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A field survey on the status of internal parasites in calves on organic dairy farms in southwestern Sweden

Johan Höglund [a,*], Catarina Svensson [b], Anna Hessle [c]

[a] *Department of Parasitology (SWEPAR), National Veterinary Institute and Swedish University of Agricultural Sciences, P.O. Box 7073, SE-75189 Uppsala, Sweden*

[b] *Faculty of Veterinary Medicine, Department of Animal Environment and Health, Swedish University of Agricultural Sciences, Skara, Sweden*

[c] *Faculty of Agriculture, Landscape Planning and Horticulture, Department of Agricultural Research, Swedish University of Agricultural Sciences, Skara, Sweden*

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Abstract

Infections with internal parasites are one of the most important causes of reduced productivity in first-grazing season cattle (FGSC). In conventional herds, nematode infections can be controlled by prophylactic anthelmintic treatments, but this is prohibited in organic production. The purpose of this investigation was to monitor the status of internal parasitism on 15 organic cattle enterprises in southwestern Sweden during the 1997 and 1998 grazing seasons, and to estimate the benefits of some management practices in parasite control. On each farm, the numbers of *Eimeria alabamensis* oocysts per gram of (opg) faeces were counted in seven fresh dung pats collected from the paddock 8–10 days after the turnout of FGSC. Faecal samples from 5 to 15 FGSC were also analysed for nematode eggs per gram (epg) faeces at four occasions during each grazing season. In addition, the FGSC and one group of second-grazing season cattle (SGSC) were weighed at turnout and housing and at the same time blood samples were collected, and analysed for serum pepsinogen concentration and antibodies against the lungworm, *Dictyocaulus viviparus*. On seven farms, 1–6 samples with more than 100 000 opg were found, indicating considerable pasture contamination by *E. alabamensis*. However, clinical signs of coccidiosis were not observed. The highest outputs of nematode eggs were observed 45–55 days after turnout. More than 500 epg were only observed in 12 (2.2%) of the calves in 1997 and in three (0.6%) animals in 1998. Only 1% of the serum samples had pepsinogen values exceeding 3.6 U tyrosine, indicative of subclinical *Ostertagia ostertagi* infection. Lungworm infection was detected in five and nine herds in 1997 and 1998, respectively. The number of seropositive animals on these farms ranged between one (10%) and seven (70%). Clinical

*Corresponding author. Tel.: +46-1867-4156; fax: +46-1830-9162.
E-mail address: johan.hoglund@sva.se (J. Höglund).

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signs of dictyocaulosis were observed on two farms. The results indicate that dictyocaulosis is a problem in organic dairy herds in Sweden. On the other hand, the study shows that good management such as usage of parasite safe pastures and supplementary feeding may help control gastrointestinal parasites. © 2001 Elsevier Science B.V. All rights reserved.

Keywords: Cattle; *Ostertagia* spp.; *Cooperia* spp.; *Dictyocaulus viviparus*; *Eimeria* spp.; Organic farming; Control methods

1. Introduction

Throughout the world, parasitic nematodes are considered to be one of the most important causes of infectious diseases in grazing livestock (Perry and Randolph, 1999). Independent economic assessments have demonstrated that losses in cattle productivity due to nematode infections can be substantial (Hawkins, 1993). In first-grazing season cattle (FGSC) in Sweden, *Ostertagia ostertagi* and *Cooperia oncophora* are considered to be the most important parasites (Dimander et al., 2000). Their effects can be synergistic, but the damage caused is generally subclinical (Parkins et al., 1990). Although the lungworm *Dictyocaulus viviparus* is less prevalent than the gastrointestinal nematodes, it is important as the causative agent of bovine parasitic bronchitis (Eysker, 1994). It has also been demonstrated that the coccidian parasite *Eimeria alabamensis* is a major cause of early grazing season diarrhoea in FGSC in northern Europe (Gräfner et al., 1982; Svensson et al., 1994, 1997). Accordingly, all these parasites are considered as potential health hazards to young-grazing cattle. Farmers in Sweden are generally well aware of these problems and most attempt to implement some form of prophylactic treatment in their young stock to control these infections. On conventional farms, these measures are often based on the strategic use of anthelmintics (Nansen, 1993). This is in contrary to organic production where the prophylactic use of anthelmintics is prohibited (Anonymous, 1999), which implies that livestock has to be managed in such a way that there is no need for prophylactic anthelmintic treatment.

Organic farming is rapidly increasing in the Nordic countries. It can therefore be anticipated that a progressively larger proportion of cattle farmers will require parasite control programmes that exclude the use of anthelmintics, and it is therefore important to evaluate how current management practices affect the level of parasitism. A recent questionnaire study in Sweden concluded that health problems associated with parasite infections were more common in organic herds than on conventional farms (Svensson et al., 2000). However, very limited field data are available to substantiate this conclusion. The objectives of the present study were to monitor parasite infections in cattle raised organically in southwestern Sweden, and to assess the influence of some managerial practices on the level of parasite infections, particularly in FGSC.

2. Materials and methods

2.1. Experimental farms

In spring 1997, organic dairy farmers of western Götaland and Värmland in the southwest of Sweden were contacted. The 15 herds closest to the campus of the Swedish University

Table 1
The number of cows, the first grazing season when organic farming principles were applied, and the year when prophylactic treatment with anthelmintics was last practised on the 15 experimental farms

Farm	No. of cows	Organic farming	Prophylactic treatment
1	40	1995	1993
2	50	1996	1995
3	300	1995	1992
4	50	1994	1992
5	50	1995	1994
6	55	1992	Never
7	60	1996	1995
8	28	1995	1992
9	60	1995	1994
10	50	1994	1992
11	45	1994	1992
12	32	1996	1995
13	50	1994	1992
14	32	1996	1995
15	45	1995	1993

of Agricultural Sciences in Skara, which were able to put to our disposal at least eight first-grazing season heifers to be turned out to pasture simultaneously in May or June 1997, were selected. The herds comprised between 28 and 300 cows and the farmers had for one to five seasons before the start of the study managed their pastures by the organic management principles according to the Swedish regulatory organisation for organic farming (KRAV) (Table 1).

2.2. Experimental animals and grazing management

All animals were selected in the first group of FGSC to be turned out on each of the 15 farms during both the 1997 and 1998 grazing seasons. However, on the larger farms the number of experimental animals was increased to 10 or to 10% of the total number of FGSC on the farm. The numbers of animals per farm and their age and breed are shown in Table 2. Only heifer calves were used, except on Farms 10 and 14, where in 1998 also a few steers were sampled. The dates of turnout for the FGSC varied from 19 May to 9 June in 1997 and from 11 May to 8 June in 1998. The animals were housed mainly in the second half of October, but the dates of housing ranged from 30 September to 11 November in 1997 and from 24 September to 10 November in 1998 (Table 2).

Seven grazing management strategies were applied. Farms 1 and 2 mainly turned their FGSC onto pastures used for this category during at least the two proceeding seasons. Farms 3–6 grazed their FGSC on pastures used by FGSC the preceding seasons only. On Farms 7–9, the FGSC were kept mostly on fields previously used for harvest of hay or silage. The main parasite control strategy on Farms 10 and 15 was to graze the calves on pastures used by adult cattle the previous year, whereas Farms 12–14 used pastures that previously had been grazed only by sheep, swine, or horses. On Farm 11, horses and calves had grazed together

Table 2
The number of experimental FGSC each study year, their average age in days (±S.D.) at turnout, dates for turnout, and housing and their breed

Farm	Experimental calves, 1997				Experimental calves, 1998				Breed
	No.	Age + S.D. (days)	Turnout (date)	Housing (date)	No.	Age + S.D. (days)	Turnout (date)	Housing (date)	
1	10	220 (36)	24 May	15 October	10	150 (20)	5 June	29 October	SLB[a]
2	10	241 (26)	29 May	30 October	8	330 (26)	2 June	10 September	SRB[b]
3	15	183 (22)	9 June	14 November	15	200 (13)	13 May	29 October	SLB/SRB
4	10	212 (56)	2 June	14 November	10	236 (27)	13 May	29 October	SLB
5	6	302 (18)	24 May	23 October	10	334 (37)	29 May	24 September	SLB
6	10	247 (29)	13 June	13 October	10	205 (7)	2 June	25 October	SLB
7	10	178 (15)	4 June	21 October	11	213 (18)	4 June	20 October	SRB
8	8	220 (74)	20 May	20 October	10	249 (69)	18 May	24 October	SLB
9	10	270 (30)	23 May	12 October	10	270 (48)	18 May	13 October	SLB
10	9	210 (19)	3 June	20 November	8	247 (21)	30 May	29 October	SLB/SRB
11	8	178 (82)	3 June	16 October	10	111 (50)	22 May	28 October	SLB
12	8	225 (81)	30 May	2 October	0				SLB
13	5	272 (26)	19 May	30 September	10	313 (36)	11 May	30 October	SLB
14	10	194 (31)	29 May	6 October	8	158 (21)	24 May	16 October	SRB
15	8	194 (53)	31 May	17 October	10	206 (41)	8 June	29 October	SRB

[a] Swedish Friesian Cattle.
[b] Swedish Red and White Cattle.

for many years. The kinds of pastures used are shown in Table 3 together with information about the previous use of the pastures for cattle. Stocking densities ranged from 1.7 to 12.8 (mean 6.3) animals per hectare in 1997 and from 2.2 to 20.0 (mean 6.3) in 1998.

The FGSC on all but one farm were nutritionally supplemented with at least 1 kg dry matter roughage and/or 0.5 kg of concentrates per animal per day for 10 days or more during the grazing season. Seven of the farmers supplemented their calves in 1997 for some weeks after turnout in spring and six in 1998, respectively. The corresponding figures for supplementary feeding in the autumn were 10 and 12 farms, respectively. Silage was provided on nine farms, hay on one, and a mixture of hay and silage was given on four farms. Concentrates, mainly as rolled grain, were given on eight farms.

In 1998, the second-grazing season cattle (SGSC), studied as FGSC in 1997, were also monitored. They were turned out in the end of April on two farms and in May on the rest of the farms and were housed mainly in October (range: September–November). The animals grazed natural pastureland except on Farms 5–6, where they were kept on cultivated pastures. On all farms, SGSC grazed pastures that had been used by SGSC or adult cows the previous season. On Farms 10 and 11, FGSC and horses, respectively, had also used the pastures in 1997.

2.3. Sampling, weighing, and parasitological examinations

Seven fresh dung pats were collected from each of the pastures 8–10 days after turnout for enumeration of the *E. alabamensis* oocysts per gram (opg) of faeces (Anonymous, 1986). In addition, rectal faecal samples were collected from FGSC for quantitative analysis of the gastrointestinal nematode eggs per gram (epg) of faeces according to a modified McMaster technique based on 3 g of faeces and with a sensitivity of 50 epg. This was performed at four occasions: before turnout, after 45–55 and 95–105 days on pasture, and 6–21 days after housing. The FGSC and SGSC were weighed prior to turnout and at housing, and at the same time blood samples were collected. Serum was obtained to determine the pepsinogen concentrations (SPC) according to a micro-method (Dorny and Vercruysse, 1998) and levels of serum antibodies specific to *D. viviparus* (DVA) were measured by the Ceditest (ID-DLO, Lelystad, the Netherlands) (Cornelissen et al., 1987). The health status of all animals were monitored daily by the farmers and diarrhoea and/or coughing was noted. In 1998, the SGSC, studied as FGSC in 1997, were also weighed and bled before turnout and after housing, and their serum examined for SPC and DVA.

2.4. Statistical analyses

The descriptive statistics were calculated using Excel® (Microsoft). The effect of management practices on the parasite status of the FGSC was evaluated by univariate and multivariate statistical methods using SPSS® as described below. In these analyses, the following factors were the dependent response variables:

1. epg2 — whether trichostrongylid eggs were found 45–65 days after turnout (yes or no);
2. opg — the number of *Eimeria* oocysts in fresh faecal pats collected from pastures 7–10 days after turnout;

Table 3
Type of pasture used for experimental FGSC, grazing history, whether or not the pasture had been grazed by FGSC the previous season and by older cattle the current or previous seasons, number of paddocks that were used, grazing density and supplementary feeding

Farm	Type of pasture[a]	Grazing history[b]	Grazing[c]	Grazing of FGSC[d]	Grazing of older cattle[e]	No. of paddocks[f]	Grazing density (animals/ha)	Supplementary feeding[g]	
								Spring	Autumn
1997									
1	4	1	–	1	0	3	5.1	–	R
2	4	1, 3, 5	–	1	2	3	5.2	C + R	–
3	2	2	–	1	0	2	11.7	–	R
4	1	2	–	1	1	2	6.3	–	R
5	1 + 4	2	–	1	0	2	1.7	–	–
6	2	2, 5	–	1	0	2	6.2	–	–
7	3	4, 5	–	1	0	3	5.9	C + R	–
8	3	5	–	0	0	1‡	12.8	C	C + R
9	3	5	–	0	0	3	10.6	–	C + R
10	1	5	–	1	1	3	3.8	C + R	R
11	1	4 M	MS	1	0	3	5.2	R	R
12	2	4, 5	–	0	0	3	4.1	–	R
13	1	4	–	1	0	3	1.8	–	–
14	4	4, 5	–	0	0	3	3.6	C	R
15	2	3†	–	1	2	2	4.7	C + R	C + R
1998									
1	1	1, 3, 5	–	1	2	4	3.1	–	R
2	1	1, 3, 5	AO	1	2	3	4.5	–	R
3	2	2	–	1	0	1	2.5	–	R
4	1	3	AO	0	2	1	3.6	–	R
5	4	2, 3, 5	AO	1	1	4	2.2	–	–
6	2	2	–	1	0	3	7.6	–	R
7	3	4, 5	–	0	1	4	7.4	C + R	–
8	3	5	–	0	0	1‡	20.0	C	C + R
9	3	5	–	1	0	3	12.5	–	R
10	1	3	AO	0	2	1	2.3	C + R	R
11	1	3, 4 M	MS	1	2	1	3.3	C + R	C + R
13	1	2, 4	–	1	0	2	2.4	C + R	R
14	1	4	–	0	0	3	7.1	–	R
15	2	3†, 4	–	1	2	4	10.7	C + R	C + R

[a] (1) Natural pastureland (uncultivated pasture; rough grazing); (2) cultivated pastureland (not used for hay-making); (3) ley (seeded grassland also used for hay-making); (4) combinations of natural pastureland and ley.

[b] (1) Calves only for at least 2 years; (2) calves only the previous year; (3) second-grazers or older cattle (M: mixed grazing older cattle and calves; †: cows with their calves); (4) grazed by other species (M: mixed grazing other species and calves); (5) ley or crop seed, no grazing at all.

[c] MS: mixed grazing with other species; AO: alternate grazing with second-grazers or older cattle.

[d] (0) No; (1) yes.

[e] (0) Not the last two years; (1) yes current grazing season; (2) yes previous grazing season.

[f] ‡: Paddock successively enlarged during the grazing season.

[g] C: concentrates (>0.5 kg/animal); R: roughage (>1 kg dry substance/animal).

3. SPC — the serum pepsinogen concentration, expressed as units (U) of tyrosine, shortly after housing;
4. DVA — whether specific antibodies against *D. viviparus* was detected shortly after housing (yes or no).

Departure from normality was observed for SPC, which consequently was log-transformed before the analyses. Because 54% of the epg2 observations were negative, epg2 was dichotomised. The dichotomised variable was 1 if epg2 was positive and 0 if epg2 was negative. The dependent variables were analysed in relation to the following qualitative and independent explanatory variables:

1. farm (1–15), Farm 1 was always the reference category;
2. year (1997, 1998) with 1997 as the reference class;
3. breed (Swedish Friesian Breed (SLB), Swedish Red Cattle and White Breed Cattle (SRB), other; not analysed for opg);
4. stocking density (number of animals per hectare);
5. whether paddocks were grazed by FGSC the previous year (yes or no);
6. whether paddocks were grazed by older cattle (never, the current, or the previous year);
7. type of pastureland that was utilised (natural, cultivated, combined, and ley);
8. length of the grazing period (days);
9. time for turnout (date);
10. timing of nutritional supplementation (spring, autumn, and both).

epg2 was analysed by multiple logistic regression, and SPC and opg by multiple regression analysis. Due to the fact that only 16% of the samples analysed for DVA were positive, analysis of the relationship between DVA and the dependent variables was made by Fisher's exact test or Mann–Whitney *U*-test. A logistic regression model including only three independent variables was also fitted but the result should be carefully interpreted. The modelling strategy used divided the variables into two blocks, A and B. The block A variables, i.e. farm and year, were forced into the model. The remaining variables in block B were entered into the models by the forward entry method. The standard stepwise criterion of $P < 0.05$ was used to retain variables in the model. However, in order to detect important associations that could be missed using the forward entry method several alternative models were fitted. These included block A and one of the variables from block B and were based on the correlation structure between these factors. In the analysis of opg, variables 4 and 5 were highly correlated. Thus only variable 5 was included in the final model.

3. Results

3.1. Parasite status

3.1.1. First-season grazers

The overall geometric mean numbers of *E. alabamensis* oocysts about 1 week after turnout in 1997 and 1998 were 483 and 729 opg, respectively. Mean values exceeding 20 000 opg were only observed on Farms 1 and 7 in 1997 and on Farms 4 and 6 in 1998. However,

Table 4
The average geometric number of *Eumeria* oocyots (opg) 8–10 days after turnout; the faecal egg counts (epg), 45–55 (sample 2) and 95–105 (sample 3) days post-turnout and 6–21 days after housing (sample 4); the pepsinogen concentrations (SPV) at turnout and housing; the number of animals seropositive to lungworm (DVA) at housing, and the average daily weight gain on pasture of FGSC on 15 organic farms in southwestern Sweden in 1997 and 1998

Farm	No. of FGSC	*Eimeria* (10^3 opg)		*Ostertagia*/*Cooperia* (epg)						Pepsinogen (U tyrosin)				*D. viviparus* (No. of positives)	Weight gain (g/day)	
		Count	$>10^6$	Sample 2		Sample 3		Sample 4		Turnout		Housing			Mean	±S.D.
				Count	>500	Count	>500	Count	>500	Mean	>3.6	Mean	>3.6			
1997																
1	10	62.0	6	76	2	14	0	64	0	0.7	0	0.8	0	2	572	132
2	10	2.66	0	171	1	19	0	69	1	0.6	0	1.3	0	1	526	116
3	15	1.87	0	2	0	42	0	10	0	0.6	0	1.0	0	0	329	105
4	10	0.04	0	0	0	0	0	0	0	0.6	0	0.7	0	1	477	98
5	6	1.08	0	5	0	25	0	2	0	0.7	1	2.6	0	0	655	166
6	10	8.16	0	244	4	1	0	3	0	0.7	0	1.2	0	7	652	67
7	10	24.3	1	0	0	0	0	2	0	0.7	0	1.2	0	0	808	76
8	9	0.02	0	5	1	47	1	32	0	0.8	0	1.0	0	0	867	165
9	8	0.11	0	0	0	6	1	22	0	0.6	0	1.7	0	0	927	82
10	8	0.52	0	23	0	4	0	7	0	0.5	0	0.8	0	0	528	54
11	5	5.55	2	71	0	28	0	16	0	0.9	0	1.5	0	0	548	89
12	10	0.04	0	0	0	0	0	5	0	0.5	0	0.8	0	0	904	109
13	8	0.09	0	6	0	28	0	5	0	0.6	0	0.5	0	0	631	44
14	9	0.08	0	0	0	7	1	112	0	0.6	0	1.3	0	0	689	153
15	8	1.35	0	153	3	39	0	17	0	0.4	0	1.8	0	3	874	264

1998																
1	10	0.19	0	3	0	9	0	9	0	0.7	0	0.9	0	0	690	75
2	8	1.91	0	128	0	28	1	5	0	0.8	0	1.1	0	0	735	144
3	15	16.8	2	13	2	5	0	5	0	0.9	0	2.3	1	3	282	112
4	10	60.3	5	4	0	14	0	3	0	0.9	0	1.7	0	0	397	101
5	10	0.18	0	56	0	6	0	3	0	0.8	0	1.3	0	2	639	211
6	10	98.6	5	146	0	3	0	10	0	0.8	0	1.5	0	2	679	111
7	11	0.97	0	3	0	2	0	3	0	0.8	0	1.3	0	2	817	169
8	10	0.03	0	0	0	3	0	3	0	0.5	0	1.6	0	3	714	110
9	10	0.02	0	2	0	13	0	2	0	1.2	0	2.6	1	0	788	135
10	8	0.00	0	2	0	14	0	52	0	0.6	0	1.3	0	1	426	59
11	10	1.58	0	64	0	27	0	41	0	0.6	0	1.4	0	2	531	217
12	0															
13	10	0.01	0	37	1	16	0	2	0	0.8	0	1.3	0	0	499	121
14	8	1.39	2	0	0	15	0	18	0	0.5	0	0.7	0	0	465	78
15	10	0.27	0	45	0	20	0	3	0	0.5	0	1.4	0	0	388	157

Table 5
Factors significantly associated with the number of *Eimeria* oocysts in faecal pats collected from pastures grazed by FGSC 7–10 days after turnout (the data have been adjusted for the influence of farm[a])

Variable	Coefficient	*P*-value
Year	−0.56	0.101
Breed	1.64	0.028
Supplementation, autumn	−5.03	0.000
Cattle, previous season	2.40	0.023
Cattle, same season	−1.40	0.016

[a] $R^2 = 0.46$.

samples containing more than 100 000 opg were also collected from herd 11 in 1997 and herds 3 and 14 in 1998 (Table 4). An opg-value exceeding 850 000 was found only in one sample from Farm 7 in 1997. No clinical outbreaks of coccidiosis were observed. There were significant differences in opg between the farms. Furthermore, there were significantly lower opg counts in samples from paddocks that had been used by older cattle previously in during the grazing season, but higher counts from paddocks used by older cattle the previous year (Table 5).

In 1997, six (4.1%) of the calves shed nematode eggs before turnout, whereas five (3.6%) did so the second year. Although a maximum number of 1350 epg was observed in a sample from Farm 6 in 1997, the epg values observed in this study were generally low to moderate, with levels ranging from 50 to 300 epg. The majority of faecal samples (98.6%) had nematode egg counts below 500 epg. In most herds, the egg excretion followed a similar pattern; it rose and reached a peak level at the second sampling occasion, 45–55 days after turnout, but declined towards the end of the grazing season and then remained below 50 epg (Fig. 1). The risk of egg excretion differed significantly between farms. It was higher

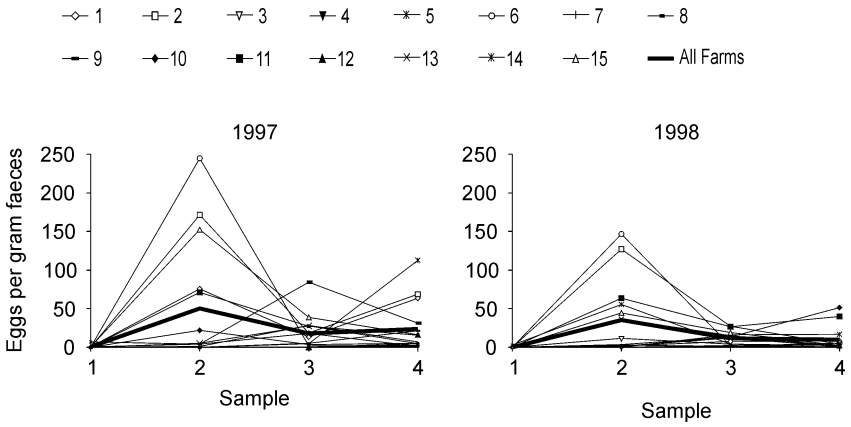

Fig. 1. Faecal egg counts in FGSC: (1) before turnout; (2) after 45–55 days; (3) after 95–105 days on pasture; (4) 6–21 days after housing. Values are expressed as geometric means for Farms 1–15 in (a) 1997 and (b) 1998. The solid lines are the average egg excretion on all farms.

Table 6
Factors significantly associated with the presence of trichostrongylid egg in the faeces of FGSC 45–55 days after turnout (the data have been adjusted for the influence of farm)

Variable	Odds ratio	*P*-value
Year	0.15	0.004
Time for turnout	0.21	0.000
Older cattle, previous year	218.58	0.000
Older cattle, same year	22.91	0.016
Stocking density	1.30	0.044

in 1998 than in 1997 and increased with higher stocking density. A postponed turnout was associated with a decreased egg excretion 45–55 days after turnout. In addition, the risk of epg2 increased if the paddocks were grazed by older cattle either the previous or the current season (Table 6).

Serum pepsinogen levels, ≥3.6 U tyrosine were recorded in three (1.1%) out of the 276 serum samples collected at housing (Table 4). The SPC was significantly higher in animals turned out early. In addition, supplementary feeding at turnout in spring and/or at housing in the autumn was associated with significantly lower SPC. There was a significant interaction between nutritional supplementation given in spring and in autumn, indicating that the effect of supplementation in autumn was different in animals that were also supplemented shortly after turnout. The corrected SPC of animals that were nutritionally supplemented both in spring and autumn were 44% lower than in FGSC that were only supplemented in spring. On the other hand, FGSC that were supplemented both in spring and autumn had tyrosine values that were 29% lower than in those given supplementation only in the autumn. There was a tendency towards higher SPC in 1998 compared to 1997 (Table 7). Diarrhoea was recorded late in the grazing season 1997 in seven (28.0%) of the animals on Farms 3 and 6. In 1998, all FGSC on Farm 13 suffered from diarrhoea.

Seroconversion against *D. viviparus* was detected on 11 (73.3%) of the farms, five in 1997 and seven in 1998, but in 28 (10.9%) of the 276 individual samples collected at housing. On most farms, between 1 and 3 FGSC were infected. However in 1997, 70% of the young cattle on Farm 6 were infected, which was significantly more than on all other farms in this study. On Farms 11 and 15, clinical signs of lungworm infection were observed in 1998, and all FGSC on these farms were treated with ivermectin (Ivomec pour-on vet®,

Table 7
Factors significantly associated with the serum pepsinogen concentration, expressed as U of tyrosine, in FGSC shortly after housing (the data have been adjusted for the influence of farm[a])

Variable	Coefficient	*P*-value
Year	0.05	0.08
Week of turnout	−0.08	0.000
Supplementation, spring	0.26	0.020
Supplementation, autumn	0.16	0.008
Supplementation, both	−0.41	0.003

[a] $R^2 = 0.42$.

Table 8
Factors associated with the presence of specific antibodies against *D. viviparus* in FGSC shortly after housing[a]

Variable	Odds ratio	*P*-value
Farm 6	4.30	0.016
Natural pastureland	1.70	0.307
Supplementation	0.23	0.016

[a] Due to the fact that only 10% of the samples analysed were positive; a model including only three independent variables was estimated.

Merial). Treatments were applied 57 and 98 days post-turnout, respectively. On five of the infected farms (6, 7, 11, 13, and 15), the pastures for FGSC had been shared with older cattle sometimes during the grazing season. However, on Farms 3, 5, 8, and 10, the calves grazed separate paddocks. The risk of FGSC acquiring lungworm infection was significantly lower in animals that were supplemented with concentrate and/or roughage at any time during the grazing period. There was no significant effect of type of pasture land utilised (Table 8).

3.1.2. Second-season grazers

Nematode egg counts and pepsinogen values of the SGSC studied in 1998 were all low and clinical signs of ostertagiosis were never observed. None of the animals that were serologically positive as FGSC in 1997 remained so at turnout in 1998. Antibodies against *D. viviparus* were demonstrated in SGSC animals on nine farms at housing in 1998. On the other hand, five animals that were serologically negative at housing in 1997 seroconverted and turned positive before turnout in 1998. Clinical signs of dictyocaulosis in SGSC animals were observed in July and in September on Farms 10 and 11, respectively.

3.2. Weight gains

Substantial weight variation was observed among the FGSC at turnout. Subsequently, average daily weight gains for the farms varied between 329 and 927 g and between 292 and 817 g in 1997 and 1998, respectively (Table 4). An average daily weight gain exceeding 800 g was recorded on five farms in 1997 but only on one farm in 1998. The daily weight gain was also significantly higher in 1997 as compared with 1998 ($P < 0.001$). There was also considerable variation in the daily weight gains of SGSC, from 352 to 982 g, with more than 800 g recorded on four farms.

4. Discussion

In this study on 15 organic farms in southwestern Sweden, low to moderate levels of gastrointestinal parasites were observed. Our results indicated that acceptable parasite control was achieved mainly by offering the animals safe pastures at the time for turnout and by strategic nutritional supplementation. However, lungworm infection seemed to be more difficult to control and caused clinical problems that required anthelmintic treatment on two of the farms.

The average excretion of *E. alabamensis* oocysts was generally low. Clinical levels of oocyst excretion, i.e. more than 850 000 opg, were observed on only one farm, where an outbreak of *E. alabamensis* coccidiosis was reported in 1995. The FGSC in the present study were indeed turned out on the same paddock as used during the 1995 episode, but it had been ploughed and grazed by horses in 1996. This means that the source of infection to the FGSC in 1997 may have been oocysts surviving on the pasture for two winters. However, it cannot be excluded that oocysts shed by calves in 1996 were picked up from an adjacent paddock. Survival of *E. alabamensis* oocysts on the pasture for one winter under Swedish conditions has previously been demonstrated (Svensson, 1995). Between 100 000 and 500 000 opg were recorded also on three other farms. Although below clinical levels, these numbers indicate a high level of pasture contamination at the time of turnout. On two of these farms, these pastures had been grazed by FGSC for at least the two preceding years. However, on one farm older cattle had used the contaminated pasture during the corresponding period. The association between significantly higher oocyst counts in herds where FGSC paddocks had been grazed by older cattle is in contrast to findings by Svensson (1995).

It has been shown that there is a positive correlation between the initial levels of exposure to infective L3 larvae and the faecal nematode egg counts approximately 60 days after turnout (Ploeger et al., 1994). However, considerable variation occurs with regard to the timing of the peak in faecal egg count in young-grazing cattle in western Europe (Shaw et al., 1998). Thus, the first sampling occasion of the FGSC in this study, 45–55 days after turnout would not necessarily coincide with the seasonal peak levels on all farms. As another estimate of parasitism, serum pepsinogen values of all cattle were analysed at the time of housing. This variable has been used as a diagnostic tool for *O. ostertagi* infections in FGSC cattle for more than three decades (Eysker and Ploeger, 2000). Pepsinogen values exceeding 3.6 and 5 U tyrosine are considered indicators of subclinical and clinical ostertagiosis, respectively (Hildersson et al., 1989). The low pepsinogen concentrations found in this study thus suggest that the methods of parasite control that were employed on the present organic farms worked satisfactorily to control ostertagiosis during the grazing seasons studied. These results are in agreement with those in a similar study carried out in Danish organic dairy herds in 1994 (Vaarst, 1995).

If the exposure to the parasites is light in the first-grazing season, subclinical production losses induced by nematodes in young cattle may be delayed to the second-grazing season (Ploeger et al., 1990). However, the signs of nematode infection in the SGSC in 1998, that were monitored similarly as FGSC in 1997 were low in this study. This suggests that the larval exposure of the FGSC in 1997 was sufficient to induce good levels of immunity against reinfection. However, no estimates of the larval availability in the paddocks grazed by the SGSC animals were done in this study. The low egg counts that were observed in the SGSC could therefore equally well have been due to low to moderate levels of larval exposure.

An unexpectedly high prevalence of *D. viviparus* was recorded in this study. Animals seropositive for lungworm were found in 12 (80.0%) of the 15 herds investigated. Similarly, Vaarst (1995) identified parasitic bronchitis as a major parasite problem in organic herds in Denmark. It has been suggested that in Sweden, the lungworms survive the housing period as inhibited larvae in cattle that acquired the infection during the grazing period (Törnqvist and Lindqvist, 1998). On farms where the FGSC paddocks were either co-grazed by older cattle, or utilised by older cattle earlier during the same grazing season, the most likely source of

infection were older animals. However, lungworm infection was also encountered on some of the farms where mixed grazing between FGSC and older cattle never occurred. This suggests that lungworm larvae can overwinter on pasture and/or that infective larvae were spread to the FGSC paddock from adjacent pastures grazed by adults. There are no studies on the overwintering capacity of the external stages of *D. viviparus* in Sweden, although it has been reported to occur, at least in some years, both in the Netherlands and in Scotland (Borgsteede et al., 1994). On the other hand, it has been demonstrated that *Pilobolus* spp., which are common fungi in the dung of herbivores, may disperse lungworm larvae to about 3 m (Doncaster, 1981; Eysker, 1991). Another possible source for larvae infecting FGSC on these farms is wildlife acting as reservoirs. However, it was recently demonstrated that roe deer and moose in Sweden are infected with a novel *Dictyocaulus* species (Höglund et al., 1999) and that neither cervid harbours *D. viviparus* (Divina et al., 2000). It is also unlikely that this roe deer/moose lungworm will induce seroconversion in cattle as this serological test is measuring patent infection only (Cornelissen et al., 1987).

In this study, an early turnout and a high stocking density were associated with higher levels of gastrointestinal nematode infection. However, more interesting is that nutritional supplementation was associated with reduced pepsinogen concentrations. The risk of lungworm infection was also significantly reduced in the supplemented FGSC. It has been demonstrated that there is an inverse correlation between the levels of nutrition and parasitism in that well nourished host better can withstand the deleterious effects of parasites (Coop and Kyriazakis, 1999). For example, in sheep resistance to *Teladorsagia* infection was positively correlated with the resilience and resistance of the host (Coop et al., 1990). The reduced time spent grazing by supplemented animals is also of some importance (Bransby, 1993). In this study, there was a significant interaction between nutritional supplementation and the time of feeding, i.e. whether it was supplied at the beginning or towards the end of the grazing period. Unfortunately, it was not possible to determine if this was due to synergism between the two, or whether the effect of late season supplementation was different in animals that were also supplemented shortly following turnout. Likewise, in this study it was not possible to evaluate whether the effect of extra feeding was different if the supplementation was in the form of roughage or concentrates. In a recent questionnaire study, we found that nutritional supplementation of calves at some stage of the grazing season was performed by 72% of organic cattle producers in Sweden (Svensson et al., 2000).

In conclusion, the present study indicates that lungworm infection is a parasitic disease problem in organic dairy herds in Sweden. It also shows that gastrointestinal parasites may be kept on low to moderate levels by good management and without prophylactic anthelmintic treatment. Usage of paddocks not utilised by first-grazing season calves during the previous season and supplementary feeding appear beneficial. However, better knowledge about the effects of strategic nutritional supplementation on the level of parasitism needs to be accomplished through further experimentation.

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