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THE SURVIVAL OF NEMATODES AND CESTODES OF SHEEP IN THE PASTURE DURING THE WINTER IN EASTERN NORWAY

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The grazing period in eastern Norway is from May to the end of October. In the winter there are usually sub-zero temperatures from November to March, and the fields are covered with snow from December to April. Under such conditions knowledge regarding the survival of parasites in the pasture is essential in the control of helminth infection in the sheep.

In USA *Kates* (1950) found that *Ostertagia* spp., *Nematodirus* spp. and *Trichuris ovis* were the only nematodes that survived the winter in significant numbers. Similar results were found by others, but some other nematode genera were found to survive severe winter climates (*Swales* 1940, *Smith & Archibald* 1965). A survey of the literature was given by *Soulsby* (1965).

In the present investigation worm-free lambs were placed in paddocks on permanent sheep pastures which had been free of sheep since the previous autumn. The investigations were done on 4 farms within 40 km from Oslo during 4 years. Negligible anthelmintic treatment had been used for the sheep on these pastures. Most of the lambs grazed in the paddocks for short periods only, in order to prevent contamination of the paddocks with eggs voided by parasites picked up from the same paddock (*Crofton* 1963).

A preliminary report of a part of this material has been given (*Helle* 1963).

MATERIAL, METHODS AND EXPERIMENTAL CONDITIONS

The farms. Farm no. 1 kept about 20 adult sheep on cultivated pastures at a moderate stocking rate. It was used for stu-

dies in 1959. At Farm no. 2 about 50 adult sheep with lambs had been kept for years on the same pasture at a fairly high stocking rate. The flock had occasionally been treated with phenothiazine. It was used for survival studies in 1960. Farm no. 3 had about 100 adult sheep which were kept on low ground 6 weeks in the spring and 6 weeks in the autumn. From the end of June to September the sheep were turned out on mountain grazing land. No anthelmintics had been given. This farm was used for survival studies in 1961. Farm no. 4 was the experimental farm Wøyen, where other investigations on sheep parasites were done, as described in other papers (Helle 1971 b). The survival studies were carried out in 1963 on the pasture designated no. 1 at that farm. No anthelmintics had been given to sheep on this pasture, and lambs grazing there in 1962 developed a heavy infection with nematodes.

The paddocks were about 20×20 meters. They were separated from the surrounding pasture by a double fence with a space of 1 m between. No sheep had used the area that year. The paddocks were placed on ground with a good grass cover which had been regularly grazed by sheep the previous year. As far as possible no person entered the paddocks when feeding and handling the lambs.

The test lambs. These were born in concrete pens which were cleaned and washed daily. The ewes had been washed before parturition. The lambs used at Farms nos. 1, 2 and 4 were removed from their mothers soon after birth and reared on slatted floor and fed with sterilized hay, concentrates and cow's milk until they were transferred to the test paddocks, as shown in Fig. 1. In 1959 1 lamb was kept under these conditions for 5 months as a control of the effectiveness of the isolation. The lambs used at Farm no. 3 were left with their mothers in concrete pens until they were 3 weeks old. Most of the lambs were born in the beginning of April.

In the test paddocks the lambs were given concentrates mixed with dried skimmed milk as supplementary feeding. Fig. 1 shows the period when each lamb was in the test paddock.

After the lambs were removed from the paddocks they were kept in concrete pens which were washed daily. They were fed on hay and concentrates until they were slaughtered, as shown in Fig. 1.

Control lambs. At Farms nos. 1 and 2 2 or 3 lambs from the

Table 1. Mean monthly temperature, mean monthly minimum temperature, the absolute minimum temperature of each month and the monthly precipitation at the climatological stations near to the experimental farms.

Observations	Station	Farm no.	Year	Month											
				S	O	N	D	J	F	M	A	M			
mean monthly temperature, °C	Asker	1	1958/59	11.9	7.7	1.5	3.9	7.0	3.0	0.3	4.2	11.2			
	Fornebu	2	1959/60	13.4	6.6	3.6	0.3	3.4	6.0	1.1	5.6	12.8			
	Ås	3	1960/61	10.7	3.7	0.4	1.8	5.2	1.5	3.3	5.2	10.1			
	Blindern	4	1962/63	10.2	7.0	0.1	6.4	8.6	8.5	3.4	4.0	10.7			
mean monthly minimum temperature, °C	Asker	1	1958/59	9.1	5.2	0.2	6.7	10.6	7.0	2.3	1.0	6.0			
	Fornebu	2	1959/60	8.7	4.0	1.8	1.9	5.7	9.1	2.5	1.2	8.2			
	Ås	3	1960/61	6.7	1.5	1.9	4.2	8.9	4.8	0.8	0.7	5.2			
	Blindern	4	1962/63	7.1	4.2	2.2	9.0	11.8	11.9	6.4	1.0	7.6			
absolute minimum temperature, °C	Asker	1	1958/59	3.5	1.0	4.6	13.4	16.7	17.0	8.6	5.6	0.4			
	Fornebu	2	1959/60	2.0	2.0	4.6	13.0	14.1	17.6	9.0	4.6	0.0			
	Ås	3	1960/61	2.0	3.6	10.0	16.8	21.6	19.6	7.5	11.7	0.6			
	Blindern	4	1962/63	2.0	2.5	11.7	17.7	20.1	19.7	14.7	6.9	1.9			
precipitation in mm	Asker	1	1958/59	54	188	86	94	65	0	72	143	25			
	Fornebu	2	1959/60	12	115	148	136	65	31	29	11	15			
	Ås	3	1960/61	70	98	171	87	43	49	18	20	47			
	Stovi	4	1962/63	86	39	79	51	2	5	23	70	133			

farm flock were slaughtered in the autumn in order to obtain a picture of the helminth fauna of the flock. At Farm no. 4 6 lambs, which had grazed in the pasture the previous year, were slaughtered in the spring of 1963. At Farm no. 3 no lambs were slaughtered, but faecal samples were examined from 4 lambs which had grazed in the pasture the previous year (1960).

Faecal examinations were done with methods described in other papers (*Helle* 1971 a) before and after the lambs had been in the paddocks.

Post-mortem examinations were done as described by *Helle* (1971 a).

Meteorological data were taken from the climatological station which was nearest to each farm. Table 1 shows the mean monthly temperature, the mean monthly minimum temperature, the absolute minimum temperature of each month and the total precipitation of the months from September to May at the respective stations.

Table 2. Number of days within each month with snow cover at the climatological stations near to the experimental farms.

Station	Farm no.	Year	Month							
			O	N	D	J	F	M	A	M
Asker	1	1958/59	0	1	24	31	28	31	16	0
Fornebu	2	1959/60	0	1	17	10	29	17	0	0
Ås	3	1960/61	0	10	12	31	22	4	6	0
Blindern	4	1962/63	0	13	29	31	28	31	11	0

Table 2 shows the number of days with snow cover within the same months.

RESULTS

The lambs used at Farms nos. 1, 2 and 4 were free of helminth eggs in their faeces before they were turned out. In 1961 the lambs used at Farm no. 3 had some eggs of *Strongyloides papillosus* in the faeces before they were transferred to the paddock. Every year a few coccidia were present in the lambs before they went out. The lamb kept under worm-free conditions for 5 months in 1959 was free of helminth eggs.

Table 3 shows differential egg counts of lambs from Farm no. 3.

Table 3. Differential egg counts of nematodes in 4 lambs which had been on pasture at Farm no. 3 in 1960.

Date	Lamb no.	EPG							
		Hae-monchus	Oster-tagia	Tricho-strongylus	Coo-peria	Buno-stomum	Cha-berbia	Nemato-dirus	Stron-gyloides
16th January 1961	25	4	0	15	23	0	8	0	200
	26	0	33	33	0	0	33	50	50
	27	0	19	112	131	0	188	100	900
	28	0	20	30	0	0	0	200	550
1st March 1961	25	0	3	43	0	2	3	50	0
	26	2	5	89	0	2	1	0	0
	27	0	0	90	58	0	2	0	500
	28	0	4	36	4	0	57	0	50
24nd April 1961	25	0	0	0	0	0	0	50	0
	26	8	8	210	4	12	58	0	0
	27	117	23	412	23	23	101	0	0
	28	—	—	—	—	—	—	—	—



Figure 1. Helminths found in the gastrointestinal tract at post-mortem examinations of the test lambs and controls. The lengths of the bars show the number of worms (log scale). The bars of the different genera of worms are placed on a horizontal row to the right of the eartag number of each lamb. The log scales of the 5 columns to the right of the figure begin with zero. All the scales to the left begin with one.

Fig. 1 shows the number of worms found in the gastrointestinal tract of the lambs from the paddocks and the control lambs (log scale). The number of worms was increased by 1 before transformation to logarithms.

In the test lambs *Ostertagia circumcincta* was found on all farms. At Farms nos. 1, 2 and 3 *O. trifurcata* was also found. At Farm no. 4 there were a few specimens of *Teladorsagia davtiani*. The *Trichostrongylus* spp. found in the small intestines of the test lambs were *T. vitrinus*, and in the abomasum *T. axei*. The *Nematodirus* spp. were *N. filicollis* at Farms nos. 1, 3 and 4. At Farm no. 2 *N. spathiger* dominated, but a few *N. filicollis* were present. At Farm no. 2 2 specimens of *Skrjabinema ovis* were found in a test lamb (no. 46), and in 2 lambs 1 specimen of *Protostrongylus* spp. was found in the bronchii.

In the control lambs the *Trichostrongylus* spp. of the small intestines were *T. vitrinus* at Farm no. 1, and *T. vitrinus* and *T. colubriformis* at Farms nos. 2 and 4. At Farm no. 4 a few *T. capricola* were also present. The *Nematodirus* spp. were *N. filicollis* on Farms nos. 1, 3 and 4. At Farm no. 2 *N. spathiger* dominated above a few *N. filicollis*. At Farm no. 1 1 lamb (no. K5) had 100 *Capillaria* spp.

Clinical condition of the test lambs. At Farm no. 1 Lamb no. 2 died of peritonitis 12th July, having had diarrhoea for 2 weeks. Lamb no. 3 had diarrhoea at that time, and there were eggs of *Nematodirus* and large numbers of coccidia in the faeces. At Farm no. 2 Lambs no. 42 and no. 43 were in good condition the whole time. Lamb no. 74 had diarrhoea when it was taken in, and it died 6 days later. The other lambs on this farm were languid with soft faeces after they had been in the paddock.

At Farm no. 3 Lamb no. 36 had diarrhoea 11 days after it had been taken in, and few days later there were large numbers of coccidia in the faeces. It was sacrificed in a emaciated condition 8 days later. At Farm no. 4 all lambs from the paddock were in good condition.

DISCUSSION

With the exception of the infection with *Strongyloides papillosus* of the lambs used in 1961, all lambs were free of helminths before they were transferred to the paddocks. In 1959 they were in the paddock for such a long time that their nema-

tode burden was patent and a contamination of the paddock with a subsequent reinfection may have occurred. The other years the lambs stayed in the paddock for 2—3 weeks only, and no reinfection was possible. Their nematode burden would then give an indication of the number of free-living stages which had been in the pasture. The advantage of using test lambs in survival studies is that the infectivity of the larvae is verified.

The results on the 4 farms correspond. *Ostertagia* spp. and *Nematodirus* spp. were the only nematodes which survived in large numbers. The highest number of *Nematodirus* was 26, 167 in Lamb no. 45 at Farm no. 2. Lamb no. 74, which died, had 16,233 *Nematodirus* spp. It is reasonable to regard *Nematodirus* spp. as the main cause of the faecal softening and the death on this farm (*Soulsby* 1965). At Farms nos. 1 and 3 the coccidia may have been partly responsible for the clinical symptoms. *Haemonchus contortus*, *Cooperia curticei*, *Bunostomum trigonocephalum*, *Strongyloides papillosus* and *Trichostrongylus colubriformis* were never found to have survived. *Trichostrongylus axei*, *T. vitrinus* and *O. venulosum* were found to have survived in very low numbers. Of *T. axei* and *O. venulosum* only 1 single specimen was found. A moderate survival of *Cooperia onchophora*, *Chabertia ovina*, and *Trichuris ovis* was found. There were, however, few specimens of *Cooperia onchophora* in the control lambs which shows that the level of infection in the flock concerned was low. On more heavily infected pastures a greater number of *C. onchophora* in the test lambs might have been found (*Smith & Archibald* 1969, *Tharaldsen* 1970, *Nilsson* 1970).

Moniezia spp. could easily survive the winter in the pasture.

These results are in agreement with those of *Kates* (1950), *Smith & Archibald* (1965), and *Andersen et al.* (1970). *Smith & Archibald* (1965) found the same difference between *Cooperia curticei* and *C. onchophora* as found in this experiment. In Sweden *Nilsson* made similar findings. At Farm no. 4 there had been a heavy infection with *Haemonchus contortus*, *Trichostrongylus axei*, *T. colubriformis*, *T. vitrinus* and *Cooperia curticei* the previous year. The absence of *H. contortus*, *T. colubriformis*, *Cooperia curticei* and the low numbers of *T. axei* and *T. vitrinus* in the test lambs show that the pastures are practically free of these nematodes in the spring. In Sweden *Nilsson* found that *T. vitrinus* could survive the winter in such a number that it might be of epidemiological importance. The number of *Capillaria* found

in the control lambs is too low to provide a basis for any conclusion on this genus.

The control lambs at Farms nos. 2 and 4 appeared to be heavily infected with most of the nematodes which occur in temperate regions. At Farms nos. 1 and 2 the control lambs were on pasture the same year as the test lambs. Therefore no direct information can be gained from them as to the pasture infection the previous year. They give, however, a reliable picture of the parasite fauna of the flocks.

It can be concluded that the winter in eastern Norway plays a significant part in the selection of the parasite fauna of a sheep pasture. It is of great significance that in the district concerned *Haemonchus contortus*, *Trichostrongylus* spp. and *Cooperia curticæi*, which are important pathogens in Norwegian sheep (*Nærland* 1948, *Helle* 1971 a, b) are almost entirely dependent upon surviving the winter within the sheep.

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SUMMARY

Using 21 worm-free lambs in paddocks on old sheep pastures on 4 farms near Oslo, it was found that *Nematodirus* spp., *Ostertagia* spp. and *Moniezia* spp. were the only helminths which could survive the winter in the pasture in great numbers. A few *Teladorsagia davtiani*, *Chabertia ovina*, *Trichuris ovis*, *Cooperia onchophora* and *Skrjabinema ovis* survived the winter. *Trichostrongylus axei*, *T. vitrinus* and *Oesophagostomum venulosum* showed a negligible ability to survive the winter in the pasture. The following species were never found to survive: *Haemonchus contortus*, *Trichostrongylus colubriformis*, *Bunostomum trigonocephalum*, *Cooperia curticei* and *Strongyloides papillosus*.

SAMMENDRAG

Overvintring av sauens nematoder og cestoder i beiter i Øst-Norge.

Ved å bruke parasittfrie lam som forsøksdyr i isolerte kveer på gammelt, sterkt infiserte sauebeiter ble det funnet at *Nematodirus* spp., *Ostertagia* spp. og *Moniezia* spp. var de eneste nematoder og cestoder som overlevet vinteren i beitet i større mengder. Noen få eksemplarer av *Teladorsagia davtiani*, *Chabertia ovina*, *Trichuris ovis*, *Cooperia onchophora* og *Skrjabinema ovis* overvintret i beitet. Ubetydlig overvintring ble funnet av *Trichostrongylus axei*, *T. vitrinus* og *Oesophagostomum venulosum*. Følgende arter overlevet ikke i beitet: *Haemonchus contortus*, *Trichostrongylus colubriformis*, *Bunostomum trigonocephalum*, *Cooperia curticei* og *Strongyloides papillosus*.

(Received September 17, 1970).