EXPERIMENTAL HELMINTHIASIS IN PARASITE-FREE CALVES ON MARSHLAND PASTURES

H. J. Smith* and R. McG. Archibald*

Introduction

Parasitic gastroenteritis of cattle has not been studied extensively in Canada. In 1956, Johnston and MacPherson (9) reported on hemonchiasis and ostertagiasis in a herd in the Ottawa Valley. Campbell *et al.* (3) in 1960, observed nematodiriasis in calves in Western Ontario. In 1957, McGregor and Kingscote (11), basing their conclusions on fecal examinations only, demonstrated that 21.3% of cattle on farms throughout Ontario were infected with gastrointestinal helminths.

In recent years, gastrointestinal parasitism, which causes unthriftiness, has been recognized as a problem in cattle in the Maritime area (5). The condition is seen more frequently on reclaimed marshland and other low-lying pastures. Calves and yearlings are usually affected more severely than adults and often remain unthrifty for prolonged periods. Since 1960, the authors have investigated a number of parasitic outbreaks in cattle in the Maritimes and, on several occasions, animals with typical clinical histories and signs of parasitism were necropsied. Few parasites were, however, recovered.

In 1962, the present study was initiated to obtain information on the epizootiology of parasitic gastroenteritis in cattle, and to determine if helminthiasis was associated with the unthriftiness observed in young grazing cattle, particularly those on marshland pastures. The results, which are presented in this paper, were obtained during the 1962 and 1963 grazing seasons, and are considered in relation to the climatic conditions prevailing at that time.

Materials and Methods

1962 Experiment

Eleven grade Holstein bull calves, one to three days of age, were purchased in mid-March at a sales barn. They were kept in one large pen with a concrete floor and were bedded with dry wood shavings. The pen was thoroughly cleaned every second day. The calves were fed a commercial milk replacer, and calf starter pellets *ad libitum*. Beginning at three to four weeks of age, the calves were also given good quality hay.

On June 8, all calves, with the exception of one control animal, were placed in a paddock on a reclaimed salt marsh pasture on which cattle had been grazed for 13 successive pasture seasons and had failed to thrive. The paddock was slightly less than an acre in area and was double-fenced (6 to 8 feet apart) to minimize contact or spread of parasites from the rest of the pasture. The pasture herbage was a mixture of native grasses, timothy, couchgrass and *Agrostis* spp., which produced a very thick sod or mat. Initially, the calves were permitted to graze closely. Beginning six weeks after being placed on pasture the calves were supplemented with approximately 1½ lb. calf starter pellets per calf daily. The control calf was placed in a parasite-free pasture and fed similarly during the trial.

All calves were weighed before being placed on pasture and again at death or slaughter. Fecal samples were taken prior to, and at 14 day intervals during the grazing season, except in the third week when random samples were checked daily to determine when the first helminth eggs were being shed. Until eggs began to appear in the feces, all fecal examinations were performed by a simple flotation method, using super-saturated sodium nitrate as the flotation solution. Subsequent examinations were performed by the McMaster technique.

All calves either died on pasture or were killed at various times during the grazing season. At necropsy, they were observed carefully for gross pathological changes and lesions. The gastrointestinal

*Animal Pathology Division, Health of Animals Branch, Canada Department of Agriculture, Atlantic Area Branch Laboratory, P.O. Box 1410, Sackville, New Brunswick.

tracts were opened, washed, and parasites recovered by passing the washings through a stack of three sieves.[1] The parasites were examined, identified and counted, using Swales' method (21). The tracts were then placed in plastic bags and stored at −8° C. for later pepsin digestion of the mucosa and submucosa to recover adherent and embedded worms and histotropic larvae. The digestion technique was similar to that described by Parnell (14). The digested material was washed through sieves.[2] A one-tenth sample of the washings from each sieve was examined for the number and species of parasites present.

1963 Experiment

Fourteen grade Holstein bull calves were obtained in mid-February and reared in the same manner as those in the 1962 studies. On June 21, 13 of the calves were placed in the 1962 paddock which had been enlarged to an area of approximately three acres. The control calf was placed in a parasite-free pasture. Neither control nor experimental calves were given any supplemental feed.

The calves were weighed and fecal examinations made at weekly intervals during the grazing season; the last weighing was October 23. Beginning 14 days after the calves entered the infected pasture and continuing for the next ten days, daily fecal examinations were carried out on all animals. As in the 1962 experiment, fecal examinations were performed by the simple flotation method until helminth eggs were found in the feces. The McMaster technique was then used.

At necropsy, examinations as described for the 1962 experiment, were made. The 1963 experiment differed from the previous year's study in that six of the surviving calves were allowed to graze until late in the grazing season.

Calves 4, 5, 7, 8, 9 and 10 in the 1962 experiment, and calves 6 and 7 in the 1963 experiment, were treated with varying dosages of thibenzole[3] three or four days before slaughter. The total numbers of parasites recovered from these animals are the sums of those recovered in the feces after treatment and those found in the gastrointestinal tract after slaughter. The results of the drug trials are not included in this report.

[1]Fisher's U.S. Standard Sieve Series Nos. 10, 20 and 40.

[2]Fisher's U.S. Standard Sieve Series Nos. 65 and 100.

[3]Thiabendazole, Merck, Sharp and Dohme, Montreal, Quebec.

Observations and Results

(a) Clinical Signs

Gradually, over a period of several weeks on the infected pasture, the calves became listless, lethargic and unthrifty. In appearance, they were rough-coated, dull, dejected and "pot-bellied". They retained their appetites, however, and continued to graze, except for morbid animals, which ceased grazing a day or two before death. Diarrhea developed in most of the calves about three weeks after they entered the infected pasture; that is, at a time coinciding with the passing of eggs in the feces. This intermittent diarrhea continued during the period of greatest parasite burden, as judged by high counts of eggs and worms. Surviving calves remained unthrifty, even though they had presumably shed most of their parasites since worm counts were low.

In 1962, the first death occurred 47 days after exposure to the infected pasture, while in 1963 the first death occurred on the 29th day. Four of the ten calves in the 1962 experiment died on pasture, while two of 13 died during the 1963 grazing season. In 1963, however, three of the calves killed were in a moribund state. In 1963, a few calves developed clinical coccidiosis concurrently with the helminth parasitism. The clinical signs in these animals were more severe.

(b) Gross Pathology

All parasitized calves were very thin; the more severely affected animals had little or no fat in the fat depots. Abomasitis was present but not marked in most animals. The characteristic abomasal lesions were small, whitish, slightly raised papules or foci, sometimes accompanied by a few hemorrhagic areas. In severely affected calves, the small intestines contained an excessive amount of mucus.

(c) Weight Gains

Weight gains or losses for both control and parasitized calves in the 1962 and

1963 experiments are given in Table I. From the weekly weighings in 1963, it was observed that some of the calves on the infected pasture began to lose weight by the end of the second week; all had lost weight by the end of the third week. In surviving calves, the greatest gains occurred from eight to ten weeks after exposure to the end of the grazing season. None, however, gained as much weight for the respective periods as the control calves.

TABLE I

BODY WEIGHT GAINS OR LOSSES OF PARASITIZED AND CONTROL CALVES BEFORE AND DURING THE GRAZING SEASON

Experiment	Calf	Days on pasture	Rate of gain before entering infected pasture (lb./day)*	Rate of gain or loss on pasture (lb./day)
1962			April 27 to June 6	June 6 to last weighing
	1	47	1.50	+0.14
	2	63	0.72	+0.12
	3	76	1.22	+0.11
	4	84	1.27	+0.50
	5	84	1.42	+0.15
	6	89	0.47	−0.05
	7	96	2.00	−0.04
	8	98	0.65	+0.33
	9	105	2.42	+0.22
	10	112	2.17	+0.32
	11 (Control)	96	1.25	+2.42
1963			May 1 to June 19	June 19 to last weighing
	1	29	1.65	−1.14
	2	33	2.30	−1.62
	3	47	1.98	−1.33
	4	48	2.12	+0.08
	5	48	1.70	+0.12
	6	56	1.70	+0.11
	7	56	2.48	+0.37
	8	75	2.14	−0.83
	9	131	1.88	+0.37
	10	137	2.04	+0.59
	11	137	1.72	+0.64
	12	143	1.88	+0.40
	13	143	2.18	+0.07
	14 (Control)	122	2.28	+1.42

*In both experiments, calves weighed two days before entering infected pastures.

(d) Fecal Egg Counts

The dates of examination and the number of eggs per gram (e.p.g.) at each examination for the 1962 and 1963 studies are given in Tables II and III, respectively. Unless otherwise specified, eggs were those of the *Cooperia* and *Ostertagia* groups. In 1962, the first egg was recovered on the 17th day after the calves were exposed to the infective pasture. In 1963, eggs were recovered in one calf on the 16th day after exposure. On the 20th day after exposure, all the calves were passing a few helminth eggs. The first *Nematodirus* egg was observed on the 20th day post-exposure. On the 22nd day, all the calves were passing a few *Nematodirus* eggs. The egg counts generally increased until a peak was reached about 6 to 8 weeks after exposure, after which the numbers began to drop off rapidly in many animals. At the end of 12 to 14 weeks, egg counts were low for all animals. Egg production of *Nematodirus helvetianus* was low, with a maximum of 250 e.p.g. being recorded. Eggs were never recovered from either of the control calves.

(e) Parasite Burdens

The total number and species of parasites recovered from each animal are given in Table IV. The three most common parasites found in these studies were *Ostertagia ostertagi*, *Cooperia oncophora* and *Nematodirus helvetianus*. *Oesophagostomum radiatum*, *Chabertia ovina*, *Trichuris ovis*, *Moniezia benedeni* and *capillaria* spp. were also present but in relatively small numbers. In the 1962 experiment, relatively large numbers of *O. ostertagi* were recovered from some calves. In 1963, the same was true for *N. helvetianus*.

During the 1962 study, there was a marked reduction in the number of *C. oncophora* and *N. helvetianus* recovered from several calves examined towards the end of the grazing season. This phenomenon was again observed in 1963 in all calves, except one, which were kept to the end of the season. In the latter year, the eight calves examined from four to 10 weeks after exposure to the marshland pasture had approximately 27,000 *C. oncophora* and 7,500 *N. helvetianus*. With the exception of one calf, those remaining on the same pasture for 16 to 20 weeks after exposure had an average of less than 7,000 *C. oncophora* and no *N. helvetianus*. In this one exception, 30 to 40%

TABLE II

EGG COUNTS* ON FECAL SAMPLES TAKEN FROM CALVES AT FORTNIGHTLY INTERVALS DURING THE 1962 EXPERIMENT

	Dates examined									
Calf	28/5	8/6	25/6	4/7	18/7	1/8	15/8	29/8	12/9	26/9
1	0		0	650	2800					
2	0		0	2450	1050	6550				
3	0		0	200	750	1550	4900			
4	0		0	100	1400	3350	2850	2650 50N†		
5	0		50	2150	3550	6750	1700	1200		
6	0		0	250	2500	5600	6300 50N	1650		
7	0		0	1400	5450	2750 50N	9050	250	1350	
8	0		0	150	1250	2450	2600 50N	1550 100N	450 50T‡	
9	0		0	400	1050	4000 50N	1400	200	150	
10	0		0	50	450	7150	1100	350	200	0 50T
11 (Control)	0		0	0	0	0	0	0	0	0

Animals placed on pasture

*Eggs per gram of feces.
†Nematodirus.
‡Trichuris.

of the 50,500 *C. oncophora* and all of the 1,020 *N. helvetianus* were immature.

In most instances, digestion of the mucosa and sub-mucosa resulted in the recovery of a few hundred to several thousand additional larvae and adult parasites, depending upon the size of the parasitic burden. This was particularly so in the severely affected animals which had excessive mucus in the intestinal lumen.

(f) Climatic Conditions

The mean monthly precipitation and temperatures recorded at Sackville during the 1961–62 and 1962–63 winters, and the 1962 and 1963 grazing seasons, are given along with the 1934–61 averages (Figure 1). The total precipitation at Sackville was relatively high both in 1961–62 and 1962–63; 51.39 and 47.69 inches respectively, as compared with an average of 39.37 inches for the 1934–61 period. The total snowfall, on the other hand, was somewhat lower than average during the winter of 1961–62 and much higher than average in the winter of 1962–63; 62.0 and 98.0 inches, respectively, as compared with the average 69.3 inches. During the early part of both winters the amounts of snow were lower than the average, but the total precipitation was about the same or a little above average. During the latter part of each winter, a greater than normal snowfall was recorded. The rainfall was above average during the mid-summer months of 1962, which is reflected in the lower than normal mean temperatures during this period. The climatic conditions during the summer of 1963 were normal for the area.

DISCUSSION

The infections which developed in the experimental calves appeared to be typical of many outbreaks which have been observed in the Maritimes in that they were mixed parasitic infections. Large numbers of *O. ostertagi*, *C. oncophora* and *N. helvetianus* were recovered from most of the calves. These three species are also common in clinical outbreaks in the Maritimes (19).

The onset of signs in the experimental calves was insidious, which is characteristic of helminth parasitism. The calves gradually became unthrifty, listless, lost weight, and developed diarrhea after a few weeks on the infected pasture. These signs are typical for *Cooperia* spp. infections in calves (1, 4). It was interesting to note that clinical coccidiosis with acute

TABLE III

EGG COUNTS* ON FECAL SAMPLES TAKEN FROM CALVES AT WEEKLY INTERVALS DURING THE 1963 EXPERIMENT

		Dates examined																
Calf	21/6	3/7	10/7†	17/7	24/7	31/7	7/8	14/8	21/8	28/8	4/9	11/9	18/9	25/9	2/10	9/10	16/10	23/10	30/10
1	Calves put on infected pasture	0	+	900 50N‡	2650														
2		0	+	2600 50N	6000 50N														
3		0	+	1500	3250 50N	2650 50N	3500												
4		0	+	2100	2900	850 50N	500												
5		0	+	650	1600 100N	3450 250N	1850 50N												
6		0	+	2100	1250	1950	1000	1100											
7		0	+	800	1400	1700	1400	900											
8		0	0	1650	2550	1000 50N	1400 50N	1700 200N	50	3000 50N	1800								
9		0	+	500	1950 50N	7600 100N	1850	2150 100N	3350 150N	2350 150N	1650 250N	2900	1850	850	350	1000	50	100	650 50T§
10		0	0	950	950 50N	1800 100N	1500 50N	1050	1500	200	100	350	0	0	50	100	0	50	50
11		0	+	500	2500	1900 50N	1250	700	2000	200	1250	1100	1250	50	50	0	100	50	50
12		0	+	1550	2400	2350 50N	1200	350	1150	1350	800	750	1250	300	150	50	50	0	0
13		0	+	600	1200 50N	1200 50N	1150	900	1000 50N	650 50N	350	1250	850	1600	100	150	50	150 50T	0
14 (Control)		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

*Eggs per gram of feces.
†All samples on this date examined by simple flotation method.
‡Nematodirus.
§Trichuris.

TABLE IV

THE TOTAL NUMBER AND SPECIES OF PARASITES RECOVERED FROM CALVES AFTER GRAZING ON MARSHLAND PASTURES IN 1962 AND 1963

Experiment	Calf	Notes	Days on infected marshland pasture	Date examined	*Ostertagia ostertagi*	*Cooperia oncophora*	*Nematodirus helvetianus*	*Moniezia benedeni*	*Chabertia ovina*	*Trichuris ovis*	*Capillaria spp.*	*Oesophagostomum radiatum*
1962	1	(1)	47	July 25	4,680	16,690	70	0	0	0	0	0
	2	(1)	63	Aug. 10	5,870	65,740	530	1	0	0	0	0
	3	(1)	74	Aug. 23	3,400	28,710	460	0	0	0	0	0
	4	(2, 3)	82	Aug. 31	1,130	37,540	630	1	0	5	0	19
	5	(2, 3)	82	Aug. 31	1,400	39,450	70	0	0	2	0	0
	6	(1)	87	Sept. 5	15,050	131,100	860	0	1	2	0	0
	7	(2, 3)	94	Sept. 12	2,090	35,600	100	0	8	6	30	87
	8	(2, 3)	96	Sept. 14	3,120	3,720	0	0	1	6	10	1
	9	(2, 3)	103	Sept. 21	1,570	4,110	20	1	0	15	20	17
	10	(2, 3)	110	Sept. 28	10,560	2,240	60	0	2	11	30	7
	11 (Control)	(2)	0	Oct. 3	0	0	0	0	0	0	0	0
1963	1	(1, 4)	29	July 20	330	13,680	1,340	0	0	0	0	0
	2	(1, 4)	33	July 24	510	24,950	7,980	0	0	0	0	0
	3	(2, 4, 5)	47	Aug. 7	1,460	32,930	15,090	0	0	0	0	0
	4	(2)	48	Aug. 8	800	34,800	110	0	0	0	0	0
	5	(2)	48	Aug. 8	420	37,990	20,780	1	0	0	0	0
	6	(2, 3)	56	Aug. 16	460	14,840	500	0	0	0	0	0
	7	(2, 3)	56	Aug. 16	130	9,120	1,320	0	0	0	0	0
	8	(2, 5)	75	Sept. 4	1,490	47,900	12,620	2	0	1	0	0
	9	(2, 5)	131	Oct. 31	7,700	15,830	0	0	1	9	0	0
	10	(2)	137	Nov. 6	2,560	4,460	0	0	1	32	0	0
	11	(2)	137	Nov. 6	1,800	400	0	1	0	10	10	0
	12	(2)	143	Nov. 12	2,080	6,530	0	0	0	18	0	0
	13	(2, 6)	143	Nov. 12	2,940	50,500	1,020	2	1	20	0	0
	14 (Control)	(2)	0	Oct. 21	0	0	0	0	0	0	0	0

1—Died.
2—Killed.
3—Treated with thiabendazole.
4—Clinical coccidiosis present.
5—Moribund when killed.
6—30–40% of *C. oncophora* and 100% of *N. helvetianus* were immature.

symptoms developed in a few parasitized calves in the 1963 experiment. Davis *et al.* (4) have also observed that coccidial infections superimposed on *Cooperia* spp. infections result in more marked clinical signs of parasitism. In this experiment, although the calves were provided with water, it was surmised that they drank from several shallow ditches which filled up during a period of heavy rains.

In the 1962 experiment, the calves kept for three months or longer after initial exposure to the infected pasture harboured appreciably fewer *C. oncophora* and *N. helvetianus* than those necropsied earlier; they also had lower egg counts. The clinical signs and fecal egg counts indicated that both groups of calves had suffered from comparable infections earlier in the season. There seems little doubt, therefore, that a rapid build-up of resistance and shedding of the parasitic burden had occurred for both of these nematode species (e.g. Mayhew *et al.* (10) have reported that with *C. punctata*, the first indication of immunity is a rapid fall in egg counts).

In the 1963 experiment, a marked

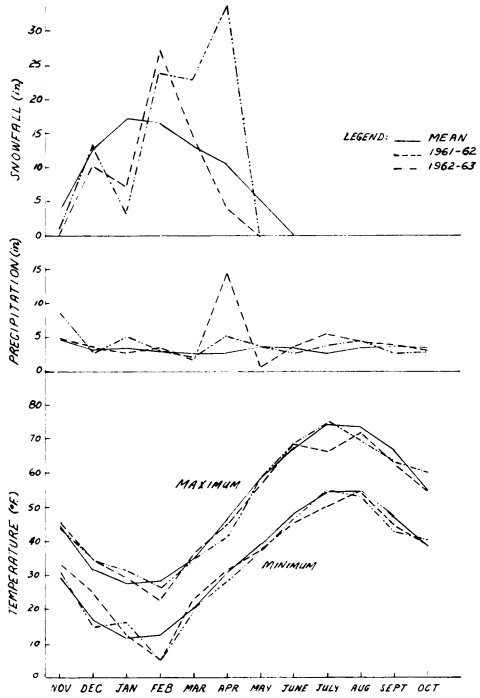

FIGURE 1. Graphs showing the mean monthly temperatures and precipitation recorded at Sackville during the 1961–62 and 1962–63 winters, the 1962 and 1963 grazing seasons and the 1934–61 averages. (Data for April, 1963, not available; data recorded at Nappan, N.S., used.)

reduction in the number of *C. oncophora* and a complete shedding of *N. helvetianus* in all calves kept until late in the grazing season was again observed, with the exception of one animal. Clinical signs, weight gains and fecal egg counts indicated that this calf had suffered from a patent infection earlier in the summer. Presumably, the animal was losing its resistance because a relatively high percentage of its *Cooperia* spp. burden and all of the *Nematodirus* spp. parasites were immature, indicating re-infection. Roberts *et al.* (15) have noted that resistance against *Cooperia* spp. occurs at a much earlier age than against other species. Once established, they observed relatively few instances of this resistance breaking down later. This may explain Becklund's (2) observation that *Cooperia* spp. were largely parasites of calves, while *O. ostertagi* predominated in the worm populations of older cattle.

The authors' findings also indicate that resistance against *N. helvetianus* develops in calves at an early age. Four out of five calves appeared to have a total resistance to re-infection.

A relatively rapid development of resistance to *Cooperia* spp. and *Nematodirus* spp. as demonstrated in these cattle, probably accounts for the authors' earlier observations that on several occasions investigation of field cases with typical histories and signs of parasitism revealed relatively few gastrointestinal parasites. If the parasitic infections were of long standing, the animals probably had shed most of their parasitic burdens by the time they were examined.

From the gross pathological and parasitological findings, the *Ostertagia* spp. infections recorded here were not as heavy as those seen in clinical outbreaks in the Maritimes. The only lesions observed were small grayish-white raised plaques, usually accompanied by erythematous zones similar to those described for single *Ostertagia* spp. infections (13). Ross (16) has observed that the severity of the lesions is primarily dependent on a challenge superimposed on a previous experience of infection, and is also influenced by the size of the larval dose. A high larval challenge is necessary to produce a marked abomasitis, while a previous experience of infection is essential to produce the very severe inflammatory changes with edema, thickening of the abomasal folds, and the wrinkled appearance of the fundic mucosa that is seen in severe outbreaks.

Resistance to *O. ostertagi* has been reported to be slow in developing (12, 15, 17) and only develops after prolonged exposure (12, 18). This appeared to be the case in these experiments, as the calves kept until late in the grazing seasons generally had more *O. ostertagi* than those examined earlier. The rate of ingestion of infective larvae on the pasture, however, was apparently not great enough to initiate the development of the severe form of ostertagiasis. Although previous experience with infection and high larval challenge is necessary to produce severe inflammatory changes in the abomasum, this period of susceptibility is limited and a continued low level of field challenge may be sufficient to enhance resistance

and to prevent development of the severe lesions (17).

In retrospect, the infections established in the experimental calves were mixed infections and all the species present possibly contributed to the debility and unthriftiness observed. Since *C. oncophora* were consistently found to be predominant and the signs observed were typical for *Cooperia* spp. infections (1, 4), it would seem reasonable to suspect that this species was of primary importance in the disease syndrome that developed. Therefore, based on the results of these experiments and other studies in the Maritimes (19), *C. oncophora* would appear to be a very important parasite in the Maritime area of Canada. While it was not the principal parasite in these experiments, *O. ostertagi* has also been responsible for many parasitic outbreaks in this area.

The role of *N. helvetianus* in these experimental infections is not clear, but the numbers present in several of the 1963 calves would suggest that this species may also be important in the grazing calf. Herlich and Porter (8) have demonstrated experimentally that this species can cause clinical signs of disease in calves five to nine months of age, while Campbell *et al.* (3) attributed parasitic disease in housed animals to this nematode.

The numbers of *M. benedeni*, *C. ovina*, *T. ovis*, *Capillaria* spp. and *O. radiatum* present were very low and probably played an insignificant role in the clinical syndrome which developed. The finding of these parasites in addition to *O. ostertagi*, *C. oncophora* and *N. helvetianus*, however, did demonstrate that these eight bovine helminth species can overwinter on pastures in the Maritimes. No *O. radiatum* were encountered in the 1963 experiment. This may be explained partly by the fact that the calves were removed fairly early in the 1962 grazing season so that relatively few *Oesophagostomum* spp. eggs were shed in that season. As for the portion of pasture added in 1963, it was not possible to determine if the cattle grazing this area in 1962 were infected with *O. radiatum* or that this species did not survive the 1962–63 winter.

The number of parasites recovered from calves, 4, 5, 7, 8, 9, and 10 in 1962, and from 6 and 7 in 1963 is probably lower because they were treated with an anthelmintic three to four days prior to slaughter. It has been pointed out that worms expelled from the stomach and small intestine may be digested as they pass down the alimentary tract (6) so that all of the parasites present may not have been recovered. Only two calves, however, were treated in 1963, while six were treated in 1962; yet the results and trends established in both years were similar. It would seem, therefore, that the number of parasites if any, lost through digestion in a few of the calves as a result of treatment, was not sufficient to alter the conclusions reached.

The influence of climatic conditions on the over-winter survival of parasites in the Maritimes has been discussed previously in connection with parasitism in sheep (20). It would appear that the findings in calves are consistent with the previous findings in lambs. The one point which was not as clearly demonstrated in the previous work as in the present studies with calves, is the extremely large numbers of *C. oncophora* which are able to survive over the winter, at least on Maritime marshland pastures. This is in direct contrast to *C. curticei*, which does not appear to survive through the winter in the Maritimes (20).

The two experiments conducted in this study demonstrated the importance of infective larvae overwintering on the pastures. Calves can become severely parasitized within two to three weeks on such infected pastures. The development of the outbreaks was similar, even though it was necessary to give supplemental feed to the 1962 calves when close grazing reduced the available forage.

Two factors (amount of snowfall and type of pasture mat) seem to have an important bearing on the survival of parasites under adverse climatic conditions, as discussed previously (20). It would appear that the snowfall recorded over the period of these studies was adequate to permit a high rate of survival of the free-living larvae, even though low average snowfalls were recorded during the early months of each winter. The thick mat on the permanent marshland type of pasture undoubtedly would give the larvae much protection during periods when they might otherwise be exposed to adverse environmental temperatures.

Summary

Gastrointestinal parasitism was produced experimentally in susceptible grazing calves by placing them on infected marshland pastures. The signs that developed resembled clinical outbreaks observed previously in the Maritime area. *Cooperia oncophora, Ostertagia ostertagi* and *Nematodirus helvetianus* were the principal parasites involved, although small numbers of *Moniezia benedeni, Chabertia ovina, Trichuris ovis, Oesophagostomum radiatum* and *Capillaria* spp. were also present. All parasitic species recovered in these experiments survived over the winter. Control calves on non-infected pastures remained free of parasites.

Clinical signs of parasitism developed in calves two to three weeks after being placed on an infected pasture. A rapid build-up of resistance and a shedding of the parasitic burden occurred in calves with both *C. oncophora* and *N. helvetianus*; these phenomena were not observed for *O. ostertagi.* The relatively rapid development and the severity of the parasitic signs in the susceptible experimental calves demonstrated the role of residual infection on Maritime marshland pastures.

Résumé

Les auteurs ont provoqué une infestation parasitaire gastro-intestinale chez des veaux sensibles à cette infection, en les faisant paître sur des pâturages marécageux. Les symptômes présentés par ces animaux ressemblaient à ceux déjà observés cliniquement, au cours d'épidémies du même genre, dans la région des Maritimes. On identifia surtout *Cooperia oncophora, Ostertagia ostertagi* et *Nematodirus helvetianus,* bien qu'on décela aussi de faibles quantités de *Moniezia benedeni,* de *Chabertia ovina,* de *Trichuris ovis,* d'*Oesophagostomum radiatum* et de quelques espèces de *Capillaria.* Toutes ces espèces parasitaires survécurent à l'hivernement. Les veaux-témoins, laissés sur des pâturages non-infestés, demeurèrent indemnes.

Les signes cliniques de parasitose apparurent chez les veaux après un séjour de deux à trois semaines dans les pâturages infestés. Les sujets développèrent rapidement de la résistance aux parasites et en éliminèrent dans le cas de *C. oncophora* et de *N. helvetianus*; ce qu'on n'observa pas pour *O. ostertagi.* Le développement rapide et la gravité des symptômes parasitaires au cours de cette expérience, chez les animaux susceptibles, démontrent l'importance de l'infestation résiduelle des pâturages marécageux des Maritimes.

Acknowledgments

The technical assistance of Mr. K. E. Snowdon is greatly appreciated.

The authors also wish to express their appreciation to Mr. A. G. LeLacheur, Plant Products Division, Canada Department of Agriculture, Sackville, N.B., for identifying the herbage on the pasture.

References

1. Alicata, J. E., and F. T. Lynd. Growth rate and other signs of infection in calves experimentally infected with *Cooperia punctata.* Am. J. vet. Res. 22: 704. 1961.
2. Becklund, W. W. Helminthiasis in Georgia cattle—a clinical and economic review. Am. J. vet. Res. 23: 510. 1962.
3. Campbell, D. J., D. L. Diamond, and A. A. Kingscote. Nematodiriasis in calves. Can. vet. J. 1: 119. 1960.
4. Davis, L. R., Harry Herlich, and G. W. Bowman. Studies on experimental concurrent infections of dairy calves with coccidia and nematodes. 1. *Eimeria spp.* and the small intestinal worm *Cooperia punctata.* Am. J. vet. Res. 20: 281. 1959.
5. Frank, J. F. Advances in controlling internal parasites of livestock. Agric. Inst. Rev. 11: 62. 1956.
6. Gibson, T. E. The use of the critical and the controlled test for the evaluation of anthelmintics against gastrointestinal worms. Proceedings of the First International Conference of the World Association for the Advancement of Veterinary Parasitology, August 22–23, 1963, Hanover, Germany.
7. Herlich, Harry. Studies on calves experimentally infected with combinations of four nematode species. Am. J. vet. Res. 23: 521. 1962.
8. Herlich, H., and D. A. Porter. Experimental infections of calves with the nematode, *Nematodirus helvetianus.* Am. J. vet. Res. 14: 198. 1953.
9. Johnson, E. F., and L. W. Macpherson. An outbreak of acute parasitic gastroenteritis in a herd of cattle in the Ottawa Valley. Can. J. comp. Med. 20: 203. 1956.

10. MAYHEW, R. L., G. C. MILLER, and B. J. TORBERT. Studies on bovine gastrointestinal parasites. XXI. Immunity to *Cooperia punctata* and *Oesophagostomum radiatum*. J. Parasit. 46: 859. 1960.
11. MCGREGOR, J. K., and A. A. KINGSCOTE. A survey of gastrointestinal helminths of cattle in Ontario. Can. J. comp. Med. 21: 370. 1957.
12. MICHEL, J. F. The phenomena of host resistance and the course of infection of *Ostertagia ostertagi* in calves. Parasitology. 53: 63. 1963.
13. OSBORNE, J. C., E. G. BATTE, and R. R. BELL. The pathology following single infections of *Ostertagia ostertagi* in calves. Cornell Vet. 50: 223. 1960.
14. PARNELL, J. W. Modification of a digestion technique for the post-mortem recovery of bursate nematodes of sheep. N.Z. vet. J. 9: 60. 1961.
15. ROBERTS, F. H. S., P. J. O'SULLIVAN, and R. F. RIEK. The epidemiology of parasitic gastroenteritis of cattle. Aust. J. agric. Res. 3: 187. 1952.
16. ROSS, J. G. Experimental infections of calves with the nematode parasite *Ostertagia ostertagi*. Vet. Rec. 75: 129. 1963.
17. ROSS, J. G., and C. DOW. Further experimental infections of calves with the nematode parasite *Ostertagia ostertagi*. Br. vet. J. 120: 279. 1964.
18. ROSS, J. G., and C. DOW. Field and experimental infections of calves with the nematode parasite, *Ostertagia ostertagi*. Br. vet. J. 121: 18. 1965.
19. SMITH, H. J. Helminthiasis in Canadian cattle with reference to recent investigations in the Atlantic Area. An address to the 17th Annual Meeting of the C.V.M.A., Charlottetown, P.E.I., July 28, 1965.
20. SMITH, H. J., and R. MCG. ARCHIBALD. The overwinter survival of ovine gastrointestinal parasites in the Maritime Provinces. Can. vet. J. 6: 257. 1965.
21. SWALES, W. E. The helminth parasites and parasitic diseases of sheep in Canada. 1. A survey and some preliminary studies on existing problems. Can. J. Res. 18: 29. 1940.

ABSTRACT

Forsyth, B. A. (1966). The laboratory and field evaluation of the anthelmintic tetramisole in sheep and cattle in Australia.—J. S. Afr. vet. med. Ass. 37, 403–413 (ICIANZ Ltd., Merrindale Res. Stn, Croydon, Victoria, Australia).

Tetramisole can be administered orally or s/c, and at the recommended dose rate of 15 mg./kg. in sheep was shown to be highly effective for the control of common gastro-intestinal nematodes and *Dictyocaulus* spp. *Haemonchus* appears to be most sensitive to the drug, the adult form being eliminated at dose levels as low as 2.5–5.0 mg./kg. *Ostertagia* spp. are the most resistant, but a 90–100% efficiency was obtained against the adults at the 15 mg./kg. dose level, although a 20 mg./kg. dose appeared to be required for complete elimination of immature forms. All other parasite species fall between these two in susceptibility to the drug. An efficiency of 95–99% was obtained against mature *Dictyocaulus* spp., at the recommended dose, and a 90–95% efficiency has been claimed against 7- to 10-day larvae. Smaller scale laboratory trials with calves, at the dose rate of 13.2 mg./kg. orally or 10 mg./kg. s/c, indicated that both dose levels were highly effective against *D. viviparus* and parasites of both the small and large intestines, but again activity against immature *Ostertagia* was poor. Both treatments appeared to be superior to thiabendazole. The results of production studies with sheep, in several areas of Victoria and N.S.W., demonstrated that increased body weight gains and wool production occurred after regular treatment with tetramisole and it compared favourably with thiabendazole. Intensive field toxicity trials on sheep indicated that tetramisole had a high level of safety under a wide range of field conditions and husbandry practices. Nearly 11,000 calves have been treated in New Zealand and Australia and no deaths attributable to tetramisole toxicity have been reported.

Reprinted from "The Veterinary Bulletin", Vol. 37, No. 8, August, 1967.