On the Natural Seeding of Marshland Pastures with Bovine Gastrointestinal Parasites

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ABSTRACT

By placing parasite-free calves in paddocks grazed by infected animals for 18 day periods at various times during the previous season it was shown that eggs of Ostertagia ostertagi, Cooperia oncophora and Nematodirus helvetianus deposited on pastures from early July to October of one year were able to survive in the Maritime area of Canada over winter either as eggs and/or larvae and contribute to residual infections on these pastures the following spring. The greatest deposition and/or survival of those eggs that were shed on pasture occurred in August and September for Cooperia and in September and October for Ostertagia. Greatest deposition of Nematodirus occurred in July and August and relatively few Nematodirus eggs shed in late September or early October were infective early in the next season.

The number of generations of worms per year was low, ranging from one to two or perhaps three per year depending on the species. There was a delay in the maturation of many worm eggs.

Residual overwintering infections play a significant role in the establishment of initial infections each summer in susceptible stock. These animals recontaminate the pastures leading to the subsequent development of large numbers of infective larvae by late summer and autumn.

RÉSUMÉ

Le fait de placer des veaux exempts de parasites dans des enclos où, l'année précédente, on avait fait paître des veaux parasités, à différents intervalles d'une durée de 18 jours, révéla que les oeufs de Ostertagia ostertagi, Cooperia oncophora et Nematodirus helvetianus, déposés dans ces enclos, du début de juillet jusqu'au mois d'octobre, pouvaient, dans les provinces maritimes du Canada, résister à la saison hivernale, comme tels et/ou sous forme de larves, et contribuer à la contamination résiduelle de ces pâturages, le printemps suivant. La contamination la plus importante des pâturages par des oeufs susceptibles de survivre jusqu'au printemps suivant se produisit en août et en septembre, en ce qui concerne Cooperia, et en septembre et en octobre, en ce qui a trait à Ostertagia. Quant à Nematodirus, ce phénomène se produisit en juillet et en août. Un nombre relativement peu élevé d'oeufs de Nematodirus, éliminés à la fin de septembre ou au début d'octobre, s'avérèrent infectants au début de la saison estivale suivante.

Le nombre annuel de générations de parasites demeura peu élevé, variant entre une et deux, peut-être trois, selon les espèces. La maturation de plusieurs oeufs accusa un retard.

Chaque été, les contaminations résiduelles des pâturages jouent un rôle important dans le développement des parasitoses initiales des animaux susceptibles. Ceux-ci contaminent de nouveau les pâturages et contribuent au développement subséquent de plusieurs larves infectantes, à la fin de l'été et à l'automne.

INTRODUCTION

Previous investigations in the Maritime area of Canada have shown that large overwintering infections of *Ostertagia ostertagi, Cooperia oncophora* and *Nematodirus*

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helvetianus are present on permanent or previously grazed pastures at the start of each grazing season (7, 8, 9, 10, 11). The numbers of infective *Ostertagia* and *Cooperia* abruptly decline as the grazing season progresses but the numbers of *Nematodirus* remain high throughout the season (11). More recently it has been shown that infective *Nematodirus* can remain on pastures over a second winter under certain conditions (8).

Overwintering residual infections have been shown to give rise to clinical disease and high worm egg outputs in susceptible calves (8, 9, 10, 11). However, precise data were not available on (i) the number of generations of the various species during a grazing season under Maritime field conditions (ii) the interval between shedding of worm eggs and greatest infectivity of pastures and (iii) the role that worm eggs, shed at various periods during a grazing season, play in residual infections on pastures the next spring.

Investigations carried out in 1970 and 1971 and presented in this paper were designed to elucidate these aspects of the epizootiology of bovine parasitic gastroenteritis.

MATERIALS AND METHODS

During the 1970 phase of these studies 27 grade Holstein calves were bought at one to five days of age and reared under parasite-free conditions as previously outlined (10) until required at about three months of age. Since calves were needed at different periods of the grazing season, 18 were obtained in mid-March, three during the first week of May and six in the first week of June. The three calves obtained in May were designated Group I while the calves bought in June were divided into two equal lots designated Groups II and III.

Prior to the beginning of grazing, ten uniform, double fenced paddocks designated A to J inclusive and each approximately 8000 square feet in area were constructed on a marshland pasture that had not been grazed during the preceding two years. The grazing schedules followed in the various paddocks during the season were as outlined in Figure 1.

On June 10, the 18 calves obtained in mid-March were put out to graze in a three acre holding pasture (HP) which had been grazed by heavily parasitized calves until October 10 of the previous year. These calves were used solely to seed the various paddocks as outlined below. On June 30, when they started to shed worm eggs, nine calves were placed in paddocks A, B and C (three in each) for 18 days. Several calves died while in one or other of the paddocks and were replaced by others from HP. Surviving calves were returned to HP following removal from the paddocks.

On July 31, three calves from HP were placed in each of paddocks D and E, which had remained vacant up to that time. On this same date, 14 days after the seeder calves had been removed, the parasite-free Group I calves were placed in paddock B for 18 days. On August 17, Group I calves were transferred directly from paddock B to the ungrazed paddock G. Paddock G was grazed only for 11 days as all Group I calves died within that time. Also on August 17, the seeder calves grazing paddock D and E were returned to HP.

On August 31, three calves from HP were placed in paddock F for an 18 day period. Also on this date parasite-free Groups II and III calves were permitted to graze in paddocks C and E, 45 and 14 days respectively, after the seeder calves had been returned to HP. Upon completion of 18 days grazing in paddocks C and E, Groups II and III calves were transferred directly to paddocks H and I for another

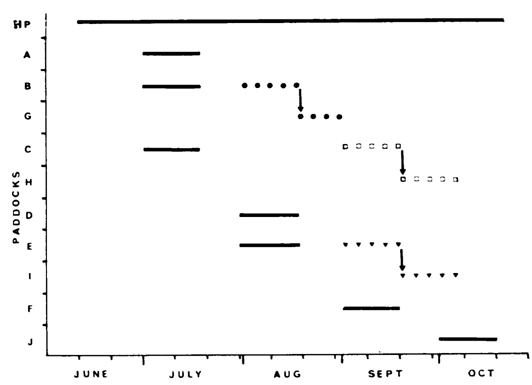

Fig. 1. Outline of grazing schedules followed in the paddocks during 1970 grazing season. Legend: ——— — calves from holding pasture (HP), ● ● ● — Group I, □□□ —Group II, ▾ ▾ ▾ — Group III and ↓ — movement of calves from one paddock to another as indicated.

18 days of grazing. Surviving calves of Groups II and III were then killed for parasitological examinations.

On September 30, a final group of three calves from HP were placed in paddock J for 18 days.

Parasitological examinations were only performed on Groups I, II and III calves and those from HP that died. The contents and washings of the gastrointestinal tracts were passed through a stack of four sieves (mesh sizes 9, 20, 35 and 65). Parasites were examined, identified and counted using Swales method (13).

During the grazing season biweekly fecal examinations were carried out on all calves during periods in which they were grazing within the paddocks. Fecal samples were examined by both the McMaster technique and the simple flotation method using supersaturated sodium nitrate as the flotation solution. The simple flotation method was employed to detect those worm eggs that might not have been present in sufficient numbers to be detected by the quantitative McMaster method.

In 1971 another group of 27 parasite-free calves were obtained in March and reared as above. On June 7, when the calves were approximately three months of age, three calves were put in each paddock except A, B and C which received two animals each. Except for two which died all calves grazed for 18 days. Upon removal from the paddocks, calves were stabled for ten days and then were killed for parasitological examinations as outlined above.

During the ten day stabling period daily fecal examinations were carried out again using both the McMaster technique and the simple flotation method.

RESULTS

1970 Grazing Season

The mean biweekly gastrointestinal helminths (GIH), in this case *Ostertagia* and *Cooperia*, fecal counts of the seeder calves are given in Figure 2. The *Nematodirus* (N) egg counts were low with a high individual count of 350 eggs per gram (epg) of feces. The numbers of GIH and N eggs shed by the seeder calves from the holding pasture gradually decreased as the grazing season progressed until no N eggs were shed in October.

The mean GIH and N egg counts of Groups I, II and III calves are given in Table I. Groups I and III calves which grazed for 18 days in paddocks B and E respectively, starting 14 days after seeder calves had been removed, shed few, if any, N eggs when they were transferred to paddocks G and I respectively. On the other hand, Group II calves which grazed in paddock C starting 45 days after the seeder calves had been removed, shed large numbers of both GIH and N eggs upon removal to paddock H.

O. ostertagi, *C. oncophora* and *N. helvetianus* worm burdens of those calves from HP which died while seeding down the paddocks with worm eggs, and of Groups I, II and III calves are given in Table II. Low N worm burdens were found in Groups I and III calves while high burdens were present in Group II calves. Significantly lower *Cooperia* burdens were established in Group I than in Group III calves even though both groups started grazing infected pastures 14 days after seeder calves were removed. The Group I calves also developed a concurrent coccidiosis based on oocyst counts and clinical signs.

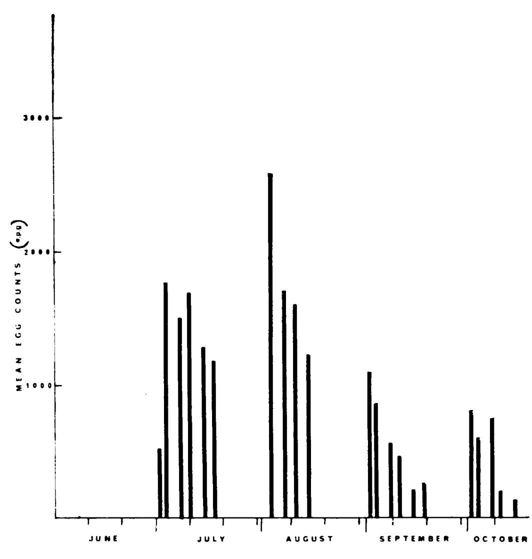

Fig. 2. Mean biweekly GIH (Ostertagia and Cooperia) egg counts of calves from the holding pasture during periods they were used to contaminate paddocks.

1971 GRAZING SEASON

O. ostertagi, C. oncophora and *N. helvetianus* burdens established in parasite-free calves grazing for 18 days in the ten paddocks which had been seeded down with worm eggs by calves at various times in 1970 are given in Table III. *Ostertagia* and *Cooperia* in varying numbers were established in all groups. Few, if any, *Nematodirus* were established in calves grazing in paddocks G, I and J.

The mean daily GIH worm egg counts for various groups of calves during the ten days prior to slaughter are depicted in Fig. 3. *Nematodirus* egg counts were low in all groups with an individual high egg count of 150 epg of feces. *Nematodirus* eggs were not recovered from calves grazing in paddocks G, I and J.

TABLE I. Mean Biweekly Ostertagia and Cooperia (GIH) and Nematodirus (N) Egg Counts of Group I, II and III Calves Immediately Following 18 Days of Grazing Infected Pastures as Outlined in Figure 1

Calves	Days Post-Contamination Pastures Grazed	Eggs	Mean Egg Counts (epg) Post Infection					
			Day 1	Day 3	Day 7	Day 10	Day 14	Day 17
Group I	14 — 32	GIH	+	+	150	700	—	—
		N	0	0	+	0	—	—
Group II	45 — 63	GIH	+	1050	8533	2700	2950	3550
		N	0	33	366	125	100	350
Group III	14 — 32	GIH	N.D.[a]	3666	466	1150	150	N.D.
		N	N.D.	0	0	0	0	N.D.

[a]N.D. — Not done

TABLE II. Numbers of Ostertagia ostertagi, Cooperia oncophora and Nematodirus helvetianus in Calves that Died or were Killed while Seeding down the Paddocks in 1970 as Outlined in Figure 1

Paddock	Group	Calf	Ostertagia ostertagi	Immature Ostertagia	Cooperia oncophora	Nematodirus helvetianus	Immature Cooperia and Nematodirus
A	HP[a]	67	8890	1220	60520	15380	13520
		75	8730	240	74120	12620	23800
B	HP	51	4570	2400	69390	4490	22940
		76	15340	1430	70160	5610	15320
C	HP	62	15630	1180	37680	3470	2310
		72	2130	970	20960	2340	3120
		73	10700	310	30240	3690	4050
G	I	79	6390	1050	6530	360	13400
		81	1850	920	2080	630	1670
		95	31160	3970	5590	280	510
H	II	94	29900	1850	71030	27200	18690
		96	24840	30	45910	34860	4820
		98	31760	2490	35330	22440	14640
I	III	49	6420	40	66860	0	2040
		97	1940	270	22380	20	14260
		99	2020	60	113770	0	44750

[a]HP — holding pasture

DISCUSSION

These investigations show that under Maritime conditions, susceptible calves which become infected early in the season (June) by grazing pastures residually infected with *Ostertagia ostertagi, Cooperia oncophora* and *Nematodirus helvetianus* are able to contaminate the pasture throughout the remainder of the grazing season even though fewer eggs are shed as the season progresses and resistance to infection develops (7, 10). The development of resistance was particularly evident in the case of *Nematodirus* as shown by the cessation of egg laying and pasture contamination with this species in October by calves grazing in paddock J. Eggs of all three species, but particularly of *Ostertagia* and *Cooperia,* shed at various times from early July to October were shown to survive and contribute to the residual infections present on pasture the following spring.

In consideration of the number of eggs shed by seeder calves on the various paddocks during the 1970 grazing season, there seems to be either a considerable variation in rate of survival or in the proportion of eggs of each species seeded down at different times during the season. For instance, even though seeder calves in August were shedding comparable numbers of worm eggs to those in July, for the most part lesser *Ostertagia* and greater *Cooperia* worm burdens were picked up by parasite-free calves grazing paddocks D and E in 1971 than by calves in paddocks A, B and C.

TABLE III. Numbers of Ostertagia ostertagi, Cooperia oncophora and Nematodirus helvetianus Established in Parasite-free Calves Grazing Various Paddocks for 18 Days in June 1971 Following the Contamination of the Paddocks in 1970 as Outlined in Figure 1

Paddock	Calf	Ostertagia ostertagi	Immature Ostertagia	Cooperia oncophora	Nematodirus helvetianus	Immature Cooperia and Nematodirus
A	53	2880	290	2530	3320	770
	94	2740	90	6210	11240	340
B	56	2820	140	5440	4010	680
	61	3970	170	4510	2490	560
C	58	820	280	10530	9830	4210
	93	1290	10	8330	4820	180
	51	0	80	1850	10	17210
D	63	370	40	14820	0	1460
	79	1190	0	52650	2220	2690
	86	130	0	47520	5690	3340
E	87	70	0	43020	9680	9730
	92	160	0	60990	8540	6970
	67	8360	710	58580	1210	7230
F	89	13360	2580	60720	980	9290
	90	6500	690	44890	1830	7640
	82	110	30	70	10	10
G	83	120	0	80	20	0
	91	120	0	40	0	0
	52	11190	310	9060	220	70
H	64	12730	340	17610	1120	970
	85	15100	4130	11250	670	410
	59	9630	130	2350	0	20
I	74	9850	950	1160	0	30
	75	5990	610	1290	0	60
	72	4170	480	1550	0	60
J	80	12880	640	14850	0	80
	81	12370	960	7370	0	120

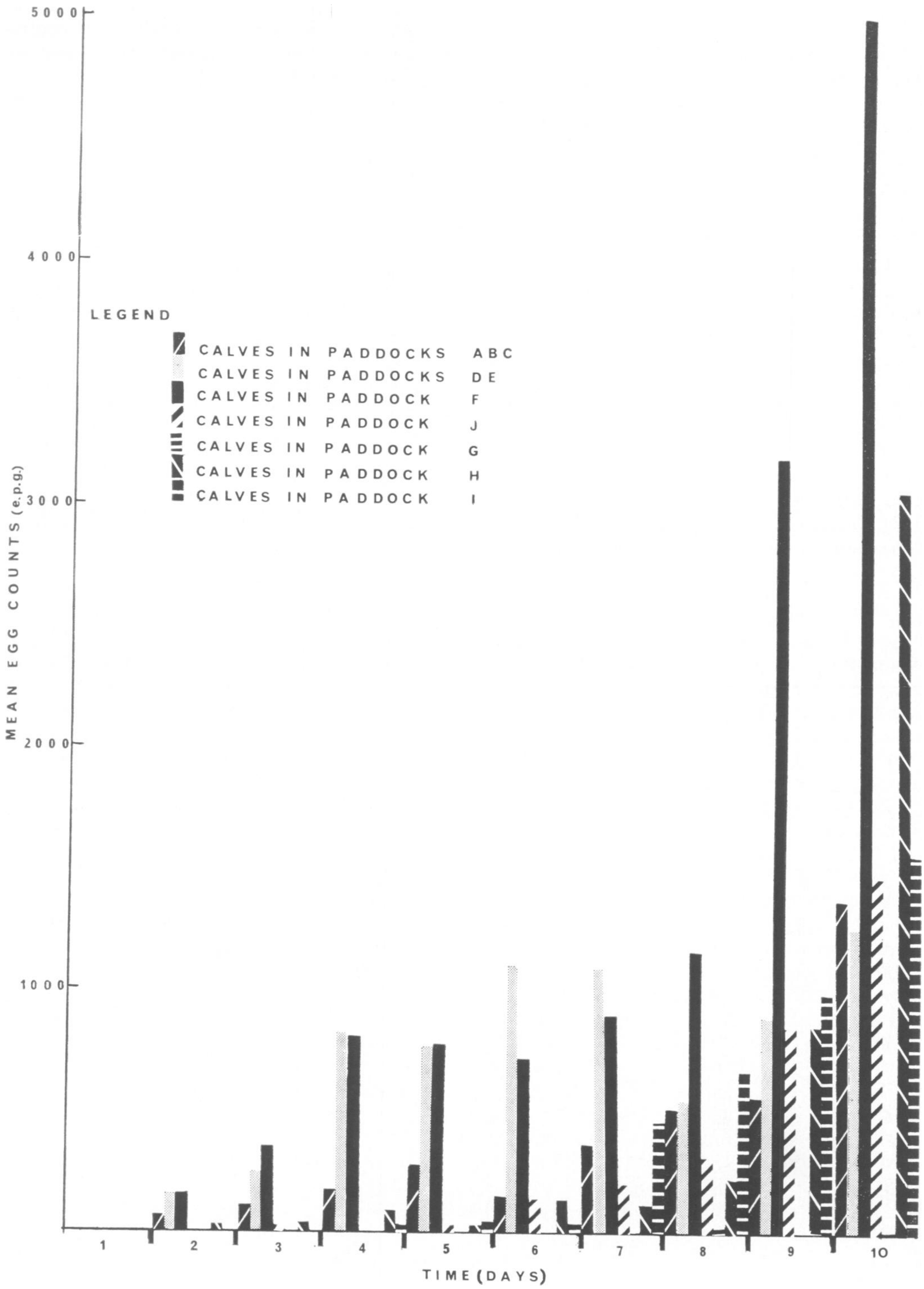

Fig. 3. Mean daily GIH (Ostertagia and Cooperia) egg counts of calves in 1971 during the 10-day stabling period following 18 days of grazing in paddocks indicated.

An examination of the worm burden established in susceptible calves in the late spring of 1971 would suggest that the greatest seeding down or survival of those eggs that were deposited on pasture occurred in August and September for *Cooperia* and in September and October for *Ostertagia*. These findings are in contrast to those of Michel and Lancaster (4) and Michel *et al* (5) in England where it was observed that contamination of pasture after the middle of July is very much less effective in establishing an infestation on the herbage than contamination before that date. Furthermore, Michel and Lancaster (4) found no evidence to suggest that worm eggs dropped in autumn persisted through the winter and finally produced measurable infestation on herbage the following summer. Climatic conditions, length of grazing season and pasture management practices differ in the two countries and undoubtedly account for the different epizootiological observations.

Nematodirus eggs seeded on pasture in this trial took several weeks to develop to the infective stage. Groups I and III calves, grazing paddocks B and E respectively, between 14 and 32 days after the seeder calves had been removed, developed light *Nematodirus* burdens while Group II calves which grazed paddock C at the same time as Group III grazed in paddock E but 45 to 63 days after the seeder calves had been removed, established large *Nematodirus* burdens. *Nematodirus* burdens established in parasite-free calves grazing paddocks B and E in 1971 indicate that a large number of eggs had been deposited in these paddocks in 1970 but few had reached the infective stage at the time the paddocks were monitored by Groups I and III calves.

It is interesting to note that *Nematodirus* eggs deposited on pastures in July and August 1970, in most instances, gave rise to moderate worm burdens in susceptible calves early in the next grazing season. On the other hand, relatively few *Nematodirus* eggs deposited on pasture in late September and early October (Group II calves in paddock H) appeared to have developed to the infective stage, at least in the early part of the next season. Rose (6) noted in south-east England that *N. helvetianus* eggs passed during the summer and winter did not hatch until spring and early summer of the following year. Previous work in this area has shown that overwintering infective *Nematodirus* larvae are present on pasture throughout the ensuing grazing season (11). It might be that *Nematodirus* eggs deposited late in one grazing season do not develop rapidly the following spring but survive to reach the infective stage at some time well into the grazing season.

This study suggests that for the most part there is only one generation of *Nematodirus helvetianus* per year in this area, with overwinter survival on pasture playing a major role in the epidemiology of this infection. Susceptible cattle become infected by grazing residually-infected pastures and in time shed eggs in their faces to maintain contamination of the pastures for the following year. Since resistance to *Nematodirus* has been shown to build up rapidly in infected cattle (7, 10), reinfection of these same animals later in the grazing season is unlikely to be significant. However, the findings do indicate that if susceptible animals are introduced to pastures in the latter part of the season (as exemplified by Group II calves in paddock C in 1970) there can be a second generation of *Nematodirus* within the same season.

In the case of the *Ostertagia* and *Cooperia* it would seem possible for two or three generations to occur each year, particularly in the presence of susceptible animals. This is based on results in 1970 which demonstrated that susceptible calves were able at various times during the season to pick up considerable burdens by grazing paddocks 14 to 32 days after contamination by seeder calves. The variation in *Cooperia* burdens in Groups I and III would appear to be consistent with the previous observation that there was either a variation in the number of eggs seeded down or in the rate of survival related perhaps to the time of season. The variation in worm burdens established by Groups I and II calves in 1970 suggests that not all worm eggs mature at the same time. It would appear that under the conditions of this study many worm eggs and larvae took considerably longer than the theoretical minimum time of approximately one week to reach the infective stage. Michel and his colleagues in England (2, 3, 4, 5) have observed that worm eggs take longer to develop to infective larvae than the theoretical minimum except perhaps for a very short period of time in the height of summer. Recently, Ford (1) has shown that a maturation period is required before peak infectivity is reached for *Trichostrongylus retortaeformis*. Bovine gastrointestinal worms may also have a similar requirement in addition to the influence of environmental factors.

It should be mentioned that, even in the absence of more than one complete generation of *Ostertagia* and *Cooperia* per grazing season, both of these worms can be perpetuated on pasture. Eggs deposited in July by calves infected earlier as a consequence of grazing residually-infected pastures were able to survive over winter. However, under practical conditions residual infection of pastures each spring would not necessarily result from eggs seeded down by a single generation of worms at a particular time during the previous year but by eggs deposited throughout the season.

Certain practical implications in regard to pasture management for the control of bovine gastrointestinal parasitism in the area under study may be drawn from these investigations. Firstly, overwintering infection of permanent pastures plays a significant role in the establishment of initial infection in susceptible animals early in each grazing season. Secondly, a build-up of infective larvae occurs on herbage in late summer and early autumn. This results from the development and maturation of eggs deposited on pastures by animals following the establishment of their initial worm burdens soon after entering pasture. Thus, permanent pastures are unsafe for young susceptible stock early in the season owing to the presence of overwintering infections and later because of maturation of eggs seeded down by animals infected earlier the same summer. It should be noted that permanent pastures become relatively free of infective *Ostertagia* and *Cooperia* by late summer if they are left vacant (11). Thirdly, the delay in maturation of large numbers of worm eggs seeded on pastures would predicate against the use of pasture rotation during a grazing season as a feasible control procedure. Animals returning to a pasture after an absence of four to six weeks or even longer would be returning at the precise point in time when numbers of infective larvae are likely to be greater rather than fewer.

Although overwintering residual pasture infections play a significant role in the perpetuation of gastrointestinal parasites from year to year in the Maritime area of Canada, it should be noted that certain nematodes are capable of remaining overwinter in the host, particularly as inhibited or hypobiotic larvae which after a period of weeks or months resume development to complete the life cycle. This has already been demonstrated to occur in this region in the case of the bovine stomach worm, *O. ostertagi* (12). Recently, the author has also observed inhibition of development in *C. oncophora* and *N. helvetianus* infections established late in the season (unpublished data).

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