas Haukeland 1996
<i>Steinernema</i> spp.	200 soil samples.	Northern Norway 60 organic 140 conventional <i>Galleria</i> & <i>Delia</i> bait Morph. to genus	Salinas Haukeland unpublished. Klingen <i>et al.</i> 2002 (for epf).
<i>S. kraussei</i>	24 soil samples	Experimental site, clear cut forest. Morph & Molec.	Eidet 1999 (MSc thesis) Klingen <i>et al.</i> 2002 (checklist)
<i>S. kraussei</i> <i>Steinernema</i> sp.	86	Soil from clear cut forest <i>Galleria</i> bait. Morph & Molec.	Salinas 2002 (abstr.)
<i>H. megidis</i>	<i>Phyllopertha horticola</i> (few)	Natural infection Morph & Molec.	Salinas & Reid 2000 (abstr.) and unpublished
<i>S. carpocapsae</i> <i>Steinernema</i> sp.	160 soil samples	Western Norway, fruit orchards <i>Galleria</i> bait. Morph & Molec.	Salinas <i>et al.</i> unpublished (manuscript)
<i>Steinernema</i> spp.	Approx 100 ongoing	Soil from clear cut forest <i>Galleria</i> bait. Morph & Molec.	unpublished

Soil samples from cultivated fields, incidence of *Steinernema* spp. 18% and more frequently found in light soils, Haukeland 1993

Table 4. Frequency of *Steinernema* according to soil type

Soil type	Number of sites with <i>Steinernema</i> (% of total)	
Sandy	4	(30.7)
Humic	4	(30.7)
Loamy sand	2	(15.4)
Clay loam	1	(7.7)
Clay	1	(7.7)
Moraine	1	(7.7)

”Targeted” sampling, (150 samples)
Salinas Haukeland 1996



Sweden

Burman et al.1986

MSc studies 1984-1986

Sturhan & Reuss 1999



Observed species	Samples/ Hosts	How & ID	Ref
<i>S. carpocapsae</i>	“collected by Pye” Soil	<i>Galleria</i> bait Morph	Poinar 1986
<i>Steinernema</i> sp.	121 soil samples. Ecol. studies	<i>Galleria</i> bait Morph	Ascard 1984 (MSc thesis)
<i>S. feltiae</i> <i>Steinernema</i> sp.	865 soil samples distribution	<i>Galleria</i> bait Morph.	Burman et al. 1996
<i>Steinernema</i> sp.	175 soil samples Ecol. studies	<i>Galleria</i> bait Morph	Sjoberg 1986 (MSc thesis)
<i>Steinernema</i> sp. “E”	Soil samples Subarctic heath	Extraction from soil IJ Morph	Sturhan & Ruess 1999

In the 1986 survey, Burman et al. found *Steinernema* in 25% of the samples with higher incidence in sandy (37%) and humous (37%) soil compared to loam (14%) and clay (13%).

Conclusions

Currently 9 species are reported from the Nordic countries:

S. feltiae; *S. affine*; *S. kraussei*; *S. intermedium*, C1;
S. bicornotum; *S. carpocapsae*; *Steinernema* sp. "E";
Heterorhabditis downesi; *H. megidis*; (excl.unidentified spp.)

Steinernematids predominate (*S. feltiae* ?)

Rather small surveys conducted so far, except DK.

Surveys of species and their ecology are not only of relevance to science but also for regulatory purposes.

Further studies could include epn fauna in forest soils, subarctic heaths (where Dipterans can be prevalent), and what about Greenland? (H. Philipsen pers. comm. will collect soil this summer)

THANK YOU!

