Danish Research Service for Soil and Plant Sciences
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Migratory nematodes in Danish barley fields

Migrerende rodnematoder i danske bygmarker

I. The qualitative and quantitative composition of the fauna

Faunaens kvalitative og kvantitative sammensætning

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Resumé

Til undersøgelse af nematodfaunaen i bygmarker blev der i juli indsamlet og behandlet jordprøver fra 27 forskellige lokaliteter fordelt over hele landet.

Antallet af nematoder pr. 200 ml jord varierede fra 2.900 til 11.700 med et gennemsnit på 6.700. Omregnet til antal pr. m^2 til 20 cm's dybde bliver resultatet 3–12 millioner med et gennemsnit på 7 millioner. Af disse populationsstørrelser udgør de planteparasitiske grupper fra 21 til 74 pct. med et gennemsnit på 49 pct. Den anden store gruppe, andre nematoder, omfatter først og fremmest microbivore nematoder, mens mycophager og prædatorer kun udgør en mindre del.

Flere arter er kun fundet på en enkelt lokalitet, mens andre var vidt udbredte. De dominerende planteparasitiske arter var: *Tylenchorhynchus dubius, Merlinius brevidens, M. microdorus, Pratylenchus neglectus* og *P. crenatus*. 11 arter, heriblandt *Merlinius microdorus,* er ikke tidligere angivet fra Danmark.

Nogle arter, f.eks. *Tylenchorhynchus dubius* og *Pratylenchus neglectus* var udbredte på alle jordtyper, mens andres udbredelse var korreleret med jordens tekstur. Det er almindeligt at finde flere arter af samme slægt på hver lokalitet, men visse arter er ikke fundet forekommende sammen. Det gælder for *Pratylenchus crenatus* og *P. thornei,* hvis udbredelse er korreleret med sandet, henholdsvis leret jord. På samme måde er *Helicotylenchus digonicus* og *H. canadensis* fundet på leret jord, mens *H. pseudorobustos* kun er fundet på udpræget sandet jord.

Merlinius microdorus er fundet i to typer. Type 1, der er bedst overensstemmende med typepopulationen, er udbredt på sandede jordtyper, mens type 2, der afviger fra type 1 ved at være mindre, afløser denne, når ler + silt indholdet overstiger 21 pct.

Pratylenchus penetrans, der anses for at være en af de økonomisk vigtigste migrerende rodnematoder, er kun fundet på forsøgsarealet ved Statens plantepatologiske forsøg i Lyngby og altså ikke på de egentlige landbrugsarealer. Den kan derfor betragtes som betydningsløs for bygdyrkningen i Danmark. Efter den fundne udbredelse vil interessen ud fra et praktisk synspunkt herefter særligt være knyttet til *Pratylenchus neglectus* og *P. crenatus*.

Nøgleord: Nematodfauna, byg.

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Summary

The number of nematodes occurring in Danish barley fields in July has been found to vary between 2,900 and 11,700 with a mean of 6,700 in 200 ml of soil. Of these numbers the plant parasitic nematodes count for 21 to 74 per cent with a mean of 49 per cent.

Some of the species have been found at one or a few of the sites only, but others were widely distributed. The most common plant parasitic species were: *Tylenchorhynchus dubius, Merlinius brevidens, M. microdorus, Pratylenchus neglectus* and *P. crenatus*. 11 species are recorded for the first time in Denmark, and among them is *Merlinius microdorus*.

Species as *T. dubius* and *P. neglectus* were found in all soil types, whereas some other species were correlated with soil texture. *P. crenatus* and *P. thornei* are not recorded from the same site, but their distribution is found to be correlated with sanded and clayish soils, respectively. The same holds for *Helicotylenchus digonicus* and *H. canadensis* at the one side, and *H. pseudorobustos* at the other.

M. microdorus occurs in two types. Type 1, which is in all respects most similar to the type population, is found in soils with a clay and silt content up to 21 per cent. Type 2, which has a shorter stylet and a shorter total length than type 1, is found only at sites with a clay and silt content exceeding 21 per cent.

Key words: Migratory nematodes, barley.

Introduction

Investigations of nematodes occurring in cereal fields in Denmark have hitherto been focused on the cereal cyste nematode, *Heterodera avenae*, the pathogenicity of which is well known.

Many migratory nematode species have a potential damaging effect (*Decker*, 1969, *Thorne*, 1961). This fact combined with the economical importance of barley in Denmark is the background for making a survey of the nematode fauna occurring in Danish barley fields.

The faunistic knowledge of migratory nematodes in Denmark mainly comes from two sources. *Sønderhousen, Christensen & Rasmussen* (1969) have made an investigation of migratory nematodes in nurseries. The other survey was about migratory nematodes associated with leguminous crops (*Andersen*, 1972).

The taxonomy of most of the more economically important nematode groups is well explored. Still in some groups the taxonomical problems are unsolved or only partly solved, and identification of populations can be difficult.

Taxonomical studies have been stressed in order to identify correctly the occurring species, genera or higher taxonomic ranks. The detailed studies are reported elsewhere (*Andersen*, 1976).

Materials and Methods

Samples of soil were taken in the last part of July 1972 from 27 sites in different parts of the country (fig. 1). At each site samples were taken from fields where barley was grown for the second year. Each sample was taken from an area of about 100 square metres and was composed of 10 subsamples taken with a 2.5 cm diameter semicylindrical auger to a depth of 20–22 cm. Until extraction the samples were stored at 5°C. Aliquots of the samples were analyzed for soil texture, humus and pH. Nematodes were extracted from 200 ml aliquot of the sample using Seinhorst's elutriation technique (*Seinhorst* 1956 and 1962a). From the resulting 50 ml nematode-suspension 3 × 2 ml aliquots were taken for counting and identification of the nematodes. Using 50 times magnification by stereomicroscope, the Tylenchides and the plant parasitic *Dorylaimida* were identified to genus, whereas the other nematodes to main groups only. Adult specimens of each occurring genus of the Tylenchides and plant parasitic *Dorylaimida* were collected for permanent mountings. For fixation and preparation were used the methods of Seinhorst (*Seinhorst* 1959, 1962 b and 1966).

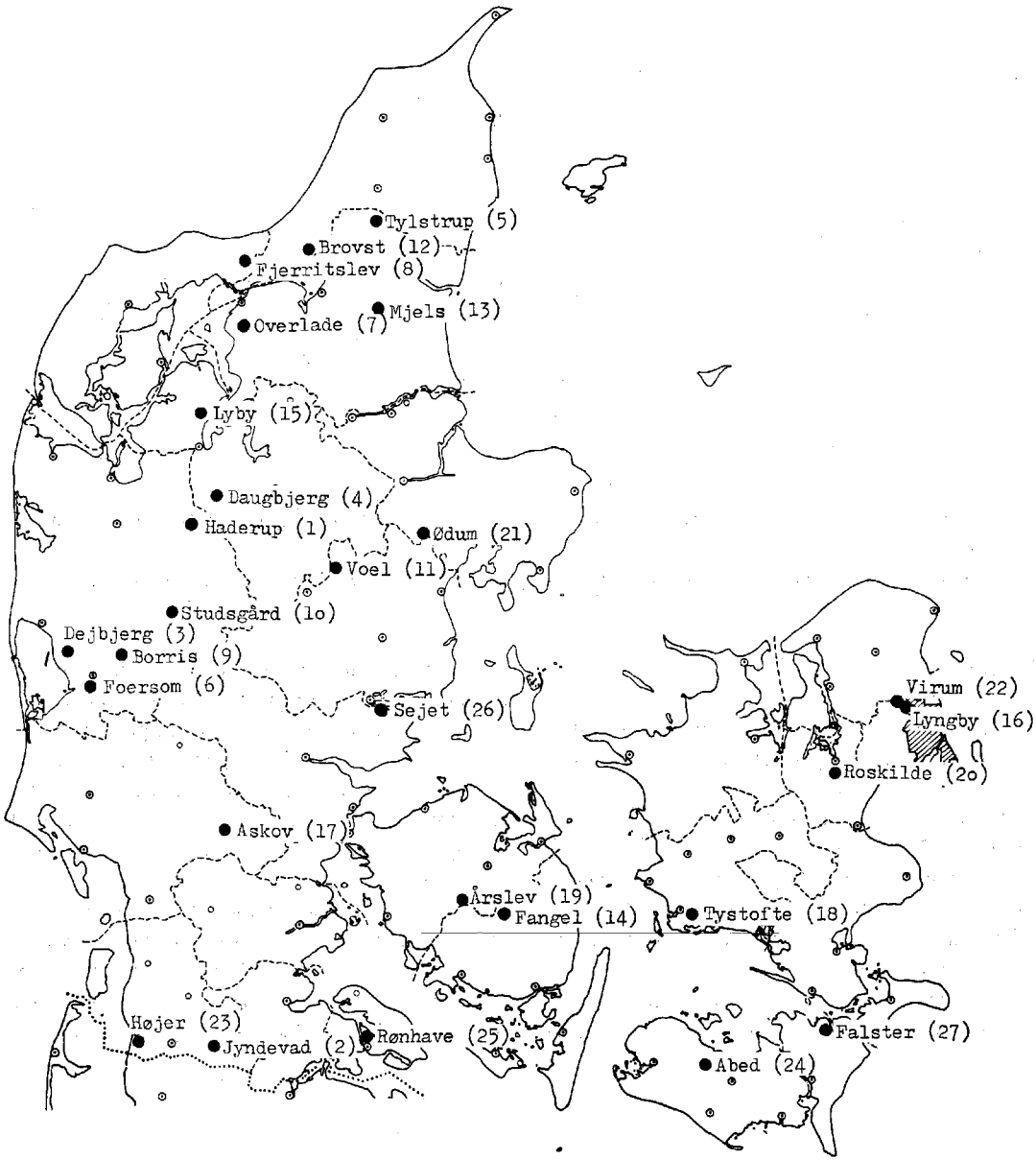

Fig. 1. Sampling sites. The numbers, 1 to 27 indicate increasing content of clay + silt.
Prøvetagningslokaliteter. Nummereringen er foretaget efter stigende indhold af ler + silt.

The reproduction of the results was evaluated with double sampling at three sites, Ødum, Borris and Jyndevad. The samples were extracted in pairs, and the percentage SD was calculated for groups containing more than 100 specimens per 200 ml of soil.

The mean SD was 14 per cent. In groups with more than 500 specimens per 200 ml of soil the SD was 9 per cent.

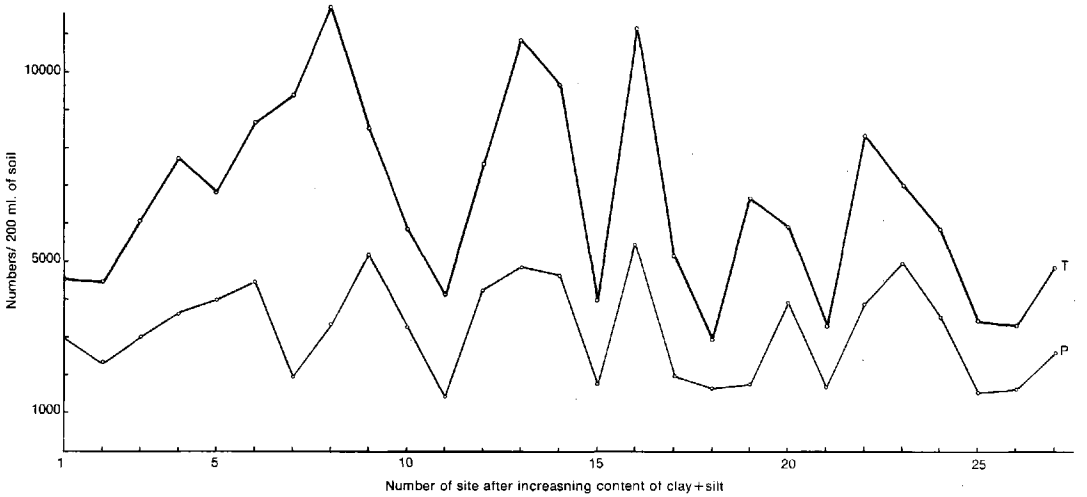

Fig. 2. Number of total nematodes (T) and phytoparasites (P) in 200 ml of soil sampled in July at site nr. 1 to 27 (See fig. 1.)

Total antal nematoder (T) og planteparasitter (P) i juli pr. 200 ml jord på lokalitet nr. 1–27. Se fig. 1.

Results

Population densities

Primary the quantitative part of the investigation was at the genus or higher group level. Fig. 2 and 3 show some of the results.

Table 1 gives a rough impression of the distribution of the species at the different sites.

The three given levels x, xx, xxx of the relative population densities were worked out on the basis of the randomly collected specimens of each genus for mounting.

Fig. 2 shows that the densities of the total nematode-fauna in barley 2nd year varied much between the single sites. However, the greatest densities occurred at the more sandy soil types.

The total number of nematodes per 200 ml of soil which corresponds to approx. 10 cm^2, varied between 2,930 and 11,708 with a mean of 6,700. The corresponding number per m^2 was calculated to approx. 3–12 $\times$ 10^6 with a mean of approx. 7 $\times$ 10^6 nematodes.

The plant parasitic nematodes contributed to the total number with 21 to 74 per cent, with a mean of 49 per cent. Fig. 2 shows the variation in numbers of the group The other main group »other nematodes« was mainly bacteriophage

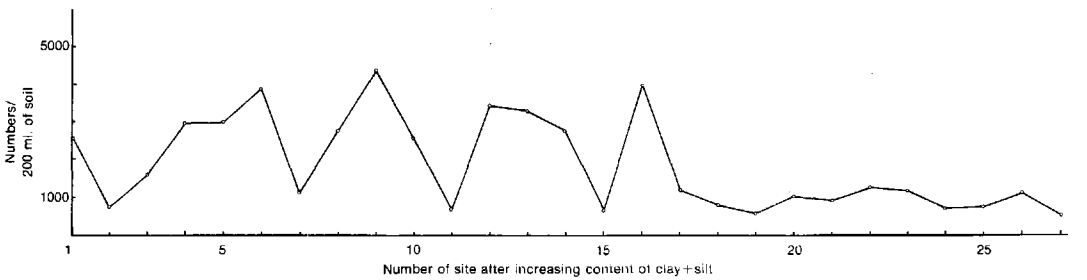

Fig. 3. Number of Tylenchorhynchus+Merlinius in 200 ml. of soil sampled in July at site nr. 1 to 27. (See fig. 1.)

Antal Tylenchorhynchus+Merlinius i juli pr. 200 ml. jord på lokalitet nr. 1–27. Se fig. 1.

Rhabditids. Mycophage and predatory nematodes were minor groups.

Among the plant parasitic groups the ectoparasitic nematodes were dominant. *Tylenchorhynchus + Merlinius, Paratylenchus* and *Trichodorus* were dominant at 18, 3 and 1 of the sites, respectively. *Tylenchus,* which contains both plant parasitic and mycophage species, dominated at 5 of the sites.

Fig. 3 shows the variation of the densities of the combined populations of *Tylenchorhynchus* and *Merlinius* in barley 2nd year. In this group there was a marked tendency to lesser densities in the clayish soil types.

Heterodera cystes and eggs were not extracted, but at 13 of the sites juvenile *Heterodera* were found.

The endoparasitic nematodes *Pratylenchus* had densities from 16 to 1,240 per 200 ml of soil, with a mean of 338. In July a major part of the *Pratylenchus* population will still be in the roots; this explains the relatively low numbers found in the soil.

The distribution of species in relation to soil types

Table 1 shows the occurrence of the species in relation to soil types, expressed as per cent clay + silt.

Some of the species were found only at one or a few of the sites and in minor densities, whereas other species were widely distributed. Some species of *Tylenchorhynchus, Merlinius* and *Pratylenchus* belong to the last mentioned category, *T. dubius* was one of the most common species and occurred in great densities, especially at the sandy sites. Its densities are partly reflected in fig. 3. *T. maximus* occurred at nearly all the sites with a clay and silt content less than 24 per cent, which is about half of all the sites.

M. brevidens showed preference for clayish soil types. Its greatest densities were found at sites with a clay + silt content from 23 to 37 per cent.

M. microdorus were found in two types. Type 2 deviates from the »normal« type 1 by having a smaller length, smaller stylet, smaller length of tail and fewer tail annules than type 1.

The two types (table 1) did not occur at the same soil types. Type 2 occurs instead of type 1 where the clay and silt content exceeds 22 per cent.

Among the occurring *Pratylenchus species, P. thornei* apparently preferred the most clayish soil types. *P. neglectus,* the most common *Pratylenchus species,* occurred at all soil types. *P. crenatus,* the second common species, most often occurred at sandy soil types.

Helicotylenchus populations occurred at approx. one third of the sites. *H. pseudorobustos* was found only at sites with clay and silt content less than 10 per cent, whereas *H. digonicus* and *H. canadensis* occurred only at sites with a clay and silt content higher than 34 per cent. However, a single specimen of *H. digonicus* was found in a sample from a site with 12 per cent clay and silt.

Trichodorus primitivus occurred at sites with a silt and clay content between 10 and 23 per cent, but the other species of *Trichodorus* and *Paratrichodorus* were more restricted to sandy soils.

Paratylenchus microdorus occurred at 8 sites, 7 of which had a clay and silt content of more than 23 per cent. The highest densities were found where clay and silt exceeded 30 per cent.

The range of pH in the soil samples varied between 5.3 and 7.8, but no species seemed to be correlated with this factor. The same holds for the content of humus, which varied between 1.9 and 5.3 per cent, mean 2.7. It was noted that the highest *Pratylenchus* density was found at the site with the greatest content of humus.

Discussion and conclusion

The distribution of the dominating species, *Tylenchorhynchus dubius, Merlinius brevidens, Pratylenchus neglectus* and *P. crenatus,* is in accordance with results from other North European investigations (*Oostenbrink,* 1961 and *Corbett,* 1970).

However, the population densities of *Pratylenchus* were smaller than the findings by *Corbett* (1970) and *Fischer* (1968). It needs not to mean that the real densities of *Pratylenchus* are smaller in Denmark than in England and Germany. The

Table 1. The relative population densities of the species at 27 sites and their distribution on different soil types.
Arternes forekomst og relative populationstætheder på 27 lokaliteter, samt deres udbredelse på forskellige jordtyper.

	Number of sites				
	total	relative densities			
		x	xx	xxx	% clay+silt
Tylenchus spp.	26	0	5	21	6–37
Psilenchus sp.	1	1	0	0	11
Ditylenchus spp.	12	11	1	0	6–37
Trophurus sculptus	1	1	0	0	37
Tylenchorhynchus dubius	24	0	4	20	6–37
Tylenchorhynchus maximus	14	3	9	2	6–23
Tylenchorhynchus judithae	1	1	0	0	10
Merlinius brevidens	14	2	1	11	10, 18–37
Merlinius quadrifer	2	0	1	1	23, 24
Merlinius microdorus, type 1	11	0	1	10	6–21
Merlinius microdorus, type 2	4	1	3	0	23–37
Merlinius nothus	7	0	3	4	8, 18–31
Pratylenchus crenatus	12	1	3	8	7–23, 31
Pratylenchus fallax	5	1	4	0	8–34
Pratylenchus neglectus	24	0	7	17	6–37
Pratylenchus penetrans	1	0	0	1	23
Pratylenchus thornei	6	0	2	4	28–37
Helicotylenchus digonicus	4	2	2	0	12, 35–37
Helicotylenchus canadensis	1	0	0	1	34
Helicotylenchus pseudorobustos	3	0	2	1	7–9
Rotylenchus fallorobustos	1	1	0	0	36
Heterodera spp. juveniles	13	10	3	0	8–37
Criconemoides spp.	2	1	1	0	8–10
Paratylenchus microdorus	8	0	1	7	10, 23–37
Paratylenchus spp.	15	4	7	4	7–30
Hexatylus viviparus	1	1	0	0	29
Thada cancellata	1	1	0	0	11
Ecphyadophora sp.	2	2	0	0	6–9
Aphelenchus avenae	20	6	13	1	7–37
Aphelenchoides spp.	23	2	18	3	7–37
Seinura demani	2	2	0	0	23, 35
Longidorus elongatus	2	1	1	0	8, 18
Longidorus leptocephalus	5	4	1	0	10, 18–31
Paratrichodorus pachydermus	7	3	2	2	7–11, 21
Trichodorus similis	5	1	1	3	8–12
Trichodorus primitivus	4	1	1	2	10, 18–23, 35
Trichodorus viruliferus	5	2	2	1	8–13

continued investigations (*Andersen*, 1979) show that in July a major – though varying part – of the *Pratylenchus* populations will be inside the roots. This, together with different extraction methods, may be the reason for the differences.

With a mean nematode density of 7 million (3–12 mill.) specimens per m^2, the nematode fauna in barley fields has greater densities than in some natural habitats (*Nielsen*, 1949), but not as great densities as in grass fields where *Nielsen* (1949) found densities up to 20 million per m^2. However, such figures cannot be compared directly, because the extraction methods were different in these investigations.

Some of the species found are new in Denmark. This is the case for *Pratylenchus fallax, Merlinius microdorus, Tylenchorhynchus judithae, Trophurus sculptus, Rotylenchus fallorobustos, Helicotylenchus canadensis, Helicotylenchus pseudorobustos* and *Trichodorus viruliferus, Hexatylus viviparus, Seinura demani* and *Thada cansellata.*

In consistency with the wide distribution of *P. fallax,* the species have been found associated with other plants (*Jakobsen,* 1976). Later *M. microdorus* and *T. judithae* have been found too (*Jakobsen,* pers. comm.). *Merlinius nanus* was not found in this investigation. *Sønderhousen* et al. (1968) found the species at about one third of the investigated sites. It may instead have been *M. microdorus,* which would be in accordance with the findings by *Jakobsen* (pers. comm.) and the findings here.

Table 1 shows that the distribution of some species was correlated with soil texture. It needs not necessarily mean that the texture is the real cause of it. The structure of the soil, moisture, temperature, O_2-consumption of other organisms and O_2-supply are factors which each of them and interactingly may have a significant influence on the activity of the nematodes (movement, feeding and reproduction). Some of the factors may to some extent be correlated with soil texture, which may be the explanation of the observed findings. The distribution of the two types of *Merlinius microdorus* where the smaller type 2 replaces the »normal« type 1 at higher clay contents, may primarily be due to the influence of temperature. This point of view is supported by results of temperature investigations in different soil types (*Schultz,* 1972) and by investigations of the influence of temperature on the size of nematodes (*Dao,* 1970 and *Sharma,* 1971).

Some of the species found are reported to be directly or indirectly harmful nematodes in different crops. Experiments have shown that the most common species, *Tylenchorhynchus dubius,* can reduce the yield of ryegrass, wheat, field-beans, potatoes and other crops (*Kyrou,* 1969, *Sharma,* 1971 and *Whitehead* and *Fraser,* 1972). However, the species do not seem to have any yield-reducing effect on barley (*Whitehead* and *Fraser,* 1972).

All the found species of *Pratylenchus* have been reported as yield-reducing agents in different cereal species. *Pratylenchus thornei* is harmful to wheat in North America (*Thorne,* 1961 and *Van Gundy* et al., 1974). *P penetrans* is considered to be one of the most pathogenic species of migratory nematodes. In a trial *Olthof & Potter* (1973) found a significant yield reduction in maize in connection with an initial population of only 666 nematodes per kg of soil. *P. penetrans* was found only at the experimental area in Lyngby and not at actual agricultural areas. Therefore it may be considered to be without economic importance for cereal growing in Denmark.

P. neglectus and *P. crenatus,* which are the most common species of *Pratylenchus* in Danish barley fields, are reported to be yield-reducing in barley in East Germany (*Decker,* 1961 and *Fischer,* 1968). Therefore it is a possibility that the two species at least under certain conditions have a potential yield reducing effect on Danish grown barley.

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References

Andersen, H. J. (1972): Migrerende rodnematoder hos bælgplanter. Tidsskr. f. Planteavl 76: 559–569.

Andersen, H. J. (1976): Migrerende rodnematoder i danske bygmarker. Licentiatafhandling, Københavns Universitet.

Andersen, H. J. (1979): Migratory nematodes in Danish barley fields. II Population dynamic in relation to continuous barley growing. Tidsskr. f. Planteavl. 83: 9–27.

Corbett, D. C. M. (1970): Cereal Pratylenchus spp. in England and Wales, and their recognition. Pl. Path. 19: 6–10.

Dao, D. F. (1970): Climatic influence on the distribution pattern of plant parasitic and soil inhabiting nematodes. Meded. LandbHogesch, Wageningen 70: 1–181.

Decker, H. (1961): Die Bedeutung wurzelparasitischer Nematoden für den Anbau von Gramineen. Wiss. Z. Univ. Halle (Math. Naturw.) 10: 297–302.

Decker, H. (1969): Phytonematologie. VEB Deutscher Landwirtsch. Verl., Berlin. 256 pp.

Fischer, R. (1968): Untersuchungen über das Auftreten von Pratylenchus neglectus Rensch (1924) in Getreidedebeständen des Bezirkes Halle. Nachr.-Bl. Pfl.schutzd. DDR 22: 44–48.

Jakobsen, J. (1976): Undersøgelse af forekomst af migrerende nematoder – særlig Pratylenchus penetrans – i rosengrundstammekulturer i danske planteskoler. Tidsskr. f. planteavl 80: 365–369.

Kyrou, N. C. (1969): Tylenchorhynchus dubius, an injurious ectoparasite of potatoes. Eur. Potato J. 12: 215–218.

Nielsen, C. Overgaard (1949): Studies on the soil microfauna. II. The soil inhabiting nematodes. Natura Jutlandica 2: 1–131.

Olthof, T. H. A. & Potter, J. W. (1973): The relationship between population densities of Pratylenchus penetrans and crop losses in summer-maturing vegetables in Ontario. Phytopathology 63: 557–582.

Oostenbrink, M. (1961): Vorfruchtwirkung und Nematoden. Wiss. Z. Univ. Halle (Math. Naturw.) 10: 303–308.

Schulz, H. (1972): Edafiske faktorers indflydelse på fodsygefremkaldende svampe og deres mulige antagonister. Statens plantepatologiske Forsøg, intern oversigt, botanisk afdeling, 1972: 28–54.

Seinhorst, J. W. (1956): The quantitative extraction of nematodes from soil. Nematologica 1: 249–267.

Seinhorst, J. W. (1959): A rapid method for the transfer of nematodes from fixative to anhydrous glycerin. Nematologica 4: 67–69.

Seinhorst, J. W. (1962 a): Modification of the elutriation method for extracting nematodes from soil. Nematologica 8: 117–128.

Seinhorst, J. W. (1962 b): On the killing, fixation and transferring to glycerin of nematodes. Nematologica 8: 29–32.

Seinhorst, J. W. (1966): Killing nematodes for taxonomic studies with hot f.a. 4:1. Nematologica 12: 178.

Sharma, R. D. (1971): Studies on the plant parasitic nematode Tylenchorhynchus dubius. Meded. LandbHogesch. Wageningen 71: 1–154.

Sønderhousen, E., Christensen, R. & Rasmussen, E. (1969): Forekomst af fritlevende nematoder i danske planteskoler, blomsterløg- og grønsagsarealer, samt undersøgelse af nogle kemiske jordbehandlingsmidlers indflydelse på jordens nematodbestand. Tidsskr. f. Planteavl 72: 245–270.

Thorne, G. (1961): Principles of nematology. Mc. Graw-Hill Book Company Inc. New York.

Van Gundy, S. D. et al. (1974): A pest management approach to the control of Pratylenchus thornei on wheat in Mexico. J. Nematol. 6: 107–116.

Whitehead, A. G. & Fraser, J. E. (1972): Injury to field beans (Vicia faba L.) by Tylenchorhynchus dubius. Pl. Path. 21: 112–113.