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Intestinal parasites in swine in the Nordic countries: prevalence and geographical distribution

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Abstract

In Denmark (DK), Finland (FIN), Iceland (I), Norway (N), and Sweden (S), 516 swine herds were randomly selected in 1986–1988. Individual faecal analyses (mean: 27.9 per herd) from eight age categories of swine showed that *Ascaris suum*, *Oesophagostomum* spp., *Isospora suis*, and *Eimeria* spp. were common, while *Trichuris suis* and *Strongyloides ransomi*-like eggs occurred sporadically. Large fatteners and gilts were most frequently infected with *A. suum* with maximum prevalences of 25–35% in DK, N and S, 13% in I and 5% in FIN. With the exception

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of the remarkably low *A. suum* prevalence rates in FIN, no clear national differences were observed. *Oesophagostomum* spp. were most prevalent in adult pigs in the southern regions (21–43% in DK and southern S), less common in the northern regions (4–17% adult pigs infected), and not recorded in I. *I. suis* was common in piglets in DK, I, and S (20–32%), while < 1% and 5% were infected in N and FIN, respectively. *Eimeria* spp. had the highest prevalences in adult pigs (max. 9%) without clear geographical differences. *I. suis* and *Eimeria* spp. were recorded for the first time in I, and *I. suis* for the first time in N. © 1998 Elsevier Science B.V.

Keywords: *Ascaris suum*; *Oesophagostomum* spp.; *Isospora suis*; *Eimeria* spp.; *Trichuris suis*; *Strongyloides ransomi*; Pig nematode; Pig protozoa; Nordic countries

1. Introduction

Several surveys have been conducted to determine the occurrence of internal parasites in pigs (see below). The numbers of species present and the prevalence rates are high when production systems are traditional (e.g., Roberts, 1940; Ajayi and Arabs, 1988), however, many recent studies have shown that superior housing and hygiene in combination with routine anthelminthic usage have lead to decreasing prevalence rates of many parasites (Pattison et al., 1980; Alfredsen, 1983; Möller, 1983; Morris et al., 1984; Kennedy et al., 1988; Mercy et al., 1989b; Roepstorff and Jorsal, 1989, 1990; Dangolla et al., 1997).

Nearly all of the most common intestinal parasites of pigs have been shown to be unevenly distributed among different age groups (e.g., Boch, 1956; Boch and Neubrand, 1962; Jacobs and Dunn, 1969; Pattison et al., 1980; Morris et al., 1984; Mercy et al., 1989a; Roepstorff and Jorsal, 1989). *Isospora suis* and *Strongyloides ransomi* are most common in piglets, *Ascaris suum* and *Trichuris suis* in growing pigs, and *Oesophagostomum* spp. , *Hyostrongylus rubidus*, and *Eimeria* spp. are most common in adult pigs. These characteristic age-dependent distributions are most probably caused by different host–parasite relationships, especially the immunogenicity of the parasite (e.g., Pattison et al., 1980; Murrell, 1986; Roepstorff and Nansen, 1994).

In 1983–1984, a Danish study on helminth occurrence was carried out in 66 sow herds (Roepstorff and Jorsal, 1989, 1990). In the framework of a joint Nordic project on porcine parasites, it became possible to expand this study and to use the Danish experience in the planning of sampling and in the elaboration of a more comprehensive questionnaire in a survey including all Nordic countries. Although swine helminth prevalences in Denmark were generally known (Mogensen, 1962; Jacobs, 1967; Henriksen, 1971; Roepstorff and Jorsal, 1989, 1990), little was known regarding prevalences in the other Nordic countries. In Sweden, there had been several epidemiological examinations of swine helminths (e.g., Nilsson, 1982), but no national survey study had been conducted. In Norway, intestinal helminth prevalence rates had been estimated in growing pigs in selected intensive herds (Tharaldsen, 1972) and in sows in randomly selected herds (Alfredsen, 1981, 1983). Only limited studies on porcine parasites in Finland and Iceland had been conducted (Lähteenmäki and Nikander, 1980; Neuvonen et al., 1982; Finnsdóttir and Richter, 1986). Therefore, there was a need to investigate the prevalences of intestinal pig parasites in the Nordic countries. Coordinating the investigation efforts in all five Nordic countries would generate comprehensive data for epidemiological analyses.

2. Materials and methods

2.1. Selection of the herds

Herd selection was from national or local registers. Extremely small sow herds (< 5 breeding sows) and specialized fattening herds without sows (< 100 fatteners produced per year) were not included in the study. Within each country, the herds were divided into two categories: (1) herds with sows (with or without raising of fatteners) and (2) specialized fattening herds. These two categories were subsequently stratified by the numbers of breeding sows or the number of fatteners produced per year, respectively. The number of herds selected per stratum was proportional to the total number of animals (sows or fatteners) in the stratum. The number of herds visited in each country was not related to the size of the national swine industry.

2.1.1. Denmark (DK)

Denmark has a large swine industry (Table 1). The pig producers are very well organized, and 82 herds were randomly sampled, as described above.

2.1.2. Finland (FIN)

Swine production is more sporadic (Table 1), and no central registers of herds were available. Therefore, the herds were selected randomly from the municipalities. The majority (88%) of the 134 sampled herds was located in the southern and central regions of FIN (Fig. 1) which have the largest pig population.

2.1.3. Iceland (I)

The number of swine herds is low (Table 1). Swine production is isolated from the European continent, and the pigs are thought to be descendants of a limited number of pigs imported from DK and Great Britain before 1940; importation has since been prohibited. It was possible to obtain a central register, and 20 herds were randomly sampled after stratification, as described above.

Table 1
Swine production in the Nordic countries, 1987

	Denmark	Finland	Iceland	Norway	Sweden
Total number of sow herds	26,258	6550	137	6777	12,650
Total number of sows	923,038	125,979	3343	97,121	226,151
Mean number of sows per sow herd	35.2	19.2	24.4	14.3	17.9
Number of fatteners slaughtered per year	16,158,000	2,180,600	36,940	1,140,000	3,458,700

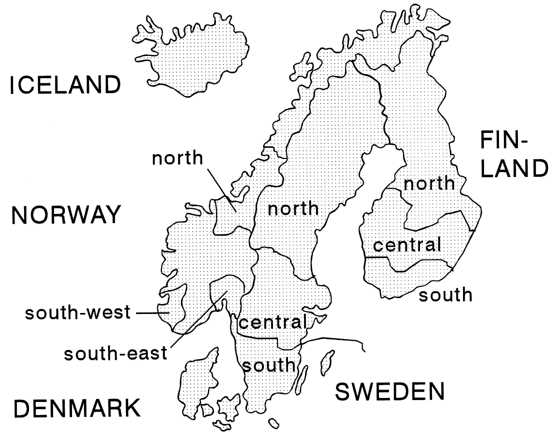

Fig. 1. The five Nordic countries. Finland, Norway and Sweden were each divided into three regions. Notice that Iceland has been moved toward the northeast to save space.

2.1.4. Norway (N)

The swine industry is small (Table 1), and it was possible to obtain regional registers. The agricultural structure in N at the time of the investigation was strongly influenced by a policy of protecting small traditional farms by making it illegal to establish new farms with more than 25 breeding sows. Because only one investigator was available for sampling, three different regions (Fig. 1) were chosen for sampling 101 herds: Akershus (southeast), Rogaland (southwest), and Nord–Trøndelag (north). These were the same geographical areas as examined by Tharaldsen (1972) and Alfredsen (1981).

2.1.5. Sweden (S)

The swine production is small (Table 1) and concentrated in the most southern areas of S. No central registers were available, and 179 herds were selected randomly from regional registers (Fig. 1).

2.2. Sampling

The sampling took place between April 1986 and August 1988. The farms were visited shortly after the farmers were first contacted. The farmers were asked not to change anything in management, hygiene, or anthelmintic treatment because of the survey. Individual faecal samples were collected randomly from each category of pigs, independently of the time of the last anthelmintic treatment (see below).

The faecal samples were collected from the rectum of the pigs, or in some cases (e.g., most piglets and most Icelandic pigs) from freshly deposited faecal material. All samples were individually labelled and kept cool during transport to the laboratory where they were kept refrigerated at 4°C for a maximum of 1 week before processing.

Samples were collected from the following eight categories of pigs: (1) Piglets, 3–40 days old (preferentially 10–20 days). (2) Weaners, approximately 25 kg body weight.

Table 2
Number of herds randomly selected for examination (and mean numbers of samples in each herd) by category of pigs

	Denmark	Finland	Iceland	Norway	Sweden	Total
Piglets	47 (4.3)	102 (3.8)	17 (3.9)	53 (4.4)	146 (4.0)	365 (4.0)
Weaners	48 (4.8)	107 (4.6)	17 (5.0)	65 (5.2)	146 (4.5)	383 (4.7)
Young fatteners	57 (6.6)	84 (5.9)	17 (5.0)	61 (6.9)	154 (5.5)	370 (6.0)
Fatteners	61 (6.8)	96 (7.1)	18 (4.9)	61 (6.0)	175 (6.0)	419 (6.2)
Gilts	47 (3.9)	94 (3.6)	13 (3.6)	66 (4.1)	126 (3.0)	346 (3.5)
Dry sows	51 (4.9)	111 (8.8)	19 (4.2)	81 (5.5)	148 (5.2)	410 (6.1)
Lactating sows	49 (4.6)	109 (5.9)	18 (4.1)	78 (3.8)	150 (4.9)	404 (4.9)
Boars	44 (3.0)	98 (1.5)	14 (2.0)	38 (1.0)	137 (2.1)	331 (1.9)
All pigs	82 (24.5)	134 (31.0)	20 (27.6)	101 (24.0)	179 (29.5)	516 (27.9)

Normally, these pigs were 8–12 weeks old. If the farmer routinely treated his weaners with anthelmintics when weighing 25–30 kg, only untreated pigs were sampled. (3) Young fatteners, approximately 45 kg body weight. Normally, these pigs were 14–18 weeks old. (4) Fatteners, approximately 90 kg body weight. Normally, these pigs were 24–28 weeks old. (5) Gilts, young sows pregnant for the first time. Normally, these pigs were 9–11 months old. If the farmer routinely treated his gilts with anthelmintics within a few weeks before farrowing, only untreated gilts were sampled. (6) Dry sows, as close to farrowing as possible. If the farmer used to treat his sows routinely with anthelmintics within a few weeks before farrowing only untreated sows were sampled. (7) Lactating sows. If possible, these sows were the dams of the piglets sampled. (8) Boars, adult males.

The most dominating races were Yorkshire and national landraces, and usually pigs were crossbreeds of two (most breeding animals) or three breeds (many growing pigs), except for N in which almost all pigs were pure landrace. If possible, samples were collected from five animals in each category from each herd (mean numbers of samples per pig category and herd are shown in Table 2). The pigs sampled were from at least several different pens. In the case of specialized farms for fattening (no breeding animals), 10 samples were taken from both young fattener and fatteners.

2.3. Laboratory techniques

2.3.1. Faecal analyses

The samples were processed in different laboratories in the participating countries after attempts had been made to standardize the egg count procedure. The modified McMaster techniques have been described and compared by Christensson et al. (1991). All laboratories used a flotation fluid with a high specific gravity such as saturated NaCl with 500 g glucose per litre (DK, I and S), NaCl (210 g) + $ZnCl_2$ (220 g) + 800 ml water (N) or saturated $MgSO_4$ + sucrose (FIN). The lower detection limits of the methods were 20 eggs/oocysts per gram of faeces (epg/opg) (DK, FIN, I, S) or 50 epg/opg (N). Oocysts of porcine coccidia are small, and the oocysts of *I. suis* in piglet faeces may be especially difficult to detect because the faeces often contain fat droplets which can obscure the oocysts. Therefore, a common routine was adopted for all samples in which oocysts were counted in two randomly selected visual fields at high magnification (80–100 ×). The lower detection limit of this method is 400–600 opg depending on the McMaster technique and the microscope. Samples, in which oocysts were detected only at low magnification, were also considered positive.

2.3.2. Larval cultures

When eggs of the strongylid type were found in samples from a herd, two individual faeces samples containing eggs were mixed with vermiculite and water. After approximately 10 days at room temperature, the cultures were baermannized, and if possible 200 infective larvae from each culture were identified as *Oesophagostomum* spp. or *H. rubidus*, according to the descriptions by Alicata (1935).

2.3.3. Oocyst sporulation

Samples containing coccidial oocysts were mixed with 2.5% potassium dichromate in a petri dish. The oocysts were left to sporulate for a minimum of 14 days at room temperature and subsequently identified as either oocysts of *I. suis* or *Eimeria* spp.

2.4. Data analysis

All data were analysed with SAS® Release 6.09 software package. An animal was recorded as infected with a parasite if at least one egg or oocyst was detected in the McMaster chamber. For calculating prevalence rates of the different pig categories, the herds were stratified by the number of fatteners (categories: young fatteners and fatteners) or the number of breeding sows (all other pig categories). Within each stratum, the prevalence (percentages of animals excreting parasite eggs or oocysts) was calculated and the national age-specific prevalences were calculated as the weighted mean for each stratum (weighted by the proportion of pigs within each stratum in the country). Total prevalence rate estimates for all Nordic pigs were calculated as weighted means (weighted by the national numbers of fatteners slaughtered per year or the national numbers of sows).

3. Results

The swine production is unevenly distributed in the Nordic countries. The southern lowlands of DK (Fig. 1) produces 70% of all Nordic pigs slaughtered (Table 1). With the exception of the low pig numbers in I, the swine production in the other countries is correspondingly concentrated in the southern areas. A total of 516 swine herds were surveyed, and a mean of 27.9 faecal samples were analysed per herd (Table 2).

Eggs of *Ascaris*, *Trichuris*, the strongylid type, and *Strongyloides*-like eggs, and oocysts of coccidia were found. All L3 larvae from faecal cultures were identified as *Oesophagostomum* spp. and therefore all strongylid eggs are considered to be *Oesophagostomum* spp. Of 165 differentiated piglet samples, 96.4% contained *Isospora*,

Table 3
Prevalence rates (%) of *A. suum*, *Oesophagostomum* spp., *T. suis*, *S. ransomi* *, and Coccidia (*I. suis* and *Eimeria* spp.) in the Nordic countries

Parasite	Pig category	Denmark	Finland	Iceland	Norway	Sweden	Total
Ascaris	Piglets	5.1	0.7	6.3	2.0	0.5	3.8
	Weaners	5.8	0.4	12.3	4.0	3.1	4.8
	Small fatteners	13.8	4.8	9.6	5.0	19.1	13.3
	Fatteners	20.8	5.0	6.4	24.6	34.5	21.5
	Gilts	24.7	3.8	12.9	16.8	27.2	22.6
	Dry sows	13.4	2.3	11.5	13.4	6.8	11.3
	Lactating sows	10.4	1.4	7.1	10.6	7.9	9.2
	Boars	11.0	1.8	4.2	16.4	7.3	9.9
Oesophagostomum	Piglets	1.9	0.8	0.0	0.0	1.5	1.6
	Weaners	8.8	0.1	0.0	0.6	5.2	7.0
	Small fatteners	3.7	1.5	0.0	0.1	4.4	3.4
	Fatteners	3.8	0.2	0.0	0.0	7.8	3.9
	Gilts	23.4	5.8	0.0	4.9	18.4	19.6
	Dry sows	25.6	8.5	0.0	5.9	30.4	23.4
	Lactating sows	21.8	8.7	0.0	4.2	23.2	19.5
	Boars	21.2	5.1	0.0	9.9	29.6	20.3
Trichuris	Piglets	0.0	0.0	0.0	0.0	0.1	< 0.1
	Weaners	0.4	0.0	0.0	0.0	0.0	0.3
	Small fatteners	0.2	0.0	0.0	0.1	0.0	0.1
	Fatteners	0.4	0.1	0.0	0.0	0.1	0.3
	Gilts	0.5	2.8	0.0	1.6	1.1	0.9
	Dry sows	1.5	1.5	0.0	0.5	0.2	1.2
	Lactating sows	0.9	2.1	0.0	0.8	0.4	0.9
	Boars	5.1	10.2	0.0	0.0	1.4	4.6
Strongyloides *	Piglets	0.0	0.0	6.8	0.0	1.0	0.2
	Weaners	0.4	0.0	11.8	0.0	0.0	0.3
	Small fatteners	0.0	0.0	6.3	0.0	0.0	< 0.1
	Fatteners	0.0	0.0	7.0	0.0	0.0	< 0.1
	Gilts	0.5	0.0	18.8	0.0	0.0	0.4
	Dry sows	1.5	0.0	4.9	0.3	0.1	1.1
	Lactating sows	0.9	0.0	4.4	0.0	0.1	0.6
	Boars	5.1	0.0	4.7	0.0	0.5	3.5
Coccidia	Piglets	19.5	4.5	31.8	0.3	20.1	17.2
	Weaners	1.6	0.5	28.0	1.1	0.0	1.3
	Small fatteners	3.2	0.3	36.4	0.0	0.4	2.4
	Fatteners	2.9	3.0	38.3	0.0	0.1	2.4
	Gilts	5.1	6.7	0.8	0.9	3.7	4.7
	Dry sows	6.8	3.6	3.2	0.8	2.8	5.4
	Lactating sows	2.8	0.3	4.0	0.0	1.1	2.1
	Boars	5.2	3.0	9.3	0.0	8.8	5.2

* A large percentage or perhaps all of the nematode eggs resembling *S. ransomi* eggs may have been eggs of free-living nematodes. The total prevalence rates are calculated as weighted means.

while 100% of the coccidia (128 differentiated samples) in the breeding animals (gilts, sows, and boars) were *Eimeria* spp. Due to low oocyst numbers and in some cases unsuccessful sporulation, differentiation was not possible for all coccidia.

The prevalence rates of intestinal parasites in the Nordic countries are presented in Table 3. The prevalence rates of all parasites showed marked national differences and often also regional differences within the larger countries (Figs. 2–4).

A. suum was one of the most common parasites in all countries, but the prevalence rates were much lower in FIN than in the other Nordic countries (Table 3). Fatteners and gilts had the highest prevalence rates in all countries, except in the relatively few Icelandic herds. The regional differences are shown in Fig. 2. It was seen that the southwestern region of N had a lower occurrence of *A. suum* than did the northern and especially the southeastern region. In FIN, the prevalence rates increased from north to south. A similar distribution was not observed in S.

Oesophagostomum spp. was most prevalent in DK and S, less prevalent in FIN and N, and was not found in I (Table 3). *Oesophagostomum* spp. was found most frequent in the breeding stock (gilts, sows and boars) in all countries (Table 3). The regional results showed that pigs of the southeastern region of N were more frequently infected with

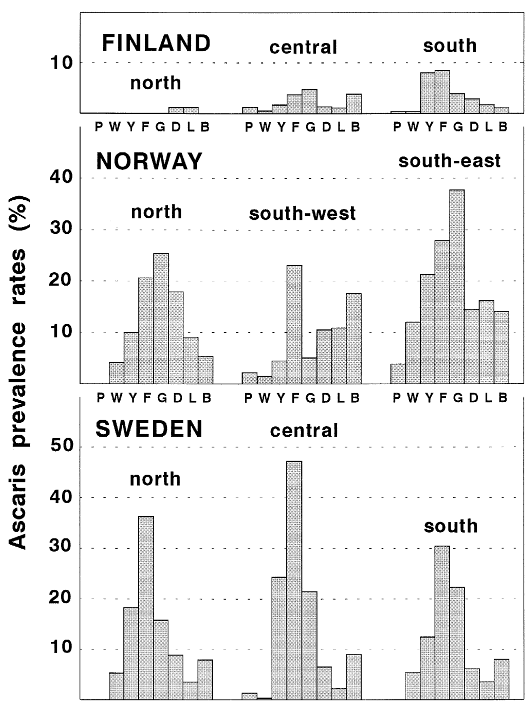

Fig. 2. Prevalence of *A. suum* (% infected animals) in the different regions of Finland (north: 16 herds; central: 62 herds; south: 56 herds), Norway (north: 40 herds; southwest: 41 herds; southeast: 20 herds) and Sweden (north: 52 herds; central: 56 herds; south: 71 herds) (see Fig. 1). Signature on *x* axis: P = piglets, W = weaners, Y = young fatteners, F = fatteners, G = gilts, D = dry sows, L = lactating sows, and B = boars.

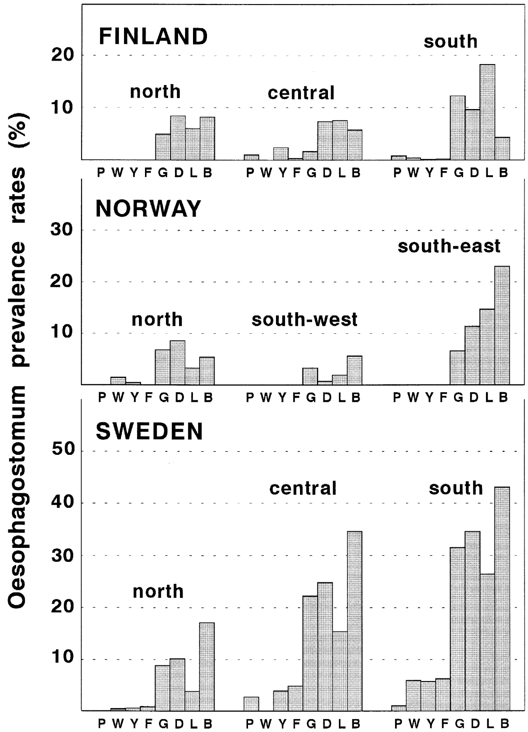

Fig. 3. Prevalence of *Oesophagostomum* spp. (% infected animals) in the different regions of Finland, Norway and Sweden (see Fig. 1). For further explanation, see Fig. 2.

nodular worms than pigs in the northern and especially the southwestern regions (Fig. 3). In FIN, the southern region showed higher prevalence rates than the central and northern regions, and in S there was a southern distribution, too, as pigs in the northern region had low prevalences while pigs in the southern region had the highest prevalences. High prevalence rates were also observed in DK.

T. suis (Table 3) was found sporadically in DK, FIN, N and S, but was not found in I. Breeding animals had the highest prevalence rates. Only 13 samples had >200 epg of *T. suis*.

Nematode eggs similar to eggs of *S. ransomi* (Table 3) were even more rare than eggs of *Trichuris*, except in I, where sows, boars, piglets and weaners were moderately infected. To confirm the presence of the parasite, larval cultures were set up from faecal samples from two Icelandic farms, which were found positive for *S. ransomi*-like eggs, but the developed adult nematodes were later identified as the free-living species *Rhabditis axei*. The prevalence rates in DK, N and S were extremely low, and only six samples exceeded 200 epg. Such eggs were not found in FIN.

Coccidia (largely *I. suis*) were very common in piglets in DK, I and S, with remarkably similar prevalence rates, while low rates were found in FIN, and only two piglets were positive for *I. suis* in N (Table 3, Fig. 4). Coccidia prevalence rates in

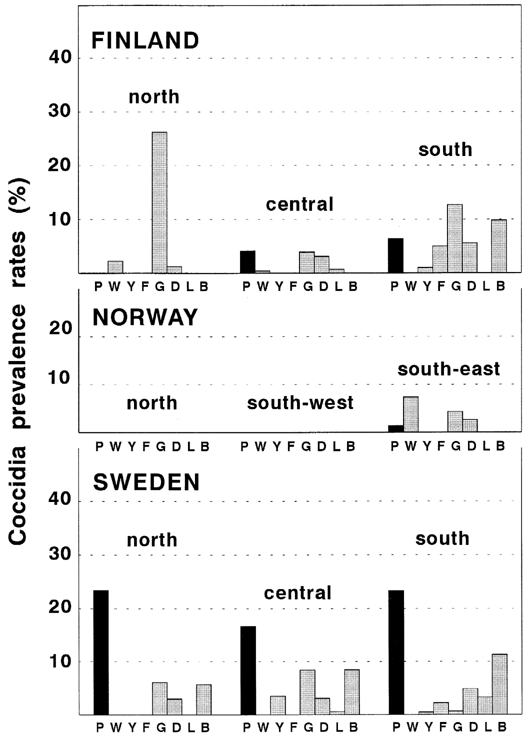

Fig. 4. Prevalence of coccidia (% infected animals) in the different regions of Finland, Norway and Sweden (see Fig. 1). *I. suis* is dominating in piglets (dark columns), while *Eimeria* spp. is dominating in the other age categories (light columns). For further explanation, see Fig. 2.

growing pigs were higher in I compared to DK, FIN, N and S, while all countries had low coccidial prevalences (only *Eimeria* spp. identified) in the adult pigs.

4. Discussion

The present joint Nordic survey on porcine endoparasites revealed that *A. suum* and *Oesophagostomum* spp. (not in I), among the nematodes, and the coccidia *I. suis* and *Eimeria* spp. were common throughout the countries, but with variation dependent on latitude and country. Also, *T. suis* (not in I) and perhaps *S. ransomi* (not in FIN) were widely distributed, but with such low prevalence rates that they may not cause measurable economic loss in most herds, although severe losses in individual herds may occur as seen in recent outbreaks of trichuriosis in FIN (Oksanen, 1991) and DK (Jensen and Svensmark, 1996).

Prevalence of parasites may be presented as the percentage of infected herds (a herd is infected if just one of the sampled pigs is positive) or as the percentage of infected animals. The first measure has been widely used (e.g., Kennedy et al., 1988; Mercy et al., 1989a) but tends to overestimate the parasite problems because many herds are only lowly infected. Furthermore, a prevalence calculated as the percentage of infected herds is strongly dependent on the sampling protocol, as an increase in the numbers of samples examined per herd will inevitably result in higher values. In the present study, the prevalence rates for each age category of swine have been calculated as percentages of egg-excreting animals. There is, however, one drawback of this, because the obtained prevalence rates may be overestimated due to the fact that uninfected pigs may excrete low numbers of eggs due to coprophagia of egg-containing faeces. This overestimation is most likely to occur for helminths of which the eggs do not hatch in the external environment (i.e., *A. suum* and *T. suis* of the present study) and the phenomenon may have a widespread occurrence in pigs (Boes et al., 1997, 1998). The probability of finding positive samples is dependent upon the age of the sampled pigs (e.g., Boch, 1956; Roepstorff and Nansen, 1994). In this survey, all major age categories of pigs were sampled, and *I. suis* was predominating in piglets, *A. suum* in fatteners and gilts, and *Oesophagostomum* spp. and *Eimeria* spp. in breeding animals. These patterns of age-specific prevalences were found in almost all examined geographical regions and countries, and illustrate that sampling of different age groups provides the most realistic estimates of the number of affected animals.

4.1. Denmark

In DK, *H. rubidus* previously had been found in sows (e.g., Jacobs and Andreassen, 1967), but this parasite may have disappeared because the transmission is most successful in outdoor production systems (Connan, 1977a). *Metastrongylus* spp. is another helminth which was indigenous to DK and which may have been eradicated as a consequence of rearing pigs indoors, thereby eliminating any contact between the pig and the intermediate earth worm host. Roepstorff and Jorsal (1989) examined 66 sow herds representative of the Danish swine population and found that prevalence rates of *A. suum* and especially *Oesophagostomum* spp. had been reduced considerably in comparison to earlier studies of weaners (Henriksen, 1971), fatteners (Mogensen, 1962) and sows (Jacobs, 1967), and the present study showed that prevalence rates had declined even further for *A. suum* in growing pigs and *Oesophagostomum* spp. in adult swine.

4.2. Finland

Metastrongylus spp. has previously been found sporadically in southeast FIN (Nikander, unpublished), but was not found in the present study. The other helminth species were the same as in a study of sows in northern and eastern FIN (Neuvonen et al., 1982). The climate in FIN is cold, but it remains unclear whether this causes the prevalence of *A. suum* to be remarkably low, even when compared to herds at the same latitude in N and S (Fig. 2). A contemporary study (Oksanen and Tuovinen, 1991) compared 23 Finnish herds with high rates of liver condemnations (due to migrating *A. suum* larvae) to 23 matched herds with low frequencies of liver condemnations. No significant differences in management or in indoor climate (temperature, relative humidity) could be demonstrated. Even during the winter, the floor temperature was most often 15–20°C, indicating that low outdoor temperatures were not the limiting factor for the embryonation of *Ascaris* eggs in Finnish pig herds, as was shown in England (Connan, 1977b; Stevenson, 1979) and S (Nilsson, 1982). *Oesophagostomum* spp. had nearly the same prevalence in FIN as in N and northern S, indicating a more southernly geographical preference of this nematode. The prevalence of *Eimeria* spp. was comparable to the low prevalence in adult pigs in S and DK. *I. suis* infections in piglets were much lower in FIN (and in N) than in S, where the infection rates were high even in the northern regions. This difference among countries may be due to some unknown differences in management or housing facilities.

4.3. Iceland

The swine industry is very small in I, and although only 20 herds were visited they represented nearly 15% of all Icelandic herds. Only *A. suum* has previously been reported in I (Finnsdóttir and Richter, 1986) and the present survey represents the first national record of *I. suis* and *Eimeria* spp.. Coccidia were much more common in growing pigs in I than in the other Nordic countries. The prevalence rates of nematode eggs resembling *S. ransomi* eggs are remarkable high. It is common to find either maximum prevalence of *S. ransomi* in piglets and weaners (e.g., Boch, 1956; Boch and Neubrand, 1962; Roepstorff, 1991), or only sporadical occurrence without any clear age relationships (e.g., Morris et al., 1984; Roepstorff and Jorsal, 1989). However, egg counts of *S. ransomi* should always be interpreted with caution, as the eggs are difficult to differentiate from eggs of some free-living nematodes and in I the faecal samples were usually collected from deposited faecal material which may have increased the contamination with free-living nematode eggs. The Icelandic as well as the other Nordic counts of *Strongyloides*-like eggs were low, and together with the identification in I of free-living nematodes in cultures of faeces containing *Strongyloides*-like eggs, this may indicate that at least some of the laboratory results, and possibly all, were falsely positive. Due to the risk of false positive egg counts, Weissenburg and Bettermann (1979) suggested that all records of *S. ransomi* in routine faecal samples should be disregarded unless identification was verified by faecal cultures.

4.4. Norway

The climate of N varies considerably from the mild coastal regions near the sea (represented by the southwest region ‘Rogaland’, Fig. 1) to the more continental climate in the southeast. The three sampled areas were identical to those of earlier survey studies of fatteners (3–6 months) from selected large herds (Tharaldsen, 1972) and sows in randomly selected herds (Alfredsen, 1981). Only *A. suum*, *Oesophagostomum* spp., *T. suis* and *Eimeria* spp. were found in these studies, but a clinical outbreak with *Strongyloides* had been previously described (Grini, 1937), while *I. suis* is now recorded for the first time. In fatteners, Tharaldsen (1972) found an *A. suum* prevalence (11.3%), which was lower than in the present study (24.6%). As the management had improved in the meanwhile, the opposite trend was expected, but the increase in prevalence may be due to different herd selection. The prevalence rates of the other parasites in fatteners were low in Tharaldsen's study, as in the present one. Alfredsen (1981) found some geographical differences in the percentage of infected herds, as *Oesophagostomum* spp., *T. suis* and coccidia were less common in southwestern N (Rogaland) than in the other two regions. In the present study, this trend was supported only by *Oesophagostomum* spp. (Fig. 3), while both *T. suis* and coccidia were rare in all regions. This geographical distribution of *Oesophagostomum* spp. is difficult to explain with macroclimatic factors. It is noteworthy that *Eimeria* spp. have been shown to cause clinical disease in Norwegian herds, shortly after susceptible animals had access to outdoor facilities (Alfredsen and Helle, 1980), and therefore even low prevalence rates of these parasites may be a potential risk.

4.5. Sweden

All the above-mentioned endoparasites are known to be indigenous to Swedish pigs, together with *H. rubidus* (Nilsson, 1967, 1982) and *Metastrongylus* spp. which has previously been reported among outdoor pigs (Nilsson, 1973) and wild boars (Christensson, unpublished). Nilsson (1982) reported two small studies of sows in 1971–1972 and 1980–1981 in southern S and demonstrated a decrease in the prevalence of *Oesophagostomum* spp. (from 91–94% to 62–70%) while the *Ascaris* prevalence increased (from 4 to 9%). He also reported that weaners (approximately 30 kg body weight), bought by specialized fattening herds in southern S in 1978–1981, had a prevalence of *A. suum* around 50%. When comparing these high prevalence rates with the present results, something must have been changed in southern S, as only 5% of the weaners were now infected with *A. suum* (Fig. 2) and 26–35% of the sows were excreting *Oesophagostomum* eggs (Fig. 3). While *A. suum* and *Eimeria* spp. had rather similar prevalence rates from north to south (Figs. 2 and 4), *Oesophagostomum* spp. had preference for the southern part, a trend also seen in N, FIN and DK (Table 3). In contrast, the even distribution of *I. suis* in piglets all over S (Fig. 4) indicates that factors other than an unfavourable macroclimate are responsible for the low prevalence with this coccidia in FIN and N (Fig. 4).

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