On the Development of Gastrointestinal Parasitism in Bovine Yearlings

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SUMMARY

A comparative study on the development of Ostertagia ostertagi, Cooperia oncophora **and** Nematodirus helvetianus **in 15-month-old yearlings and three-month-old calves demonstrated that yearlings have considerably greater resistance to gastrointestinal parasitism than calves. This was manifested by the establishment of smaller worm burdens, marked stunting of worms and a markedly lower worm egg output in the yearlings. The characteristic marked rise in egg counts observed in calves a few weeks after exposure to a heavy gastrointestinal parasite infection did not occur in the yearlings. It was concluded that fecal examinations have a limited usefulness as a reliable aid to diagnosis of gastrointestinal parasitism in older cattle.**

RÉSUMÉ

Une étude comparative sur le développement d'Ostertagia ostertagi, de cooperia oncophora et de Nematodirus helvetianus **chez des bovins de 15 mois et chez des veaux de trois mois a démontré que les animaux les plus âgés offrent considérablement plus de résistance aux infestations gastro-intestinales que les plus jeunes. Cette résistance s'est manifestée par une infestation plus légère et une entrave au développement des vers, ainsi que par le rejet d'un nombre moindre d'oeufs chez les animaux plus âgés. L'augmentation caractéristique du nombre d'oeufs éliminés dans les quelques semaines qui suivirent l'exposition à une importante infestation gastro-intestinale fut remarquée chez les veaux mais pas chez les autres animaux.**

L'auteur conclut que l'examen des fèces a une valeur limitée, en tant que méthode sûre pour le diagnostic des infestations gastro-intestinales chez les bovins plus âgés.

INTRODUCTION

Studies carried out in the Maritimes since 1962 have shown that calves exposed to heavy natural infections of *Ostertagia ostertagi*, *Cooperia oncophora* and *Nematodirus helvetianus* developed clinical signs of parasitism within two to three weeks. At this time, there is a rapid build-up of worm egg output to reach a peak about four to six weeks after exposure, followed by a marked decline in egg output during the next four or five weeks (6, 7). In 1965 it was shown that yearlings exposed to heavy pasture infections for the first time at 15 months of age were, on the average, as susceptible to establishment of *Ostertagia* and *Cooperia* as the three to four-month-old calves, but not to *Nematodirus*. However, in spite of comparable *Ostertagia* and *Cooperia* worm burdens in both yearlings and calves, high worm egg counts were only observed in the calves up to the time both groups were slaughtered 28 to 32 days after exposure to infection.

In 1968, further investigations were undertaken to study and to compare the development and effects of gastrointestinal parasitism in susceptible yearlings with those in calves. The results of this study are given in this report.

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MATERIALS AND METHODS

A diagram illustrating the experimental design is given in Fig. 1. Six parasite-free grade Holstein calves (Group A) were obtained from a sales barn on March 23, 1967, at one to three days of age. They were reared under parasite-free conditions as previously described (6) until June 22 when they were placed on a two-acre marshland pasture which had been reseeded in 1964 and had remained free of livestock since that time. On November 6, they were stabled and tied in individual stanchions. During the stabling period the animals were fed approximately 1 lb of a commercial dry cow ration per day and hay *ad libitum.* On December 22, 1967, 8,000 infective *Trichostrongylus axei* larvae originating from a caribou were given to calf no. 58 via stomach tube to determine if they would establish in bovines and, if so, to check on the effects a known previous exposure might have on the worm burdens of bovine species established when the animal was later exposed.

On March 21, 1968, a further six grade Holstein calves (Group B) were obtained and also reared under parasite-free conditions. On June 27, 1968, both the Group A and Group B animals were placed on a two and a half acre marshland pasture on which heavily parasitized animals (8) had grazed until October 12, 1967. The animals either died or were killed on the dates indicated.

During the 1967 grazing period and the following stabling period, weekly fecal examinations were performed on the Group A calves by the simple flotation method using super-saturated sodium nitrate as the flotation solution. During the 1968 grazing season twice-weekly fecal examinations were performed on both the Group A and Group B animals using the simple flotation method until an animal began to shed eggs, at which time the McMaster quantitative method was employed. Fecal cultures on two composite samples from each group were conducted weekly using Roberts and O'Sullivan's method (5) and incubated for eight days. The larvae were identified according to Dewhirst and Hansen (1). Feces from the same three animals made up a composite sample each week unless an animal died or was killed, in which case the composite came from those remaining.

Both groups of animals were weighed weekly while on the infected pasture.

At necropsy the gastrointestinal tracts

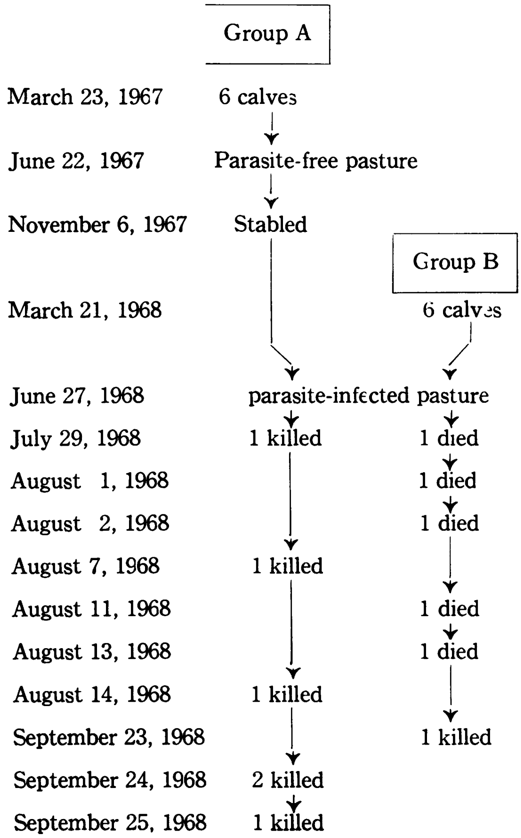

Fig. 1. Diagram illustrating the experimental design.

from all animals were labelled, fixed in 10% formalin and examined for parasites as previously outlined (7). Mature *Ostertagia* and *Cooperia* worms (20 males and 20 females) were randomly collected from each animal, mounted in lacto-phenol solution, and measured with the aid of an eyepiece micrometer. The number of eggs in the uterus of each female worm was counted at the same time.

The data were analyzed statistically by the Student t test.

RESULTS

1967 Pasture and The Overwintering Stabling Periods

During the grazing period fecal examinations indicated that calves 90 and 98 started to shed an occasional *Nematodirus* (N) egg late in the season. During the stabling period, a few N eggs were ob-

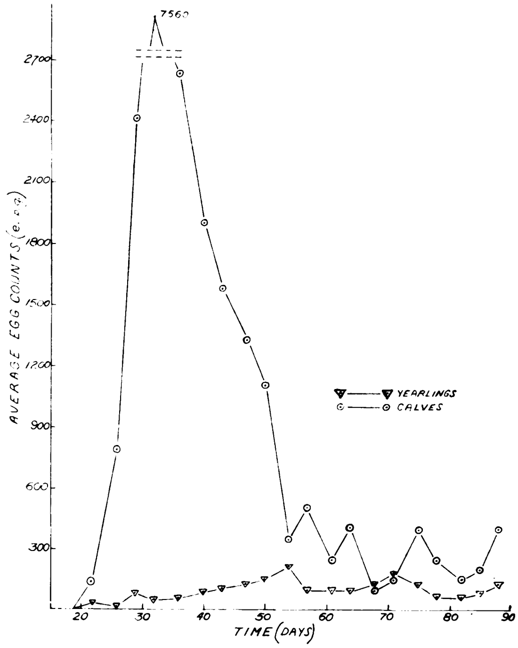

Fig. 2. Average GIH egg counts (epg) of parasitized yearlings and calves from June 27, 1968, to September 25, 1968. (Averages are for those animals remaining at each sampling.)

served once in the feces of calves 93 and 98. Gastrointestinal helminth (GIH) eggs were recovered from calf 90 on two occasions and from calf 98 several times. (GIH refers to *Ostertagia* and *Cooperia* spp. and *Trichostrongylus* sp. if present.) GIH eggs were never observed in the feces of animals 89, 93 and 97, although *Moniezia* eggs were present in all three. Calf 58 only started to shed worm eggs five weeks after experimental infection with infective *Trichostrongylus* larvae. Fecal cultures showed that GIH eggs in calf 58 were *Trichostrongylus,* while those in calves 90 and 98 were *Ostertagia* eggs.

1968 Pasture Period

The Group A animals (now yearlings) were very unthrifty during their first four or five weeks on the infected pasture. Although several started to gain weight slowly at about the fifth or sixth week, weight gains were negligible during the first two months. Weight gains at slaughter for the group ranged between five and 92 lbs depending upon when they were taken from the pasture. During the period of marked unthriftiness the feces of several yearlings became very soft and intermittent diarrhoea occurred in three animals.

The signs observed in the Group B calves were much more marked than in the yearlings. Beginning two to three weeks after entering the pasture, all calves exhibited marked, watery diarrhoea, loss of weight and unthriftiness. Five of the six calves either died or were killed in a moribund condition between 32 and 47 days of entering the pacture. Weight losses ranged between 13 and 67 lbs with the greatest losses in those animals dying early in the season.

Parasites Recovered

The average egg counts for the Group A yearlings and the Group B calves are depicted in Fig. 2. The counts for the yearlings seldom rose above the 200 eggs per

TABLE I. The Species and Number of Parasites Recovered from Yearlings and Calves Exposed to an Infected Pasture for Varying Periods of Time as Indicated

Group	Animal	Days on Pasture	O. ostertagi	T. axei	Immature Ostertagia and Trichostrongylus	C. oncophora	N. helvetianus	Immature Cooperia and Nematodirus	Trichuris sp.	M. benedeni
A	90	32	2,940	0	210	8,560	2,450	12,230	0	0
	93	41	2,290	0	50	6,510	0	980	0	0
	98	48	31,090	0	800	3,740	0	340	6	0
	89	89	430	0	20	2,490	0	80	1	0
	97	89	1,100	0	50	5,030	0	20	3	0
	58	90	3,120	1,060	100	8,170	0	1,830	1	1
B	64	32	33,630	0	690	20,190	28,640	5,430	0	0
	66	35	28,320	0	1,240	27,150	1,390	980	0	0
	4	36	6,910	0	140	12,160	4,460	2,100	0	0
	73	45	14,400	0	490	32,740	35,180	42,440	0	0
	72	47	11,080	0	20	16,310	39,260	27,560	0	1
	2	88	6,290	0	540	17,210	20	1,230	1	1

gram (epg) of feces level at any time during the grazing season, with an individual high egg count of 550 epg. In contrast, the egg counts for the calves rose rapidly, commencing about three weeks after the calves entered the infected pasture and reaching a peak of 7,560 epg during the fifth week. During the next three weeks, the counts dropped rapidly and remained about 400 epg or less in the surviving calf during the remainder of the pasture season.

Nematodirus eggs were never recovered from the yearlings, except from animal 93 on one occasion. On the other hand, *Nematodirus* eggs were recovered from the feces of all Group B calves with numbers ranging up to a high of 750 epg.

Fecal cultures revealed that a majority of the worm eggs shed by the yearlings were *Ostertagia* sp. while a majority of those shed by the calves were *Cooperia* sp. *Trichostrongylus* eggs were only obtained from the cultures containing feces from the experimentally infected yearling 58 and from calf 2 late in the grazing season.

At about day 50 following introduction to the infected pasture the proportion of *Ostertagia* eggs in the feces of calf 2 became greater than that of *Cooperia* and remained so for the rest of the season.

The numbers and species of parasites recovered from both the yearlings and calves

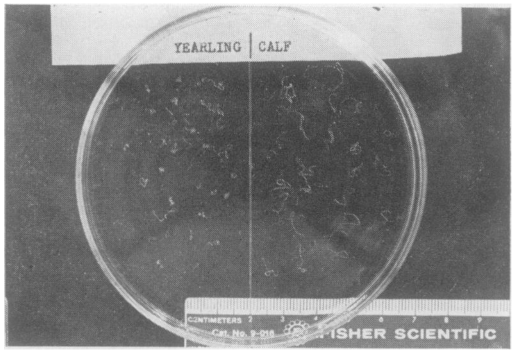

Fig. 3. Photograph showing the relative sizes of Nematodirus helvetianus from a yearling and a calf examined 32 days after exposure to the same infected pasture. Twenty specimens of each sex were chosen at random from each animal.

are given in Table I. Considerable numbers of *O. ostertagi* and *C. oncophora* were present in both the yearlings and calves, although for the most part the burdens in the yearlings were smaller, regardless of the length of time the individual animals were exposed to infection. Animal 90 was the only yearling to carry a burden of *Nematodirus*, while all Group B calves, except calf 2, had considerable *N. helvetianus* burdens at the time of slaughter.

The *O. ostertagi*, *C. oncophora* and *N. helvetianus* recovered from the yearlings were appreciably smaller than those from

TABLE II. Mean Lengths and Mean Number of Eggs in utero of Both Ostertagia ostertagi and Cooperia oncophora Taken from Both Yearlings and Calves Exposed to Heavily Infected Pastures for Varying Periods of Time[a]

Group	No.	Days Exposed	O. ostertagi Mean Lengths (mm) Males	O. ostertagi Mean Lengths (mm) Females	O. ostertagi Mean Number of Eggs	C. oncophora Mean Lengths (mm) Males	C. oncophora Mean Lengths (mm) Females	C. oncophora Mean Number of Eggs
A	90	32	6.14	7.45	7.5	7.06	9.97	45.3
	93	41	6.72	7.66	6.4	6.94	9.73	14.7
	98	48	6.45	7.46	11.6	6.19	8.32	28.7
	89	89	7.00	7.47	17.6	6.16	8.55	24.9
	97	89	6.42	7.37	7.7	6.51	8.43	24.1
	58	90	6.05	7.09	11.9	6.51	8.89	42.1
Group Mean			6.46	7.41	10.4	6.56	8.98	29.9
B	64	32	7.33	8.81	30.8	8.41	10.54	61.2
	66	35	7.22	8.09	14.0	8.51	11.22	58.5
	4	36	7.54	9.12	39.6	8.24	11.32	94.8
	73	45	7.19	8.57	22.8	8.37	11.45	116.4
	72	47	7.20	8.37	20.8	7.76	11.04	96.5
	2	88	6.36	7.23	15.6	8.03	10.82	41.8
Group Mean			7.14	8.36	23.9	8.22	11.06	78.2

[a]Twenty male and 20 female worms of each species were randomly selected from each animal.

the calves (Table II and Fig. 3). The size of the *Ostertagia* worms from the various yearlings did not vary appreciably, but the *Cooperia* from the two yearlings examined within six weeks of exposure were greater in size than those from the four animals that were allowed to remain on the infected pasture for longer periods. The *Ostertagia* from the five calves which died within seven weeks of exposure to the infection were all approximately the same size but appreciably larger than those from calf 2 which had a prolonged exposure to infection. Differences in the size of the *Cooperia* from the various calves were not as pronounced. The mean differences in the sizes of the *Ostertagia* and *Cooperia* worms from the yearlings and calves were significant at the 0.01 probability level.

The mean number of eggs *in utero* of *Ostertagia* and *Cooperia* worms from the yearlings was low (less than half as many) compared to that of the calves and was significant for both species at the 0.01 probability level. However, there was considerable variation in the average number of eggs from the worms of individual animals in both groups. In the case of calf 2, there were appreciably fewer eggs, particularly in the *Cooperia* worms, than in the worms from the other five calves which had died much earlier in the infection.

DISCUSSION

The results of this investigation illustrate the marked differences in host response and in parasite populations that may occur in susceptible yearlings and calves when exposed to heavy natural infections of gastrointestinal parasites. The number of *Cooperia* established in the yearlings was appreciably less than in the calves exposed for approximately the same periods of time. This observation differs somewhat from that made during a previous investigation (7) in which comparable *Cooperia* infections were established in both yearlings and calves. However, it would appear that the pasture contamination with *Cooperia* was not as great in this study, based on the average number of *Cooperia* found in the susceptible calves.

As observed previously by the author (7), there is a marked resistance of yearlings to the establishment of *Nematodirus* burdens as indicated by the fact that only one of six yearlings in this study was infected at the time of examination. The infected yearling was the first animal killed after the group was put out to graze on the infected pasture. It may be that some of the animals allowed to remain on the pasture for longer periods initially had *Nematodirus* burdens and had shed them by the time examinations were carried out. This is suggested by the fact that a few *Nematodirus* eggs were shed by yearling 93 on day 26 after exposure but no worms were present when the intestinal tract was examined on day 41. On the other hand, *Nematodirus* burdens were established in all calves as indicated by worm burdens and fecal examinations but a resistance did develop and shedding of the burden did occur in calf 2.

Nematodirus eggs were never recovered from yearling 90 which had a *Nematodirus* burden of 2.450 worms. This was unusual since *Nematodirus* worms shed very low numbers of eggs relative to other worm species. The author previously reported failure to recover *Nematodirus* eggs from a calf which harboured over 9,000 worms at necropsy (7).

The average number of *Ostertagia* established in yearlings was also less than in calves; however, the range in the size of the worm burdens in individual animals was great in both groups of animals.

Another marked difference in the worm populations of the yearlings and calves was the distinct "stunting" of the *Ostertagia*, *Cooperia* and *Nematodirus* worms which established in the yearlings. The worms from all the yearlings were stunted or retarded in growth regardless of whether the animals had a short or prolonged exposure to infection. Stunting of the *Ostertagia* worms, similar in size to those in the yearlings, did occur in calf 2, which had a prolonged exposure to infection. Michel in 1963 (2) also observed stunting of *Ostertagia* in experimental calves given daily doses of *Ostertagia* larvae over a period of time. The *Cooperia* in calf 2 were somewhat smaller than the worms of this species from the other calves, but they were not as stunted as those in the yearlings.

Perhaps the most practical finding of this study was the consistently low egg output of the *Ostertagia* and *Cooperia* worm burdens in the yearlings. The average egg counts in the yearlings seldom rose above 200 epg at any time during the course of the infection, while the mean fecal counts in the calves showed the characteristic rapid rise a few weeks after the animals were exposed to infection, followed by a logarithmic decrease in egg output during the next several weeks (3, 6, 7).

The low fecal egg counts observed in the yearlings may be attributed to several factors. First, the number of eggs produced by the worms in the yearlings was significantly lower than by the worms in the calves. On an average, the worms in the yearlings had less than half as many eggs *in utero* as those of the calves. Secondly, fewer worms were established in the yearlings. Thirdly, yearlings normally have a greater volume of feces so that it would seem reasonable to assume that the number of eggs per gram of feces from a yearling would be lower than that of a calf shedding the same total number of eggs.

It is not known whether the various manifestations of resistance — lower worm burdens, stunting of worms, reduced worm egg output — observed in the yearlings are the result of a true age resistance or a possible sensitization by light infections. While fecal and larval culture examinations indicated that some of the yearlings had light infections of *Ostertagia* and *Nematodirus,* infections were never observed in yearlings 89 and 97, and *Cooperia* were never found in any of the yearlings at any time prior to exposure to the heavily contaminated pasture. Yet the infections established in all animals were similar. Furthermore, yearling 58, which had received 8,000 infective *T. axei* six months prior to exposure, did not appear to have any greater resistance than the other five yearlings not so infected.

Michel (4) states that nearly all reported cases of age resistance can be interpreted in terms of the greater ability of older animals to undergo an immune response. The findings in the yearlings and calves of this study are consistent with this definition and probably are best exemplified by the *Cooperia* and *Nematodirus* worm burdens. In the first one or two yearlings killed early in the course of the infection, there was evidence to suggest that the resistance was not quite as great as it was in the yearlings killed a little later. On the other hand, resistance did not develop in the calves until considerably later.

The end result of the greater resistance of yearlings to gastrointestinal parasitism is their greater ability to withstand the effects of parasitism. This is clearly demonstrated in this investigation where five of six calves died after exhibiting marked clinical signs of parasitism, while the yearlings, although they exhibited signs of unthriftiness and diarrhoea, did survive the infection. Consequently, the difference in susceptibility between calves and older animals to gastrointestinal parasitism is an important consideration in the development and management of pasture grazing programs.

Finally, the consistently low egg output exhibited by worms in the yearlings suggests the limited usefulness of fecal examinations as a reliable aid to diagnosis of gastrointestinal parasitism in cattle. Michel (3) points out that the absolute value of egg counts of cattle is low so that some laboratories use a figure of 500 epg and some a figure as low as 200 epg as significant counts. The results of this investigation would certainly indicate the utilization of the latter value for older animals.

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