THE OVERWINTER SURVIVAL OF OVINE GASTRO-INTESTINAL PARASITES IN THE MARITIME PROVINCES

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Introduction

For many years parasitism has been recognized as a major cause of unthriftiness and losses in sheep in Eastern Canada (1, 13). Although new parasiticides and treatment regimes have become available, parasitism is still a serious problem in the Maritimes where sheep-raising has been a primary industry for many decades.

Since 1960, the authors have been conducting investigations on parasitism in Maritime sheep, particularly on the Nova Scotia community pastures where large numbers of sheep from small farm flocks are grazed together. Originally, sheep were grazed on the same pastures during consecutive grazing seasons. This practice suggested that residual pasture infection might be an important factor in parasitic outbreaks which occurred from time to time.

Griffiths (5), and Swales (14), have shown that certain ovine parasites were able to survive overwinter on pastures at Macdonald College, Quebec. Due to the close proximity of the sea Maritime weather conditions may differ somewhat from those encountered in Western Quebec. Experiments were undertaken during 1961 and 1962 to determine what species of ovine parasites survive on the pastures during Maritime winters and the role such overwinter survival might play in the development of parasitic outbreaks during the following grazing season.

Materials and Methods

Experiment 1

In this experiment conducted in 1961, eight Shropshire crossbred lambs were used. The lambs were taken from their dams at birth and given one feeding of colostrum after the dams' udders were thoroughly washed. They were then reared on bottles, using a commercial milk replacer. Good quality hay and dairy ration were fed *ad libitum* from two weeks of age. The pen was thoroughly cleaned three times per week. On June 7th, lambs 10 to 12 weeks of age were placed on a parasite-free pasture at the Animal Pathology Laboratory, Sackville, N.B. One week later, six lambs were taken to the Cape Mabou community pasture, and placed in two paddocks which were erected prior to the 1961 grazing season in the area grazed by sheep in 1960. Paddock A was 4,300 sq. ft. in area, while paddock B was 4,900 sq. ft. Both paddocks were double fenced (6–8 feet apart). The lambs were provided with water and salt lick only.

On August 3, 50 days after exposure, two lambs from paddock A and one lamb from paddock B were killed and examined for parasites. The remaining three lambs were killed on October 3, 111 days after exposure. The controls were examined on June 22 and September 22 which were 16 and 107 days respectively, after being placed on the parasite-free pasture.

All lambs were examined for gastro-intestinal parasites by opening the abomasum and intestines with scissors and passing the washings through a stack of three sieves (Fisher's U.S. Standard Sieve Series No.'s 10, 20 and 40). The parasites were examined, identified and counted, using the method of Swales (13).

Experiment 2

In 1962, 12 crossbred Shropshire lambs were obtained and reared as in 1961, except that diluted canned milk was added to the milk replacer and pelleted commercial calf starter was used instead of dairy ration. These lambs were also placed on a parasite-free pasture for a short period at 10–12 weeks of age. In 1962, lambs

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were placed on the Cape John community pasture as well as the Cape Mabou pasture. The four lambs on the Cape John pasture were taken there on June 4 and placed in a paddock, with an area of 10,000 sq. ft., erected in that part of the pasture used by sheep in 1961.

On June 13, six lambs were taken to the Cape Mabou pasture. Three lambs were again placed in paddock A, while the remaining three were placed in a new paddock (C) with an area of 7,225 sq. ft. and located where sheep had grazed the previous year. As in the 1961 experiment, all paddocks used in 1962 were built and double-fenced prior to the grazing season.

One lamb on the Cape John pasture was killed and examined for parasites 52 days after exposure, one at 80 days and two at 149 days. At the Cape Mabou pasture two lambs from paddock A and one lamb from paddock C were killed and examined for parasites 42 days after exposure, while the remainder were killed 139 days after entering the pasture.

The two control lambs were killed on October 3 which was 126 days after being placed on a parasite-free pasture. Parasitological examinations were carried out as in the 1961 studies.

Observations

(a) *Location of Pastures*

The Cape Mabou community pasture is situated on the western side of Cape Breton Island (Fig. 1) facing the Northumberland Strait. The pasture is at an elevation of 800–900 feet above sea level and inland a distance of approximately two to three miles. The terrain is a rolling, well-drained plateau.

Paddock A was located on a slight slope facing in a south-westerly direction, paddock B was situated in the bottom of a small gully opening toward the north and drained by a brook originating from an open spring, while paddock C was in a flat, exposed area. The paddocks were situated so that water run-off from adjacent areas into the paddocks was unlikely.

The Cape John community pasture

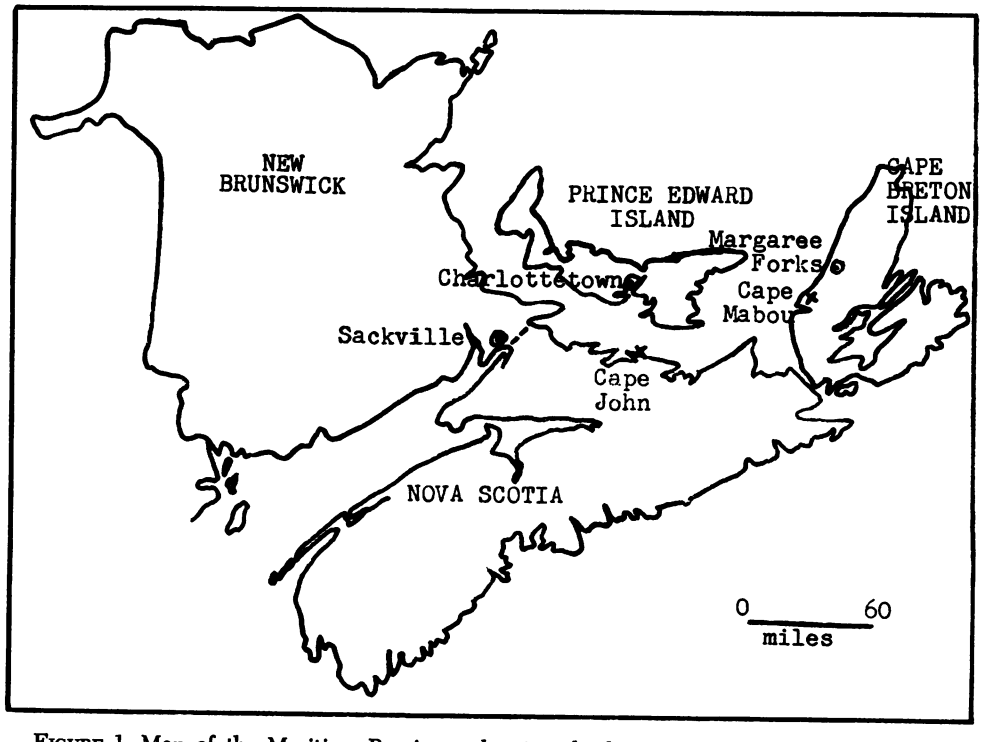

FIGURE 1. Map of the Maritime Provinces showing the location of the community pastures and climatological stations.

(Fig. 1) is situated on a peninsula extending into the Northumberland Strait on the north shore of Nova Scotia. The pasture extends from sea level to an elevation of approximately 100 feet. The paddock at Cape John was located a few hundred yards from the sea in an exposed area.

(b) *Grazing on pastures adjacent to paddocks*

In 1961, the practice of alternating sheep and cattle on different parts of the two community pastures on successive years was instituted. Therefore, with the exception of paddock A during 1962, only cattle grazed the areas adjacent to the paddocks during the trials.

(c) *Soil and Herbage on Pastures*

The soil type, mat covering, and herbage in the pastures and paddocks used in this study are given in Table I.

(d) *Parasites on the Pastures*

During 1960, the gastro-intestinal tracts from 31 ewes and lambs on the Cape Mabou pasture were examined for the presence of parasites. The parasitic species present in the flock were *Haemonchus contortus, Ostertagia circumcincta, O. trifurcata, Telodorsagia davtiani, Trichostrongylus axei, T. colubriformis, T. vitrinus, Nematodirus spathiger, N. filicollis, Bunostomum trigonocephalum, Capillaria spp., Cooperia curticei, C. oncophora, Moniezia expansa, Strongyloides papillosus, Trichuris ovis, Chabertia ovinus, Oesophagostomum columbianum, O. venulosum* and *Dicrocoelium dendriticum*. During 1961, 23 ewes and lambs from Cape Mabou pasture were examined for parasites. The same species were again present, except that no specimens of *Nematodirus filicollis* or *Dicrocoelium dendriticum* were identified. During 1961, eight lambs from the Cape John pasture were examined and the same parasitic species were recovered as on the Cape Mabou pasture.

(e) *Climatic Conditions*

Since it was not possible to record daily weather data on each of the community pastures, the data from the nearest weather stations were obtained. For the Cape Mabou pasture, the nearest weather station was at Margaree Forks, while the weather station at Charlottetown across

TABLE I

THE SOIL, MAT AND HERBAGE ON THE CAPE MABOU AND CAPE JOHN COMMUNITY PASTURES

Paddock	Soil	Sod	Grasses Present	Predominant Grass	Comment
A. Cape Mabou	Thom soil Sandy loam	Thick	Timothy, Bluegrass, Browntop, Wild White Clover	Timothy	1956—seeded (3 tons lime per acre. 600 lbs. fertilizer, #6-12-12, per acre). 1959—400 lbs. fertilizer, #6-12-12, per acre.
B. Cape Mabou	Thom soil Sandy loam	Thick	Bluegrass, Browntop, Wild White Clover	Bluegrass	Unbroken Pasture. 1956—1 ton lime per acre. 600 lbs. fertilizer, #6-12-12, per acre. 1961—400 lbs. fertilizer, #6-12-12, per acre.
C. Cape Mabou	Thom soil Sandy loam	Thick	Timothy, Browntop, Ladino, Wild White Clover	Timothy	1957—seeded (3 tons lime per acre; 600 lbs. fertilizer, #6-12-12, per acre. 1959, 1961 } 400 lbs. fertilizer, #6-12-12, per acre.
Cape John	Nappan soil Sandy loam	Thick	Timothy, Browntop, Wild White Clover, Bluegrass	Browntop	Unbroken Pasture. 1958—500 lbs. fertilizer, #6-12-12, per acre. 1961—600 lbs. fertilizer, #6-12-12, per acre.

the Northumberland Strait was closest to the Cape John pasture (Fig. 1). For comparative purposes, the 1934–62 averages recorded at Sackville, New Brunswick, the geographical centre of the Maritimes, were used. The average monthly temperatures and precipitation recorded at these weather stations for the 1960–61 and 1961–62 winters and the 1961 and 1962 grazing seasons are summarized in Tables II and III.

(f) *Clinical Signs*

In both experiments, the lambs in the paddocks on the community pastures developed scouring. The most common form was a soft, mushy type of feces which developed about 4–6 weeks after the lambs entered the pastures, resulting in extensive soiling about the buttocks and escutcheon. In most instances, the feces returned to a more or less normal consistency within a few weeks' time. Several of the lambs that remained until the latter part of the grazing season again developed scouring which was characterized by a dark color and a fluid consistency. In the control lambs, the feces remained normal.

The lambs on the community pastures remained alert and normal in behavior but they failed to gain and finish properly. They were thin, lean, and at the end of the grazing season were about 30–40 lbs. lighter than the controls despite the fact that adequate grazing was present.

Results

The results of Experiments 1 and 2 are given in Table IV. Thirteen parasitic species were shown to survive overwinter, although all species were not necessarily found in all lambs. *Ostertagia spp.*, *Trichostrongylus spp.* and *Nematodirus spp.* were present in most lambs, frequently in large numbers. *Ostertagia spp.* did not build up excessively large infestations, except in two or three instances. *Trichostrongylus spp.* were not found in large numbers in lambs taken from the pastures early in the season but infestations built up during the course of the grazing season as all lambs left on the pasture until late

TABLE II

Average Monthly Temperatures and Precipitation From November, 1960, to November, 1962, at Margaree Forks, N.S.

Year	Month	Temperature °F			Total Precipitation	Snowfall, in.
		Maximum	Mean	Minimum		
1960	Nov.	46.0	40.0	34.1	4.13	1.9
	Dec.	36.1	29.1	22.1	3.91	14.7
1961	Jan.	25.1	17.6	10.2	6.12	55.4
	Feb.	24.0	14.8	5.6	2.96	10.4
	Mar.	29.7	21.8	13.9	3.61	28.9
	Apr.	40.5	34.8	29.1	1.40	4.9
	May	57.2	47.5	37.8	3.10	1.1
	June	70.4	59.7	49.0	3.36	—
	July	74.5	63.1	51.8	.59	—
	Aug.	76.1	65.0	53.9	1.65	—
	Sept.	71.3	61.2	51.1	1.90	—
	Oct.	59.0	50.6	42.3	4.17	—
	Nov.	48.7	43.2	37.7	5.95	4.3
	Dec.	36.4	32.0	27.7	6.81	19.2
1962	Jan.	30.7	22.4	14.2	4.22	32.7
	Feb.	22.8	12.8	2.9	4.03	30.7
	Mar.	35.3	27.6	19.9	2.83	17.1
	Apr.	45.7	37.6	29.6	4.83	12.9
	May	54.1	44.5	35.0	1.51	3.1
	June	66.3	55.3	44.4	2.43	—
	July	66.2	58.7	51.2	5.57	—
	Aug.	72.6	63.3	54.0	4.25	—
	Sept.	62.9	55.0	47.4	3.04	—
	Oct.	55.5	47.5	39.5	5.90	—

TABLE III

AVERAGE MONTHLY TEMPERATURES AND PRECIPITATION FROM NOVEMBER, 1961, TO NOVEMBER, 1962, AT CHARLOTTETOWN, P.E.I., AND THE 1934–62 MEAN AT SACKVILLE, N.B.

Year	Month	Temperature °F			Total Precipitation	Snowfall, in.
		Maximum	Mean	Minimum		
1961	Nov.	45.7	40.5	35.4	4.08	6.6
	Dec.	33.5	28.6	23.7	4.36	23.8
1962	Jan.	27.7	18.1	8.5	2.14	20.1
	Feb.	18.9	10.6	2.4	3.85	34.6
	Mar.	33.5	27.3	21.1	3.45	30.7
	Apr.	44.5	36.8	29.2	6.39	16.2
	May	54.4	45.4	36.5	1.41	0.9
	June	65.4	56.4	47.5	3.44	—
	July	65.4	58.5	51.7	6.33	—
	Aug.	70.4	63.2	56.0	4.90	—
	Sept.	62.3	55.7	49.2	4.79	—
	Oct.	53.9	47.3	40.7	4.07	—
1934–62 Mean	Jan.	27.3	19.5	11.7	3.29	17.4
	Feb.	28.2	20.2	12.2	2.98	16.6
	Mar.	35.0	27.5	20.1	2.61	13.1
	Apr.	46.4	38.4	30.4	2.78	5.4
	May	58.8	49.1	39.4	3.56	0.1
	June	67.7	57.9	48.1	3.32	—
	July	74.5	63.4	54.2	2.64	—
	Aug.	73.7	64.0	54.3	3.43	—
	Sept.	66.7	56.9	47.1	3.66	—
	Oct.	55.1	46.6	38.2	3.46	0.3
	Nov.	44.2	36.9	29.6	4.51	3.8
	Dec.	31.6	24.1	16.7	3.13	12.6

in the autumn had relatively large numbers of these parasites. Large numbers of *Nematodirus spp.* presumably survived overwinter on the pastures as heavy infections were found in several lambs exposed to the pastures for 42 and 50 days. Large numbers of *Nematodirus spp.* were also recovered from several lambs late in the grazing season. Lambs examined early in the summer also tended to have large numbers of tapeworms, while those examined late in the season had small numbers or none. It is interesting to observe that *Oesophagostomum venulosum* were able to survive overwinter on both the Cape Mabou and Cape John pastures. All lambs on the Cape John pasture had *Oesophagostomum venulosum*, while only two of 12 on the Cape Mabou pasture were infected. *Trichuris ovis* was recovered only from lambs that were exposed to the infected pasture 80 days or longer.

The number of parasites within each genus was recorded but the percentage of each species present was not accurately determined. *Ostertagia circumcincta* was the most prevalent *Ostertagia spp.* present. Within the *Trichostrongylus* genus, *T. colubriformis* and *T. vitrinus* were common. *N. spathiger* accounted for a very high proportion of the *Nematodirus spp.* examined.

DISCUSSION

These trials were carried out to determine what ovine parasites could survive overwinter on pastures in the Maritime provinces and if such residual infection could lead to clinical parasitism during the ensuing grazing season. The work, which was performed over a period of two years, demonstrated that 13 species of parasites did survive on the pastures, although each species was not necessarily recovered from each experimental lamb or even from each experimental paddock. *Haemonchus contortus*, *Bunostomum trigonocephalum*, *Cooperia curticei* and *Oesophagostomum columbianum*, known to be present on the pastures the previous season, were not recovered from the experimental lambs. The results of these trials concur with the findings of Griffiths (5) and Swales (14) at Macdonald College, Quebec, although

TABLE IV

THE NUMBER AND SPECIES OF PARASITES RECOVERED FROM PARASITE-FREE LAMBS AFTER EXPOSURE TO PASTURES GRAZED THE PREVIOUS SEASON BY SHEEP

Experiment No. and year	Lamb No.	Location of Paddock	Paddock	Date put on Infected Pasture Day/Month	Days on Infected Pasture	*Ostertagia circumcincta* *O. trifurcata* *Telodorsagia davtiani*	*Trichostrongylus axei* *T. colubriformis* *T. vitrinus*	*Nematodirus spathiger* *N. filicollis*	*Cooperia oncophora*	*Moniezia expansa*	*Trichuris ovis*	*Chabertia ovinus*	*Oesophagostomum venulosum*	*Strongyloides papillosus*
(1)	12S	Cape Mabou	A	14/6	50	9,150	700	11,125	320	87	0	3	0	0
	19S	" "	A	14/6	50	6,400	710	15,720	210	273	0	0	0	0
1961	30S	" "	B	14/6	50	3,950	150	2,220	60	56	0	1	0	0
	32S	" "	A	14/6	111	4,320	22,300	820	0	0	9	6	1	0
	47S	" "	B	14/6	111	4,640	7,020	12,330	0	0	3	0	0	0
	41S	" "	B	14/6	111	3,780	15,230	0	0	1	3	0	0	0
	37S	Sackville		Control		0	0	0	0	0	0	0	0	0
	25S	"		"		0	0	0	0	0	0	0	0	0
(2)	8T	Cape Mabou	A	13/6	42	6,630	280	19,550	60	220	0	0	0	0
	56T	" "	A	13/6	42	2,050	200	250	0	172	0	2	0	0
1962	4T	" "	C	13/6	42	2,900	0	1,250	30	52	0	0	0	0
	65T	" "	A	13/6	139	1,850	5,130	0	0	0	13	0	0	0
	41T	" "	C	13/6	139	0	6,850	4,630	0	14	96	0	4	0
	54T	" "	C	13/6	139	220	2,270	19,020	0	4	110	0	0	20
	34T	Cape John		4/6	52	1,560	240	1,010	110	38	0	0	6	0
	63T	" "		4/6	80	16,610	430	2,490	70	2	1	1	17	0
	13T	" "		4/6	149	2,170	16,040	22,610	30	2	13	0	737	0
	15T	" "		4/6	149	3,370	7,160	7,310	0	0	7	0	336	0
	52T	Sackville		Control		0	0	0	0	0	0	0	0	30
	20T	"		"		0	0	0	0	0	0	0	0	30

they worked with fewer species of parasites.

These trials also demonstrated that clinical parasitism could result, or could build up from, residual pasture infection. No deaths resulted from the infections, but clinical signs of scouring, unthriftiness and poor gains were evident.

The winter weather conditions recorded in the Maritimes during 1960–61 and 1961–62 do not differ greatly from those recorded at Macdonald College by Griffiths (5) and consequently, great difrences in parasite survival were not encountered. Swales (14) has shown that the presence of snow is very important in the survival of parasites. In the presence of snow, soil temperatures approximate the freezing point; in the absence of snow, soil temperatures fluctuate with air temperatures. In the Maritimes, during 1960–61 and 1961–62, there was well over 100 inches of snowfall, while the 28-year average snowfall at Sackville, the geographical centre of the Maritimes, is about 70 inches. It would appear that in most years, at least, there is plenty of snow to offer protection from the extremes in air temperatures recorded.

In addition to weather, the mat is another factor which offers protection to larvae. It is present in ever-increasing amounts on older pastures. Crofton (3) states that when it is well developed, it holds an almost permanent store of moisture. The presence of moisture and the presence of relatively large pockets of air trapped in the mat and herbage limits the rate of temperature change and ensures that changes in external atmospheric temperatures are only slowly reflected. The soil, mat, and herbage on the community pastures, which are typical of many sheep pastures in the Maritimes, would tend to offer maximum protection to parasites. Several of the pastures had not been broken and seeded for many years, while others had been in sod for five years. The several applications of fertilizer over a period of years would tend to enhance the herbage and mat.

The mat probably played an important role in affording protection to infective larvae during the 1961 grazing season. During July, August, and September of that season the precipitation was considerably less, and the temperatures higher, than those of 1962 and, indeed, of the Maritime averages; yet the species and numbers of parasites which were recovered from the lambs did not differ appreciably from those recorded in 1962.

The finding of large numbers of *Nematodirus spathiger* and *N. filicollis* in lambs on pasture only six and seven weeks is an indication that a large residual infection was present. The *Nematodirus spp.* are characterized by the fact that the first, second, and third-stage larvae occur within the egg, which enables these species to resist freezing and desiccation (3, 7). Actually, conditioning of the eggs by freezing is one of the main ecological factors in the life history of *N. filicollis* (3). On the other hand, *N. spathiger* eggs hatch readily and several generations can occur in one year (3). Under favorable conditions only four to four and one-half weeks are necessary for the completion of the life cycle. It is possible that some of the *N. spathiger* recovered in the first lambs examined were second generation forms, but since the *Nematodirus spp.* are poor egg producers, it is likely the majority of parasites recovered were the result of residual infection.

In a few of the lambs killed late in the pasture season, large numbers of *Nematodirus spp.* were recovered. This undoubtedly was the result of self-augmentation since *N. spathiger* was the most common species observed in these studies.

Ostertagia spp. are another group of parasites which have been observed by many workers to be resistant to prolonged exposure to temperatures below freezing (3). Kates (6) has grouped *Ostertagia spp.* and *Nematodirus spp.* as being forms most resistant to climatic changes. This ability to resist adverse weather conditions ensures a heavy residual infection by these species and also accounts for the large numbers of these species observed in the lambs examined early in the season. The number of *Ostertagia spp.* found in lambs at the end of the grazing season, in most instances, was less than that recovered in the early lambs. Michel (8), studying the changes in the worm burden in calves receiving daily doses of infective larvae of *Ostertagia ostertagi*, has demonstrated, among other things, that a constant loss

of adult worms occurs at a rate depending on the number present and that a resistance to the establishment of newly acquired worms begins to operate after prolonged exposure to infection. Similar phenomena in lambs would explain the failure to observe a build-up of *Ostertagia spp.* in these experiments.

As reported earlier, *Ostertagia circumcincta* is the most common species in Maritime sheep (10). Why *Ostertagia trifurcata* and *Telodorsagia davtiani* should be present, but in relatively small numbers compared to *O. circumcincta*, is unexplained. Crofton (3) notes that *O. trifurcata* is found frequently in sheep in all parts of the world but it has never been recorded as being present in large numbers.

The findings of this study indicate that relatively small numbers of the three *Trichostrongylus spp.* commonly found in sheep, *T. axei*, *T. colubriformis* and *T. vitrinus*, did survive overwinter. In all lambs examined during the first 80 days on pasture, very small numbers of *Trichostrongylus spp.* were recovered. It is obvious, however, that the *Trichostrongylus spp.* were able to build up during the grazing season, as clincal trichostrongylosis developed in several lambs late in the season. Campbell (2) has previously pointed out that clinical trichostrongylosis is common in Canada in the autumn when moderate temperatures and significant rainfalls occur, permitting a massive hatching of latent embryonated *Trichostrongylus spp.* eggs.

Trichuris ovis has no free-living larvae. The host is infected by swallowing the egg in which the first-stage larvae has developed (3). While detailed studies on this species have not been made, all available evidence indicates this species can survive low temperatures (3). The findings in the present trials show that this species did survive overwinter on the pastures in the Maritimes. The prepatent period of this species in sheep has been reported to be from seven to 12 weeks (3). This would tend to explain why adult *Trichuris ovis* were not recovered in any lamb examined with 52 or less days of exposure on the infective pasture while all lambs exposed for 80 or more days were infected.

Chabertia ovina were shown to survive overwinter on Maritime pastures, although only 6 of 16 lambs exposed to the infective pastures were found to be infected. It is not known whether the small number of *Chabertia spp.* recovered was due to a very low survival rate or to a light original infection on the pastures. The latter is suspected, as the number of *Chabertia spp.* recovered from sheep on the community pastures is relatively low.

Oesophagostomum columbianum did not survive overwinter on pastures in the Maritimes. This finding concurs with that of Swales in western Quebec (14). On the other hand, *O. venulosum* did survive overwinter on both community pastures, although the infection was much greater on the Cape John pasture. There appears to be some evidence that *O. venulosum* may be slightly less sensitive to cold conditions than *O. columbianum* (3). This is substantiated by these trials.

The *Oesophagostomum spp.* are very susceptible to desiccation. It has been reported that nodular disease is only serious in areas with summer rainfall of 20 inches or more (3). It would appear that the Maritimes are ideal for oesophagostomiasis, as the average summer rainfall is approximately 20 inches and in wet seasons considerably higher. This fact, coupled with the generation time of 35 days for *O. venulosum*, readily accounts for the large build-up of *O. venulosum* which occurred on the Cape John pasture during 1962. Previous work has indicated that heavy infestations with *O. columbianum* also occur in lambs in the Maritimes (11), but the survival of this species apparently depends upon the ability of its larvae to invade the intestinal mucosa and remain there for long periods enclosed in nodules formed by the host's tissues.

As reported earlier, *Cooperia oncophora* do survive Maritime winters on pastures (12). Small numbers were recovered in the early lambs, while those that remained on the pastures for the entire grazing season usually did not harbor this parasite. This is consistent with the previous suggestion that a rapid build-up of resistance to *C. oncophora* occurs in lambs, resulting in a marked reduction or throw-off of parasites (12). *Cooperia curticei* were not recovered from these same lambs,

suggesting that this species does not survive overwinter. Kates (6) and others (3) have concluded that *C. curticei* is essentially a warm climate species, with a survival pattern similar to that of *Haemonchus contortus*. It would appear, therefore, that *Cooperia oncophora* and *C. curticei* differ in their ability to withstand adverse climatic conditions.

Haemonchus contortus is another species which cannot survive freezing and winter conditions. The conditions under which this species will survive and haemonchiasis occur have been fairly well delineated (3). As previously determined by Swales (14), *H. contortus* was again shown not to survive Canadian winters.

While *H. contortus* are recovered from animals on the community pastures, outbreaks of haemonchiasis have not been observed. This would appear to be generally true throughout the Maritimes, as the authors have only occasionaly encountered haemonchiasis in their work. The outbreaks that are seen, frequently occur in ewes in late spring and early summer. Gibbs (4) has commented on this type of haemonchiasis in breeding ewes at Macdonald College, Quebec.

Gordon's co-ordinates for the limits of haemonchiasis are a mean monthly temperature of 18° C. (64.4° F.) and a mean monthly rainfall of two inches (3). It would appear that adequate precipitation generally occurs in the Maritimes for haemonchiasis but the mean monthly temperatures are normally below those under which the disease might be expected to occur. In August, 1961, when the mean temperature was high enough for haemonchiasis to occur, a relatively low rainfall was recorded. The weather probably explains why haemonchiasis appears to occur only sporadically in the Maritimes. In an exceptionally warm, wet summer, it seems probable that a greater number of *H. contortus* outbreaks might occur in the Maritimes than otherwise seems to be the case.

Bunostomum trigonocephalum is another species which was known to be present on the pastures and which failed to survive overwinter on the pastures. Various workers have reported that this species does not survive overwinter (3, 5, 14).

The tapeworm, *Moniezia expansa*, remained on the pastures overwinter and was recovered in large numbers in early lambs, while only a few were observed in those lambs examined late in the season. Griffiths (5) had previously observed that this species survived at Macdonald College.

It should be pointed out that the only parasite recovered from the control lambs was *Strongyloides papillosus*. Griffiths (5) found that it was practically impossible to raise lambs free of this parasite. The absence of all other species except *S. papillosus* suggests that the parasites picked up by the experimental lambs originated on the pastures. Furthermore, all paddocks were constructed in the early spring prior to the entry of livestock onto the pastures, so that accidental contamination was not possible. The double fence was erected to prevent the lateral migration of parasites from adjacent pastures into the paddocks and, secondly, to insure that the experimental lambs could not escape. With the exception of paddock A, during 1962, only cattle grazed in adjacent pastures during these trials. This, in effect, further isolated the experimental lambs from possible contact with infected sheep.

The lambs in these trials were kept under a set-stocking type of pasture management, (i.e., they remained in the same paddock or area throughout the grazing season). It might be argued that this would predispose to a greater pick-up of infective larvae than might occur if the lambs were with a large flock in a greater grazing area. Crofton (3) has studied behavior and grazing habits of sheep. He reported that a flock tends to avoid fresh feces or is attracted to areas where there are ageing pellets. In England, an area is usually regrazed by a flock as a whole every five to ten days and this compares closely to the time necessary for the development of the infective stages of many trichostrongyles. The fact that the experimental lambs were confined to adequate but small areas might not necessarily dictate that they would become more heavily parasitized than if they were with a flock grazing a larger area. Furthermore, during the latter half of the grazing season, the number of lambs in each paddock was reduced by one to two animals.

Whitlock (14) has shown that under

field conditions one of the most important predisposing factors to outbreaks of trichostrongylidosis in young animals is a deficient milk supply. Since the experimental lambs were weaned animals, it is quite probable that greater numbers of parasites were recovered than might be expected in suckling lambs. However, in most flocks, there are a few ewes with an obviously diminished milk flow for one reason or another, whose lambs might be expected to be as susceptible to parasitism as weaned lambs. Since the present trials did demonstrate residual infection on Maritime pastures and the build-up of several species in weaned lambs, it seems reasonable to believe that parasitism would occur in some lambs, at least, of flocks kept under similar pasture management.

The Nova Scotia community pastures proved to be very suitable for these studies. Firstly, because sheep and lambs originate in many small farm flocks, the likelihood existed that most of the ovine parasites indigenous to the Maritimes were present on the pastures. Secondly, it was possible to study the overwinter survival of parasites in different regions under different local conditions.

The Cape Mabou pasture was located on a rolling plateau which is typical of many Cape Breton and Eastern Nova Scotia pastures, while the Cape John pasture is typical of many coastal farms. The experimental paddocks were located so as to give as great a sampling as possible of conditions existing on the pastures. Such factors as exposure (to sunlight and wind), drainage, type of sod and mat, type of vegetation, etc., were considered.

The weather data were obtained from the climatological stations nearest to the pastures under study. While these data do not necessarily give the actual weather existing on the pastures, they do reflect the weather prevailing in the region.

As pointed out earlier, weather conditions often determine whether a parasite will survive or build up on pastures. Therefore, the epidemiology of parasitism in a region is governed to a large extent by the climate. In Montana, for example, where high temperatures and low precipitation occur, survival and build up of parasites appears to be minimal (9). In the Maritimes, on the other hand, where more moderate temperatures and greater precipitation prevail, residual infection is much more important. *Nematodirus spp.* and *Ostertagia spp.* do survive in large numbers, giving rise to initial large infections, while *Trichostrongylus spp.* and *Oesophagostomum venulosum* are able to build up to clinical proportions during a single grazing season, at least under the conditions of these experiments.

Summary

Thirteen ovine parasitic species were shown to survive overwinter on pastures in the Maritime area. These included *Ostertagia circumcincta, O. trifurcata, Telodorsagia davtiani, Trichostrongylus axei, T. colubriformis, T. vitrinus, Nematodirus spathiger, N. filicollis, Cooperia oncophora, Trichuris ovis, Chabertia ovinus, Oesophagostomum venulosum* and *Moniezia expansa.*

Haemonchus contortus, Cooperia curticei, Bunostomum trigonocephalum and *Oesophagostomum columbianum,* four species present in Maritime sheep, were not demonstrated to survive overwinter on pastures under Maritime climatic conditions.

It was demonstrated that *Ostertagia spp.* and *Nematoridus spp.* species survived in numbers sufficient to give rise to large initial infections. While only a small percentage of *Trichostrongylus spp.* and *Oesophagostomum venulosum* appeared to survive, it was demonstrated that large infestations of these species could build up during a single grazing season under Maritime summer climatic conditions and set-stocking type of pasture management.

Residual pasture infection was shown to be an important factor in the epidemiology of ovine parasitism in the Maritimes.

Résumé

Il fut démontré que dans la région des Maritimes treize espèces de parasites attaquant le mouton survivent à l'hiver dans les pâturages. Parmi ceux-ci on retrouve les *Ostertagia circumcincta, O. trifurcata, Telodorsagia davtiani, Trichostrongylus axei, T. Colubriformis, T. Vitrinus, Nematodirus spathiger, N. Filicollis, Cooperia oncophora, Trichuris ovis, Chabertia ovinus, Oesophagostomum venulosum* et *Moniezia expansa.*

Dans les conditions climatiques de la région, il ne fut pas établi que quatre espèces présentes chez le mouton des Maritimes: *Haemonchus contortus, Cooperia curticei, Bunostomum trigonocephalum* et *Oesophagostomum columbianum*, survivaient à l'hiver dans les pâturages.

On a découvert que les espèces *Ostertagia spp.* et *Nematoridus spp.* survivent en nombre suffisant pour causer de nombreuses infections initiales. Même si un faible pourcentage de *Trichostrongylus spp.* et *Oesophagostomum venulosum* semble survivre, on s'est rendu compte que de fortes infestations de ces espèces peuvent avoir lieu durant une seule saison de paissance dans les conditions climatiques d'été, sur les pacages à taux fixes.

On conclut que la contamination résiduelle des pacages est un important facteur de l'épidémiologie des parasites ovins dans les Maritimes.

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