Gastrointestinal Nematode Parasites in Saskatchewan Cattle: Egg Count Distributions in Beef Animals

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ABSTRACT

Fecal samples were collected systematically in the spring from cows and yearlings entering, and in the fall from calves leaving, five community pastures in central Saskatchewan. Fecal samples were also collected systematically in the spring from cows entering, and in the fall from calves leaving, an experimental rotational grazing system. Samples were collected from 1398 animals and were examined by a quantitative fecal flotation technique with a sensitivity of ten eggs per gram.

Distributions of nematode egg counts for 11 of the 12 cattle populations sampled were well described by a series of negative binomial distributions. A common value of *k* (a measure of aggregation) could be fitted to the counts from animals of all ages in four of the five community pastures, as well as to the counts from the cows from the fifth community pasture and from the rotational grazing system. A second value of *k* could be fitted to the counts from the calves from these two pastures. In addition, in three of the community pastures animals in the different age groups had the same mean count.

Key words: Cattle, nematodes, negative binomial, Saskatchewan.

RÉSUMÉ

Cette expérience consistait à prélever un échantillon fécal chez un nombre déterminé de vaches et de bovins âgés d'un an, au mois de mai, à leur arrivée dans cinq pâturages publics du centre de la Saskatchewan, ainsi que chez un nombre déterminé de veaux, au mois d'octobre, à leur sortie des pâturages précités. Elle consistait aussi à prélever un échantillon fécal printanier, chez un nombre déterminé de vaches, à leur arrivée dans un pâturage rotatif expérimental, et chez un nombre déterminé de veaux, au moment de leur sortie automnale de ce pâturage. On préleva ainsi des matières fécales chez 1398 sujets et on les examina à l'aide d'une technique de flotation d'une sensibilité de dix oeufs par gramme de fèces.

La distribution des numérations d'oeufs de nématodes concernant 11 des 12 groupes de bovins échantillonnés se trouva très bien décrite par une série de distributions binomiales négatives. Il s'avéra possible d'ajuster une valeur commune de *k*, une mesure d'agrégation, aux numérations d'oeufs relatives aux bovins de tous les âges qui occupaient quatre des cinq pâturages publics, ainsi qu'à celles des vaches du cinquième et du pâturage rotatif expérimental; on réussit également à ajuster une deuxième valeur de *k* aux numérations d'oeufs relatives aux veaux de ces deux pâturages. De plus, les bovins des divers groupes d'âge qui occupaient trois des pâturages publics affichaient une numération moyenne identique.

Mots clés: bovins, nématodes, binôme négatif, Saskatchewan.

INTRODUCTION

In Canada, surveys of gastrointestinal helminths of cattle have been reported only from Ontario (1-4) and Quebec (5). Other studies, concerned with the epizootiology (6,7), clinical significance (8), or production significance (9-11) of these parasites, particularly the nematodes, have, indirectly, provided data on their occurrence. Only one such investigation has been reported from western Canada (9). Also, there are no published reports of statistical distributions of gastrointestinal nematode egg counts in naturally infected cattle. It has been found, however, that the negative binomial describes the distribution of such eggs in sheep (12-14), of the adult nematodes in sheep (15), and of a variety of helminth parasites in various hosts (16,17). The negative binomial distribution is determined by two parameters, the mean, and *k*, a measure of aggregation of the parasites.

This paper describes the results of a preliminary survey, based on quantitative fecal flotations, of the prevalence and distribution among hosts of gastrointestinal nematodes in selected populations of Saskatchewan beef cattle examined at the beginning or end of a summer grazing season.

MATERIALS AND METHODS

Five community pastures (A-E) in central Saskatchewan were selected for inclusion in the study on the bases of geographical location and cooperation from the stock owners and pasture managers. This area of Saskatchewan is characterized by a continental climate: monthly mean temperatures

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-17°C to +19°C; annual rainfall 270 mm; annual snowfall 95 cm. Herbage in the community pastures consisted mainly of a brome/alfalfa/crested wheat grass mixture. The animals entered the pastures in late May and left in mid-October. During the summer the stocking density on the pastures was approximately one cow-calf unit per two hectares.

Each pasture was visited on one or more days during May, as the cattle were entering, and rectal fecal samples were collected from adult cows and, at two pastures, from yearlings also. The sampling was systematic, taking every *n*th animal entering the pasture on the day(s) visited; *n* varied from pasture to pasture. At four of the pastures, samples were collected from approximately one in eight of the animals; at the fifth pasture (E), samples were collected from approximately 1 in 40 of the animals. Samples were identified by pasture and animal age, were transported to the laboratory on ice (but not frozen) and were stored at approximately 4°C prior to examination, which was completed within 36 hours of sampling. Samples were examined using a modified McMaster quantitative flotation technique (18); each egg counted represented ten eggs per gram (epg).

Three of the pastures were visited again in October, as the cattle were leaving, and rectal fecal samples were collected systematically from approximately one in six of the calves. These samples were identified, transported, stored and examined as above.

In addition to animals from community pastures, cattle from an experimental intensive rotational grazing system (F) in east-central Saskatchewan were also examined. In this system, groups of approximately 30 cows and their calves were rotated every two to three weeks among a set of four to six approximately eight hectare paddocks. The herbage in most of these paddocks had a composition similar to that in the community pastures but a few were seeded with Russian wild rye. Each group of animals had its own set of paddocks. Cattle entered the paddocks at the end of May and left in early October. Samples were collected from approximately 60% of the cows at the beginning of the grazing season in May. In mid-November, after the grazing season, samples were collected from approximately 85% of the calves. Samples were obtained from 730 cows, 225 yearlings and 434 calves.

Egg count data were fitted to negative binomial distributions by the method of maximum likelihood estimation and were tested for goodness of fit by the chi-square statistic (19). Hypotheses of equality of populations were tested by likelihood ratio statistics (20).

RESULTS

The results of the quantitative flotations are summarized in Tables I and II and in Fig. 1. The data include neither *Nematodirus* spp., which were found very rarely, nor *Trichuris* spp., which were not found.

Among the community pasture animals, 53% of cows, 44% of yearlings, and 65% of calves were infected with egg-producing adult gastrointestinal nematode parasites. Among the animals on rotational grazing, 63% of the cows and 95% of the calves were infected.

The egg count data for the twelve populations of cattle, except for the cows from community pasture E (Eco), were well described by a series of negative binomial distributions (Table I). The data from pasture E cows, however showed considerable departure from this distribution ($p<0.01$). For this population, there was an excess of samples with 10 epg and a paucity of samples in the 30-60 epg range.

The values of *k* were not equal among these populations ($X^2=62.94$ on 11 df, $p<0.0001$). However, it was possible to partition the populations into two groups: 1) calves from community pasture D (Dca) and from rotational grazing (Fca), and 2) all other populations, such that values of *k* were equal within these two groups (Table II). The mean egg count values of the populations were, however, significantly different within the two groups (group 1: $X^2=6.88$ on 8 df, $p<0.01$; group 2: $X^2=49.44$ on 9 df, $p<0.001$). Within the second group the same mean value could be fitted to all ages of animals within any pasture (Table II). Such a fit did not differ significantly from one involving different parameters for each population ($X^2=14.92$ on 14 df, $p>0.03$). The

TABLE I. Egg Count Data and Estimated Statistical Parameters for Twelve Populations of Saskatchewan Beef Cattle

Pasture and Age Identification	Number of Animals Sampled	Number of Farms Represented[a]	Prevalence of Infection (%)	Mean Count (epg)	Range of Counts (epg)		Goodness of Fit		
						k	X^2	df	p
Aco	216	44	49.1	12.5	0-140	0.59	5.70	4	0.224
Bco	138	36	46.4	11.3	0-120	0.59	0.90	2	0.638
Cco	90	19	61.2	19.9	0-130	0.70	4.97	4	0.290
Dco	80	21	55.0	23.6	0-390	0.39	4.03	4	0.402
Eco	47	12	55.4	26.4	0-240	0.34	7.67	1	0.006
Fco	168	1	62.5	19.1	0-170	0.75	7.26	5	0.205
Aye	66	26	41.0	8.3	0- 60	0.64	0.21	1	0.647
Bye	159	35	46.0	12.0	0-180	0.46	4.12	3	0.249
Bca	125	NA[b]	44.0	11.0	0-150	0.47	0.81	2	0.667
Cca	60	NA	58.4	18.8	0-160	0.61	2.16	2	0.339
Dca	104	NA	91.4	66.3	0-430	1.23	6.79	10	0.745
Fca	145	1	95.2	91.2	0-530	1.44	15.46	15	0.419

[a] Other than those for Fco and Fca, these data may not be totally accurate because two or more owners with the same name may or may not keep their animals on the same farm

[b] NA not applicable (calves from several farms grazed in the same community pasture)

TABLE II. Estimates of Negative Binomial Parameters of Egg Count Data for Twelve Populations of Saskatchewan Beef Cattle, Fitting Common *k* Values Within Group, and Common Means to Different Ages in Pastures

Pasture and Age Identification	Mean Egg Count (epg)	*k*
Aco Aye	11.5	0.55
Bco Bye Bca	11.5	0.55
Cco Cca	19.5	0.55
Dco	23.6	0.55
Dca	66.3	1.35
Eco	26.4	0.55
Fco	19.1	0.55
Fca	91.2	1.35

parameters estimated in this fashion are presented in Table II and the fitted distributions are plotted in Fig. 1.

DISCUSSION

The results presented in this paper provide an indication of the prevalence and distribution of gastrointestinal nematode parasites in Saskatchewan beef cattle, at least as measured by fecal egg counts. However, the data must be interpreted with caution. First, no attempts were made either to identify the nematode parasites producing the eggs or to relate fecal egg counts to parasite populations within the animals. Second, the prevalences in the populations sampled would be underestimated because the flotation technique used is not likely to detect egg counts of <10 epg. In a survey of cattle in Quebec, a McMaster technique with a sensitivity of 50 epg gave prevalences of gastrointestinal helminths, primarily nematodes, of 14%, 25% and 32% in adults, yearlings and calves, respectively (5). Sodium nitrate flotations on the same samples gave prevalences of 50%, 62% and 64.6% (5). Although such simple flotations, without centrifugation, may also underestimate prevalences (21), for adults and calves the latter figures are very similar to those reported in the present study. Comparable surveys in the northern United States (22-27), using quantitative flotation techniques with a range of sensitivities, have shown similar prevalences. In general, prevalences recorded were directly related to the sensitivity of the technique used for fecal examination. Third, the intensity of infection, as measured in the present study by means, ranges and distributions of egg counts, may have been affected by variations in the flotation technique's efficiency of egg recovery at different egg concentrations. Such variations have been reported for a modified McMaster technique with a sensitivity of 50 epg, efficiency increasing from 16% at 7 epg through 63% at 30 epg, to 88% at 60 epg (21). However, the greater sensitivity of the technique used in the present study should have reduced the significance of this source of variation.

In comparing the means and ranges of egg counts from the various populations, values recorded were similar for most groups of the same age and were the same for different age groups in most pastures. Exceptions were the calves from pastures D and F (Dca and Fca). Probably the high mean and range upper limit of the Fca population were due to the intensive system in which these animals were grazed over the summer. It is more difficult to explain why calves from one of the community pastures (Dca) should also have a relatively high mean and range upper limit. The pasture was newly established and, therefore, was perhaps particularly suitable for the development and survival of the parasites' free living stages.

Probably the most interesting features of the present results are the way in which egg counts from 11 of the 12 cattle populations fitted a series of negative binomial distributions and the way in which all the populations, except for two groups of calves (Dca and Fca), showed the same degree of egg count aggregation, as measured by the parameter *k*. In an aggregated distribution such as the negative binomial, most hosts have a few parasites and a few hosts have many. Although more than one mathematical distribution can be applied to relationships between metazoan parasites and their hosts (16), the negative binomial has been found to describe the way in which helminth parasites are distributed among hosts in many systems (16,17), including four genera of gastrointestinal nematodes in sheep (15). In most of the systems studied, these distributions have been based on counts of parasites in hosts. However, using data from a McMaster technique with a sensitivity of 50 eggs per gram, the negative binomial was found to fit the distributions of fecal egg counts of gastrointestinal nematodes from sheep in 13 flocks in Scotland (12) and, using a McMaster technique with a sensitivity of 100 epg, to fit egg count distributions from sheep naturally infected with mixed trichostrongyles and *Nematodirus* spp. (13), and *Haemonchus contortus* (14). In these studies, the distribution was fitted to the data from each of a series of samplings carried out over several months. The range of *k* values for egg counts for the Scottish sheep populations (0.42-1.45), for *N. battus* eggs (0.12-2.05), for *N. fillicollis* eggs (0.27-1.14) and for *H. contortus* eggs (0.5-1.4) were similar to that (0.39-1.44) for the 11 cattle populations in the present study for which the negative binomial distribution fitted well. Ranges of *k* values for adult parasite counts in sheep (1.22-1.49) and for mixed trichostrongyle egg counts (0.98-5.30) were higher than those reported in the present study, indicating less aggregation. These *k* values must, however, be interpreted with care. Differences in host species, geographical location, management systems, egg counting and statistical techniques and the fact that the ranges for the values of *k* for the other egg count studies were calculated from several sets of samples taken over several months, may all influence the distribution of parasites and their eggs.

Because in the present study no attempt was made to quantify parasite populations within the hosts, it was not possible to relate egg counts to adult parasite numbers. For *Ostertagia ostertagi*. the most important and most studied gastrointestinal nematode of cattle, this relationship is difficult to analyze (28,29). It was not possible , therefore, to attempt identification of the factors generating the egg count distributions found in the present study. Indeed, identification and particularly quantitation, of the factors generating parasite distributions within hosts remain elusive (17).

In the present study the eggs counted probably came from several

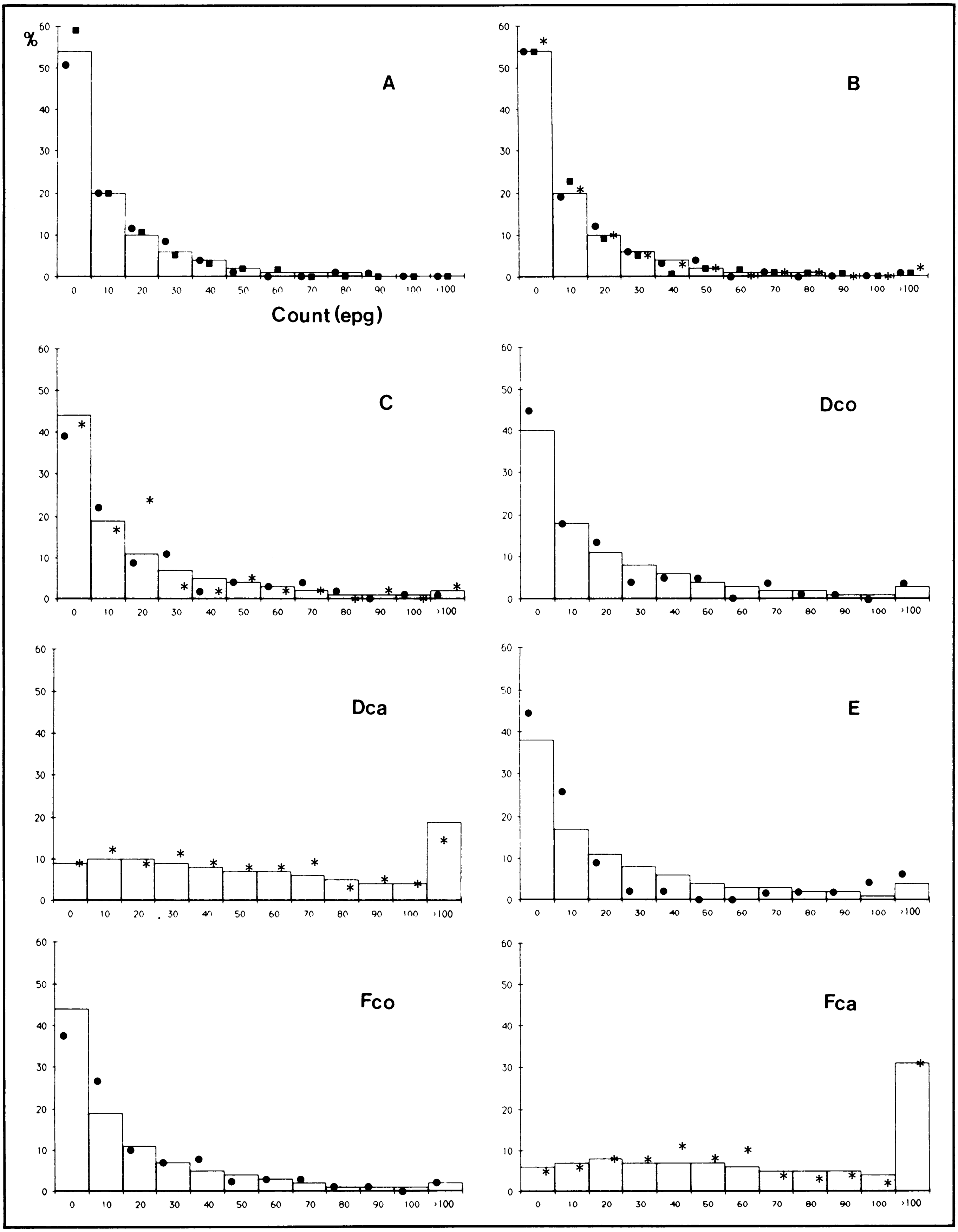

Fig. 1. Expected (columns) and observed (points) nematode egg count data for cows (●), yearlings (■) and calves (*). (Data from animals on the same pasture are on the same histogram except for pastures D and F.)

different genera of nematodes, and the adult parasite populations probably differed qualitatively and quantitatively among the animals sampled. It should also be noted that five of the cow populations (Aca-Eca) and the two yearling populations sampled were composed of a number of subpopulations, each from a different farm. In the present study, however, egg count distributions from samples of cattle from 11 different populations comprising three age classes, and sampled in five different locations on two occasions during the year, were well described by a series of negative binomial distributions. Further, egg counts from 8 of the 11 populations showed a very high degree of aggregation ($k<1$). These distribution data, together with the data for egg count means and ranges, show and interesting degree of uniformity of egg counts among Saskatchewan beef cows and yearlings at the start of a grazing season. There was, however, less uniformity among calves at the end of a grazing season. Individual and age differences in host susceptibility, differences in grazing systems and the effects that these factors have on the timing of maturation of the gastrointestinal nematodes acquired by the calves during the summer probably all had a role in the generation of the calf data.

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