Prevalence and intensity of helminth parasites and coccidia in specific age groups of dairy cattle in southwestern Montana

by Marian Therese Teitsch

A thesis submitted in partial fulfillment of the requirements for the degree of \ Master of Science in Veterinary Science

Montana State University

Abstract:

A survey was conducted to determine the identity, prevalence and intensity of helminth parasites and coccidia in southwestern Montana dairy cattle and to evaluate host age and specific management procedures in their possible relationship to endoparasitic infections. Fecal samples' were collected at five intervals during 1986 from ten dairy farms in Gallatin County. Four specific groups of cattle, the "A," "B," "C" and "D" groups represented separate age categories within each of the ten herds. The "A" group was composed of pre-weaned calves less than three months old, that were housed in indoor or outdoor hutches. Open heifers, three to approximately twelve months of age were denoted as the "B" group. The "C" group ranged in age from 13 to 24 months while the "D" group was comprised of cattle which had calved at least once and were included in the active milking herd.

Data concerning the prevalence and intensity of various helminth parasites and coccidia were gathered and compiled. The results showed that 28.6% of all cattle examined during the survey were positive for gastrointestinal nematode eggs. Five and two-tenths percent, 34.0%, 3 8.8% and 22.0% of the A, B, C and D age groups, respectively, were similarly infected. The most prevalent type of infection (21.5%) was the Cooperia-Trichostrongylus-Ostertagia group, followed by the Haemonchus-Oesophagostomum group (11.6%), Nematodirus spp. (5.6%), Trichuris sp. (1.0%) and Strongyloides papillosus (0.2%). All D age group adult cattle were negative for Nematodirus spp. The B and C age groups had the highest prevalence of infection with gastrointestinal helminths.

The B age group passed the highest number of helminth eggs per gram of feces. The actual distribution of worm burdens followed a negative binomial distribution, with the majority of cattle sampled having light infections.

Dictyocaulus viviparus larvae were recovered only from groups B and C. Five of ten herds were positive for lungworms in group C, whereas group B at two of the ten farms harbored D. viviparus. Mean larval counts for both B and C groups infected with D. viviparus were 40.0 larvae per gram of feces. Lungworm prevalence in pastured replacement heifers was greater than in dryrot managed heifers.

Of 2,000 fecal samples, 33.4% contained one or more of seven Eimeria species identified during the survey. Eimeria canadensis was the most prevalent oocyst observed.

This study indicates that although subclinical parasitism is widespread among the dairy cattle surveyed, groups B and C were the most heavily parasitized with various helminth species and were the only age groups positive for lungworm. Therefore, it is felt that these age groups should be monitored closely and treated for helminth parasites if deemed necessary.

PREVALENCE AND INTENSITY OF HELMINTH PARASITES AND COCCIDIA IN SPECIFIC AGE GROUPS OF DAIRY CATTLE IN SOUTHWESTERN MONTANA

by

Marian Therese Teitsch

A thesis submitted in partial fulfillment
of the requirements for the degree

of

Master of Science

in

Veterinary Science

MONTANA STATE UNIVERSITY
Bozeman, Montana

June 1987

APPROVAL

of a thesis submitted by

Marian Therese Teitsch

This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

13 May 1987 — David E. Worley
Date — Chairperson, Graduate Committee

Approved for the Major Department

May 13, 1987 — C A Speer
Date — Head, Major Department

Approved for the College of Graduate Studies

May 18, 1987 — Henry L Parsons
Date — Graduate Dean

STATEMENT OF PERMISSION TO USE

Signature Marian T Fisher

Date May 13, 1987

ACKNOWLEDGEMENTS

I would like to take this opportunity to express my thanks to all those people who offered encouragement and guidance during this study in Montana. I feel especially thankful for the understanding, patience and assistance of Dr. David E. Worley without whom this project would not have been possible. I thank Dr. Jack Catlin, Dr. William Quinn, and Dr. Donald Burgess for their contributions, time and enthusiasm.

I am grateful to Skip Sterner and my sister Sue, who helped me in the field and to Roli Espinosa for encouragement and help with all aspects of the thesis. Appreciation is expressed to Dr. Richard Lund for assistance with statistical analyses, Mrs. Josephine Jensen for typing the manuscript, and to my family for their continual support throughout the study.

Finally, I would like to thank Dr. Emery Field for his interest and assistance and extend special thanks to the ten dairy cooperators who allowed access to cattle for this study.

TABLE OF CONTENTS

PAGE

ACKNOWLEDGEMENTS.......................................iv

LIST OF TABLES...vi

LIST OF FIGURES..vii

ABSTRACT...viii

INTRODUCTION...1

MATERIALS AND METHODS..................................9

RESULTS..16

DISCUSSION...45

SUMMARY..64

REFERENCES CITED.......................................66

APPENDIX...75

LIST OF TABLES

TABLE PAGE

1. Sampling dates for dairy cattle parasite survey......11
2. Percent of 'B' group heifers infected with helminth parasites at five seasonal intervals........19
3. Percent of 'C' group heifers infected with helminth parasites at five seasonal intervals........19
4. Prevalence of gastrointestinal helminth parasites in 'A' group calves on ten dairy farms..............21
5. Prevalence of gastrointestinal helminth parasites in 'B' group heifers on ten dairy farms..............22
6. Prevalence of gastrointestinal helminth parasites in 'C' group heifers on ten dairy farms..............23
7. Prevalence of gastrointestinal helminth parasites in 'D' group cattle on ten dairy farms..............24
8. Mean gastrointestinal worm egg counts for all cattle sampled during the survey....................28
9. Prevalence (%) of Eimeria spp. in cattle on ten dairy farms..................................41
10. Composite prevalence (%) of Eimeria spp. on ten dairy farms..................................42

LIST OF FIGURES

FIGURE PAGE

1. Location of ten dairy farms surveyed for helminth parasites in southwestern Montana........10
2. Prevalence of gastrointestinal nematodes in dairy cattle in Gallatin County, Montana..........17
3. Frequency distribution of gastrointestinal nematode egg counts in ´B´ group heifers..........30
4. Frequency distribution of gastrointestinal nematode egg counts in ´C´ group heifers..........31
5. Frequency distribution of gastrointestinal nematode egg counts in ´D´ group cattle...........32
6. Mean worm egg counts for cattle infected with gastrointestinal nematodes on ten Montana dairy farms...34
7. Mean worm egg counts for ´B´, ´C´ and ´D´ groups of cattle infected with the _Cooperia_-_Trichostrongylus_-_Ostertagia_ group of nematodes........35
8. Mean worm egg counts for ´B´, ´C´ and ´D´ groups of cattle infected with the _Haemonchus_-_Oesophagostomum_ group of nematodes.....................37
9. Mean worm egg counts for ´B´and ´C´ groups of heifers infected with _Nematodirus_ spp..........38
10. Mean larval counts for ´B´and ´C´ groups of heifers infected with _Dictyocaulus viviparus_...40

ABSTRACT

A survey was conducted to determine the identity, prevalence and intensity of helminth parasites and coccidia in southwestern Montana dairy cattle and to evaluate host age and specific management procedures in their possible relationship to endoparasitic infections. Fecal samples were collected at five intervals during 1986 from ten dairy farms in Gallatin County. Four specific groups of cattle, the "A," "B," "C" and "D" groups represented separate age categories within each of the ten herds. The "A" group was composed of pre-weaned calves less than three months old, that were housed in indoor or outdoor hutches. Open heifers, three to approximately twelve months of age were denoted as the "B" group. The "C" group ranged in age from 13 to 24 months while the "D" group was comprised of cattle which had calved at least once and were included in the active milking herd.

Data concerning the prevalence and intensity of various helminth parasites and coccidia were gathered and compiled. The results showed that 28.6% of all cattle examined during the survey were positive for gastrointestinal nematode eggs. Five and two-tenths percent, 34.0%, 38.8% and 22.0% of the A, B, C and D age groups, respectively, were similarly infected. The most prevalent type of infection (21.5%) was the _Cooperia_-_Trichostrongylus_-_Ostertagia_ group, followed by the _Haemonchus_-_Oesophagostomum_ group (11.6%), _Nematodirus_ spp. (5.6%), _Trichuris_ sp. (1.0%) and _Strongyloides papillosus_ (0.2%). All D age group adult cattle were negative for _Nematodirus_ spp. The B and C age groups had the highest prevalence of infection with gastrointestinal helminths.

The B age group passed the highest number of helminth eggs per gram of feces. The actual distribution of worm burdens followed a negative binomial distribution, with the majority of cattle sampled having light infections.

Dictyocaulus viviparus larvae were recovered only from groups B and C. Five of ten herds were positive for lungworms in group C, whereas group B at two of the ten farms harbored _D. viviparus_. Mean larval counts for both B and C groups infected with _D. viviparus_ were 40.0 larvae per gram of feces. Lungworm prevalence in pastured replacement heifers was greater than in drylot managed heifers.

Of 2,000 fecal samples, 33.4% contained one or more of seven _Eimeria_ species identified during the survey. _Eimeria canadensis_ was the most prevalent oocyst observed.

This study indicates that although subclinical parasitism is widespread among the dairy cattle surveyed,

groups B and C were the most heavily parasitized with various helminth species and were the only age groups positive for lungworm. Therefore, it is felt that these age groups should be monitored closely and treated for helminth parasites if deemed necessary.

INTRODUCTION

An initial step in determining the economic importance of internal parasitism in Montana dairy cattle is to define the extent of the condition. Data on prevalence, intensity and distribution of these parasites are a prerequisite to effective parasite control and yet, no comprehensive surveys on parasitism of Montana dairy cattle have appeared in the literature. Internal parasitism of cattle may be one of the most significant diseases affecting the cattle industry today (Swisher and McGilliard, 1978). Because internal parasitism of dairy cattle is primarily subclinical, it is detectable only by laboratory methods (Yazwinski and Tilley, 1980). Therefore, the presence and damaging effects of internal parasites are often difficult to detect and rarely suspected by dairymen. Internal parasitism is an especially important disease in young dairy heifers. These animals, if housed in a contaminated environment, quickly acquire worm burdens (Anderson and Waller, 1983) which can place constraints on the rate of development, feed intake and utilization, weight gain, and possibly lifetime productivity of affected cattle (Yazwinski and Tilley, 1980; Gibbs, 1982). It has been speculated as well that nematodiasis of young cattle may have a harmful effect on milk production during first lactation (Gibbs, 1982).

The prevalence and severity of helminth disease is due to many factors, some of which include climate, weather, management practices, host age, heredity and physiological state (Anderson and Waller, 1983). Although it appears that helminth populations undergo seasonal variation, helminths are constantly present in dairy animals and larvae are constantly available to infect new hosts and reinfect previously infected hosts (Gutierres et al., 1979).

Subclinical parasitism in dairy cattle has been reported for a number of years and in many countries (Fréchette and LaMothe, 1981). Some of the studies involved necropsy data, while others based their results on fecal egg counts. In Germany, Barth et al. (1981) reported that 100% of mature dairy cattle examined were harboring moderate nematode burdens, yet only 13.0% were passing detectable numbers of eggs. In Ireland, 23 helminth species were identified, with Ostertagia spp. being the most common (Taylor and Cawthorne, 1972). Rose (1968) recorded similar data in southeast England, while Fox and Jacobs (1981) determined that 85.2% of 460 adult cows in Great Britain harbored patent nematode infections. In Great Britain, Ostertagia ostertagi was identified as the most prevalent species (Hong et al., 1981), as was the case in the Netherlands (Borgsteede and van der Burg, 1982). In Switzerland, Eckert and coworkers (1981) noted that high percentages of calves on alpine pastures were excreting coccidian oocysts during the grazing season. In contrast, statistics for coccidiosis are nonexistent in France. Parasitic gastroenteritis in France is mainly due to infections with Ostertagia ostertagi and Cooperia oncophora (Raynaud et al., 1981a). Dictyocaulus viviparus, the cattle lungworm, was commonly found in wet grazing areas in northwestern and central France (Raynaud et al., 1981a). Dictyocaulus viviparus was also noted in Pakistani cattle in a survey which found that 304 of 726 cattle examined (41.87%) were found to be infected with various helminthic species (Afzal et al., 1981). In a survey conducted in the Libyan Arabic Republic, Goda (1974) found that 52.7% of the cattle sampled were infected with Dictyocaulus viviparus and in Korea, D. viviparus was found in the lungs of necropsied cattle (Lee et al., 1973). Sauvage and coworkers (1974) reported high prevalence of Haemonchus spp. (65.1%), Bunostomum phlebotomum (13.3%), and Oesophagostomum radiatum (12.7%) in Ugandan calves less than a year of age. Based on their study, 16.0% of these cattle had 500 or more eggs per gram of feces, while 50.0% had 200 eggs per gram of feces. Overend (1984) reported that small numbers of abomasal trichostrongyles were found in 93.0% of Australian cattle surveyed. In this study and in surveys conducted in New Zealand (Brunsdon, 1964; Brunsdon, 1969; McKenna, 1983), Ostertagia spp., Trichostrongylus spp., and Cooperia spp. appeared to be the most prevalent. In the tropical climate of Puerto Rico, Dikmans (1952) determined that Haemonchus contortus and Oesophagostomum radiatum were the most prevalent species. Dictyocaulus viviparus has been shown to be widespread in the province of Quebec (Gupta and Gibbs, 1975). Ostertagia spp. and Cooperia spp. are the gastrointestinal helminths of primary importance in Quebec (Fréchette and Gibbs, 1971), while in British Columbia, Bruce (1921) reported that coccidia were prevalent in range cattle of all ages. Subclinical parasitism in dairy cattle therefore has been reported in many surveys from many areas of the world.

Reports from across the United States indicate that parasitism is widespread and not restricted to any one geographic area (Malczewski et al., 1975). Surveys indicate further that dairy cows generally have low worm burdens (< 3000) and low fecal egg counts (< 10 eggs per gram of feces), although there is a high prevalence of infection (> 80%)(Herd, 1983b).

In a Maine dairy cattle survey, the overall prevalence of gastrointestinal parasites was 95.7, 98.7 and 96.7% for adult cattle, heifers, and calves, respectively (Gibbs et al., 1975; Yazwinski and Gibbs, 1975). Ostertagia spp. and Cooperia spp. comprised the highest percentage of the total worm burden in a survey conducted by Randall and Gibbs (1977). In this survey, Nematodirus spp. and Oesophagostomum spp. were less prominent species, and Moniezia sp., the cattle tapeworm, was found in 25.1% of the cattle surveyed. Dictyocaulus viviparus was rarely noted in these surveys. Stoddard (1971) found that 74.0% of calves, 87.0% of heifers and 40.0% of the adult cattle in New Hampshire were infected with gastrointestinal parasites. Coccidial infections were reported to be common but comparable to infection rates in Wisconsin, Montana and Illinois. Ostertagia spp., Trichostrongylus spp. and Cooperia spp. were the most common genera of parasites in New York calves (Baker, 1949), while in Ohio, cows and heifers were passing eggs of the aforementioned species in addition to eggs of Haemonchus spp. (Herd et al., 1980). In Pennsylvania, Rothenbacher and coworkers (1980) found an overall infection rate of 44.0 percent with an average egg per gram count of 13.0 in cattle from three to 24 months of age. In adult cattle, the average egg per gram count decreased to 3.6. Studies in North Carolina indicated that Haemonchus spp. were the most prevalent gastrointestinal helminth while Eimeria bovis was the most common coccidian oocyst observed (Bell, 1957; Grisi and Todd, 1978). In Florida, Cooperia spp., Haemonchus spp. and Ostertagia spp. were found in 100%, 85.0%, and 75.0%, respectively, of calves from four to twelve months of age (Becklund, 1961). Ostertagia spp. were the most prevalent gastrointestinal helminth in Georgia cattle (Andrews et al., 1953; Becklund, 1962).

Ciordia (1975), in a survey of gastrointestinal parasitism in Georgia, found that 98.0% of calves, 80.0% of heifers and 58.0% of adult cattle were infected with internal parasites. Coccidia were present in 71.0% of these cattle, with the highest prevalence noted in calves, while Moniezia sp. was present in both calves and heifers. Nine eimerian species were found in the feces of calves in Alabama (Christensen, 1941; Davis and Bowman, 1951), while in Mississippi, five species were reported (Ward, 1946). A survey done in Arkansas (Yazwinski and Tilley, 1980) revealed that Cooperia spp. were the most prevalent nematodes on twenty farms surveyed. Two studies carried out on Wisconsin dairy farms determined that Haemonchus sp. was a major parasite as were Ostertagia spp. (Grisi and Todd, 1978; Gutierres et al., 1979).

Ten species of coccidia were found in another Wisconsin study (Hasche and Todd, 1959). In Kentucky, lungworm larvae were found in 86.0% of calves surveyed on pasture (Lyons et al., 1981). Sharma and Case (1962) found that Haemonchus sp. was most prevalent in a study completed in Missouri. Data from Iowa (Zimmermann and Hubbard, 1961) showed that coccidia were present in 34.8% of cattle surveyed. These cattle had a 47.4% prevalence of trichostrongyles, while Leland and coworkers (1973) found a 67.3% prevalence rate for gastrointestinal nematodes in a Kansas survey. In Oklahoma, 95.0% of all nematodes were Ostertagia spp.

(Cooperider et al., 1948). In Texas (Smith, 1967; Bell, 1977) as in New Mexico and Arizona (Becklund and Allen, 1958), Haemonchus spp. and Ostertagia spp. were most prevalent in dairy cattle. Dictyocaulus viviparus was often seen and was a primary cause of death in Texas calves (Smith, 1967). A survey for gastrointestinal parasites of cattle in Wyoming showed that Cooperia spp. and Ostertagia spp. were most common (Honess and Bergstrom, 1963). Eight eimerian species were identified in 72.0% of Oregon cattle (Nyberg et al., 1967) while in Washington, Malczewski and coworkers (1975) found that 77.0% of fecal samples examined contained Eimeria oocysts. Ostertagia spp. were reported as the most prevalent nematode in cattle, while Dictyocaulus larvae were seen in only 1.0% of cattle there (Malczewski et al., 1975).

Data concerning internal parasites of dairy cattle are available from many areas of the United States but are lacking in the state of Montana. Relatively little information was available on bovine endoparasitism in the northern Great Plains and Rocky Mountain region of the United States prior to the studies of Jacobson and Worley (1969), who conducted a survey which defined the incidence, distribution and intensity of helminth parasites and coccidia in Montana beef cattle. In their survey, 85.6% of 486 calves and 59.1% of 479 cows were infected with gastrointestinal nematodes. The prevalence of the Cooperia-Trichostrongylus-Ostertagia complex was greatest with a 69.7% infection rate. The average egg per gram of feces (EPG) count for all cattle in the survey was 16.8 while the mean egg count for calves was 26.7 EPG and 6.7 EPG for adult cattle. Moniezia sp. was found in 10.1% of calves and 4.2% of adult cattle, while 64.9% of all cattle were infected with coccidia. The distribution of Dictyocaulus viviparus, previously unrecognized in Montana, was studied by Jacobson and Worley (1969) as well. Dictyocaulus viviparus larvae were detected in fecal samples of 7.1% of 422 calves. All adult cattle were negative for this parasite. In a later study, Winters and Worley (1975) detected lungworm in 27 of 35 herds surveyed. This survey revealed that 7.8% of all cattle were positive for lungworm with a prevalence of 6.6%, 11.5% and 3.3% prevalence in calves, yearlings and cows, respectively.

Since similar information on endoparasitism in Montana dairy cattle is non-existent, a survey was designed to determine the identity, prevalence and intensity of helminth parasites and coccidia in southwestern Montana dairy cattle, and to evaluate host age and specific management procedures in their possible relationship to endoparasitic infections in these cattle.

MATERIALS AND METHODS

Ten dairy farms in Gallatin County were identified as stations for the study of internal parasites of dairy cattle in southwestern Montana. Two of the farms were located in the Bozeman area, one near Manhattan, six in the vicinity of Amsterdam, and one outside of Belgrade (Figure 1). The ten dairy farms were chosen on the basis of two criteria: 1) importance as a center of dairy production, and 2) the dairy manager's willingness to participate in the study. The farms were located in a relatively concentrated area with the two most distant farms lying approximately 32 miles apart. Although the farms were located within relatively close proximity of one another, the topography varied from valley lowland to mountainous terrain, at elevations ranging from approximately 1,311 to 1,527 m above sea level. Management practices and degree of mechanization varied from farm to farm as well, creating unique environments at each site.

A total of 2000 fecal samples was collected at five intervals from milk fed calves housed in hutches, heifers from three to approximately twelve months of age, older heifers thirteen to twenty-four months of age, and adult milking cattle. These samples were collected during the period of 31 January 1986 to 11 November 1986. Five seasonal

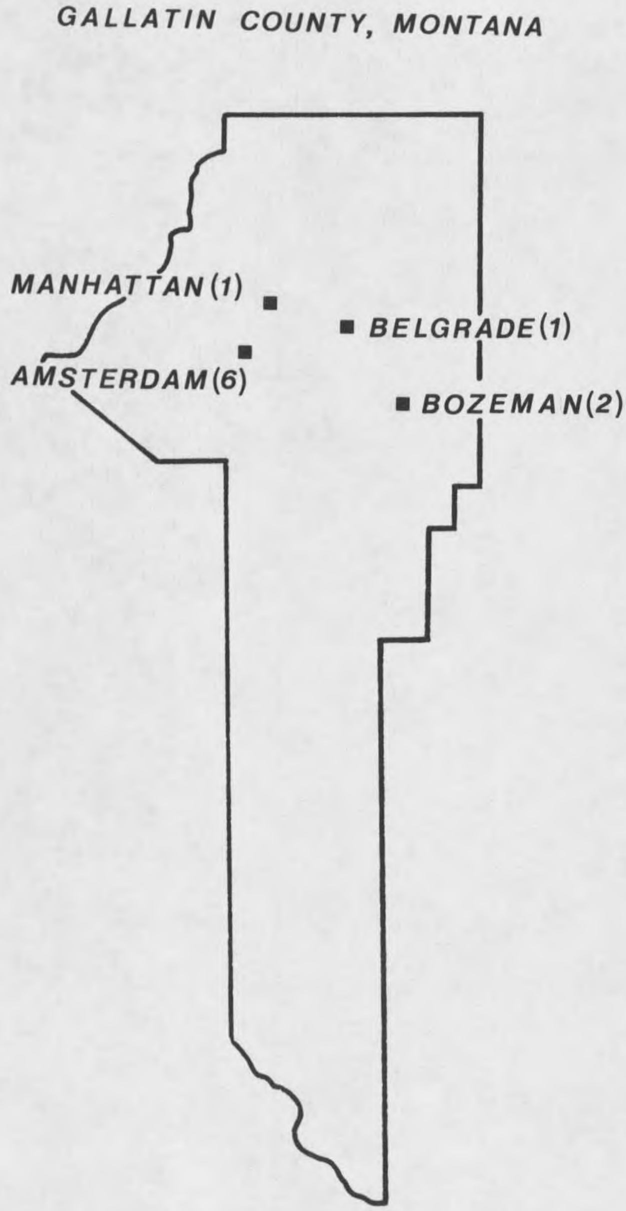

Figure 1. Location of ten dairy farms surveyed for helminth parasites in southwestern Montana.

sampling periods were chosen for all ten farms (Table 1). Samples were obtained from cattle which were grouped and coded according to age and stage of development. Since the majority of the dairymen participating in this study grouped their cattle according to either age or level of development, the following groups were relatively uniform from farm to farm. All fecal samples were obtained from calves by the direct rectal method. All other cattle fecal samples were obtained within a few minutes after deposition by random lot or pasture sampling methods. On each farm, five random

Table 1. Sampling dates for dairy cattle parasite survey.

	Season				
Dairy farm	Winter 1986	Spring 1986	Summer 1986	Fall 1986	Late Fall 1986
1	21 Feb	03 June	04 Aug	15 Sept	06 Nov
2	20 Feb	13 May	21 July	12 Sept	30 Oct
3	31 Jan	17 Apr	20 June	10 Sept	28 Oct
4	31 Jan	04 Apr	16 June	11 Sept	11 Nov
5	06 Feb	06 May	14 July	12 Sept	04 Nov
6	20 Feb	20 May	28 July	09 Sept	23 Oct
7	27 Feb	09 June	11 Aug	15 Sept	06 Nov
8	07 Feb	29 Apr	07 July	16 Sept	04 Nov
9	27 Feb	27 May	04 Aug	12 Sept	30 Oct
10	07 Feb	22 Apr	30 June	09 Sept	23 Oct

samples were obtained from calves in hutches, fifteen samples from open heifers, and ten samples were collected from both bred heifers and milking cattle. The calves were generally housed in indoor or outdoor hutches up until two to three months of age, at which time they were weaned. These animals, which were coded as the "A" group, were then placed in outdoor pens or on pasture depending on the management practice which characterized each individual farm. The "B" group was composed of open heifers ranging from three to four months of age to approximately fifteen months of age. The bred heifers, or "C" group, were generally sixteen to twenty-four months of age. Animals classified as milking cattle, the "D" group, were those cattle which had calved at least once and were currently part of the active milking herd.

Fecal samples were transported to the laboratory where a 60-gram portion of each was immediately processed for lungworm (Dictyocaulus viviparus) larvae with the standard Baermann technique (Baermann, 1917). Some of the samples were refrigerated at 4 $^{\circ}$ C for approximately twelve hours before they were processed. A ten-gram portion of each fecal sample was then assayed for gastrointestinal parasites with the Lane centrifugal flotation method (Lane, 1928). When assaying for lungworm larvae, 250 ml funnels were used. A 60-mesh screen, six centimeters in diameter, was placed in the funnel, approximately four cm. from the top. The feces was weighed and placed in an 18 cm^2 piece of cheesecloth and then placed in the funnel which had been previously clamped and filled with water.

The Lane quantitative flotation method (Lane, 1928), as modified by Dewhirst and Hansen (1961), was used to determine the total number of nematode eggs per gram of feces (EPG), the presence or absence of tapeworm eggs and the presence and frequency of coccidian oocysts. A saturated NaCl solution (Specific gravity = 1.2) was used as the flotation medium. Differential worm egg counts were made according to the egg classification criteria of Levine (1978).

Coccidian oocysts were differentiated on the basis of morphologic features. Oocysts were not counted but were ranked according to relative frequency. When one to several oocysts were present under a 22 mm. coverslip, the infection was designated as a +1. If one to three oocysts were observed per low power field (75X), the infection was classified as a +2. Four to seven or more oocysts per field were ranked as a +3. Individual species of *Eimeria* were not ranked according to frequency but were noted if present, to determine the relative species fluctuations between dairy farms and at the same dairy farm.

With the assistance of committee members and a local veterinarian, a questionnaire was written to determine management practices at each of the ten dairy farms.

Questions were written with reference to four major management categories: 1) feeding, 2) housing, 3) use of medications and 4) health problems (Appendix). To determine basic similarities and differences between the dairy farms and in an attempt to categorize the farms on the basis of management, similar questions under the four management categories were formulated for the four cattle age groups on each farm. With the cooperation of each dairy manager, the questionnaires were completed.

Seasonal helminth parasite prevalence data for B and C group heifers were analyzed. For each of the five sampling periods, the number of B and C group heifers infected with the Cooperia-Trichostrongylus-Ostertagia complex (classified as group I nematodes), the Oesophagostomum-Haemonchus complex (classified as group II nematodes), Nematodirus spp. and Dictyocaulus viviparus (the cattle lungworm) were compared. General seasonal trends in the number of infected B and C group heifers infected with the above helminths were noted. Since the survey was conducted over a one year period, it was concluded that observations over a more extensive period would be necessary to correlate seasonal trends with bovine endoparasitism at the participating farms.

Data were analyzed using the completed questionnaires. Summary statistics and comparison of means tests (Lund, 1985) were used for data analysis as well. Chi-square tests were used to determine if significant differences existed between prevalence data for cattle on the ten dairy farms. Chi-square tests were also used to determine if significant differences existed among management practices on the ten farms. The Spearman rank test (Lund, 1985) was used to determine whether parasite populations could be correlated with an overall management index derived from analysis of each question form. The Fischer test (Lund, 1985) was used to determine if significant differences existed in the prevalence of *D. viviparus* for heifers maintained under drylot versus pasture conditions. P values < 0.05 were considered statistically significant.

RESULTS

Of 2000 bovine fecal samples from all animals examined during the survey, 28.6% were positive for gastrointestinal nematode eggs. Analysis of prevalence data by dairy farm indicated that gastrointestinal nematode infections ranged from 4.0% at farm 1 to 44.5% at farm 7 (Figure 2). Forty-three percent, 39.5%, 38.5%, 35.0% and 31.5% of the cattle from farms 3, 10, 5, 6 and 2, respectively, were infected with gastrointestinal nematodes, indicating an 11.5% difference in prevalence of infection between farm 3 and farm 2. Stomach and intestinal nematode eggs were found in 23.0%, 17.5% and 9.5% of bovine fecal samples from farms 9, 8, and 4, respectively.

Prevalence data analyzed by age group revealed that 5.2% of 250 calves 3 months and younger were infected with gastrointestinal nematodes, while 34.0% of 750 open heifers (B group) harbored similar infections. In the C group (bred heifers), there was a 38.8% prevalence of gastrointestinal nematode infection, while the mature dairy cattle (D group) maintained a 22.0% infection rate. Prevalence data revealed that the B and C groups were generally the most heavily parasitized groups at all ten farms. The A group had the lowest rate of infection with gastrointestinal nematodes. The prevalence of gastrointestinal parasite

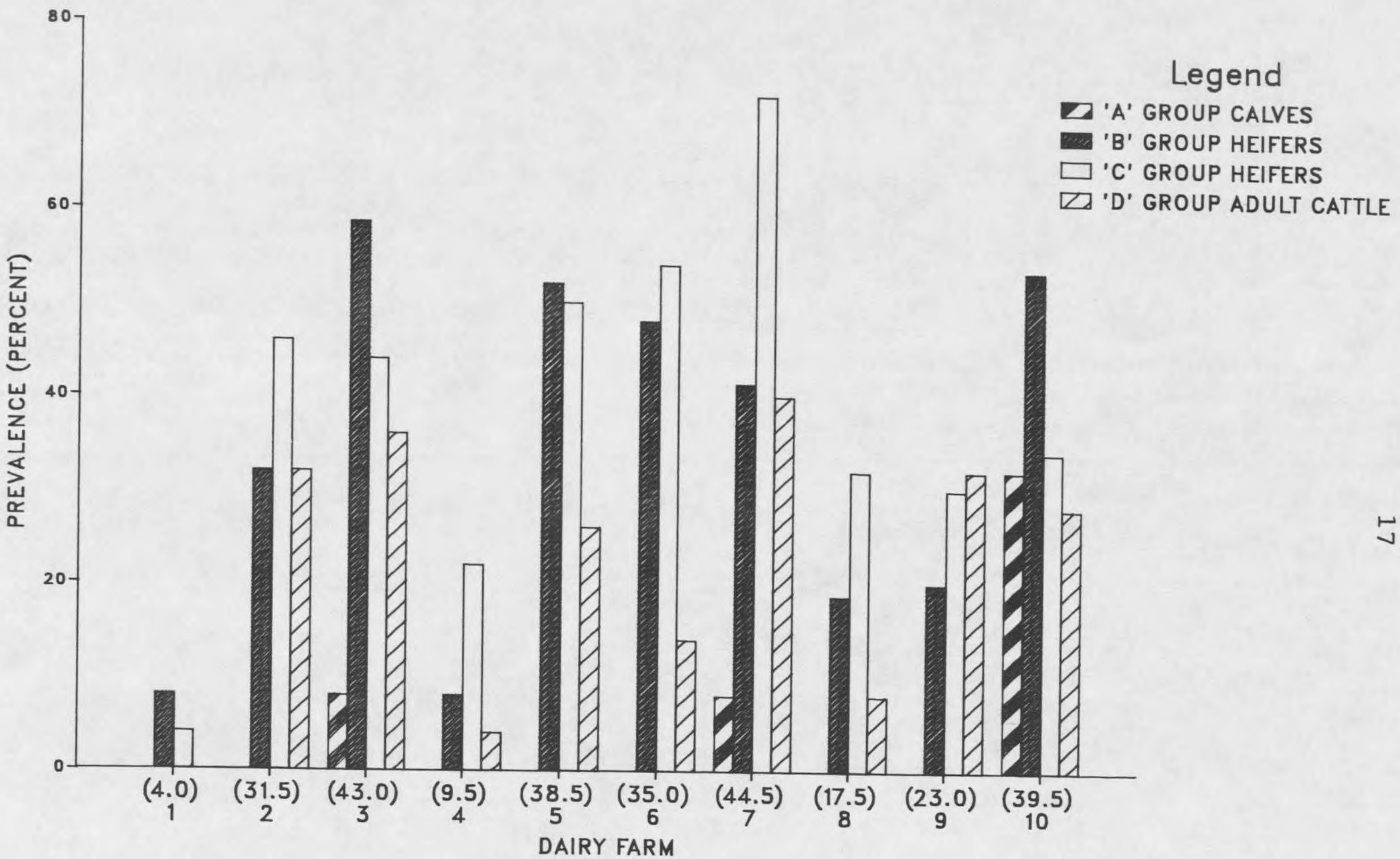

Figure 2. Prevalence of gastrointestinal nematodes in dairy cattle in Gallatin County, Montana.( )= overall % infected animals per farm.

infection in the D group was generally greater than the rate of infection in the A group, yet less than the infection rates of both groups B and C. The chi-square test was used to compare the total number of infected animals in each separate age group. No significant difference was noted in the number of infected animals between the B and C groups. However, these two groups had significantly greater numbers of infected animals than either the A or D groups ($p<.001$).

Because heifers in the B and C groups were the most heavily parasitized, parasite prevalence data for these two groups were analyzed to determine if seasonal variations in the number of infected animals in these groups occured during the course of the study (Tables 2 and 3). Overall percent prevalence of group I, group II, Nematodirus spp. and Dictyocaulus viviparus were calculated for B and C group heifers for each of the five seasonal sampling periods.

Prevalence data revealed that the number of B group heifers infected with group I nematodes was lowest in the winter sampling period (12.0%), rose in the spring, remained relatively high through the summer period and reached a peak in the fall (31.0%). The number of B group heifers infected with group II nematodes followed a similar trend. A fall peak in the number of B group heifers infected with Nematodirus spp. was noted as well. However, the number of heifers infected with this parasite remained high through

Table 2. Percent of 'B' group heifers infected with helminth parasites at five seasonal intervals.*

Parasite	Winter 1986	Spring 1986	Summer 1986	Fall 1986	Late Fall 1986
		Sample Period			
Group I[a]	12.0	27.0	25.0	31.0	25.0
Group II[b]		4.0	14.0	29.0	27.0
Nematodirus spp.	10.0	9.0	9.0	14.0	11.0
Dictyocaulus viviparus			3.0	3.0	

* Blank space denotes zero value.
a *Cooperia*-*Trichostrongylus*-*Ostertagia*
b *Haemonchus*-*Oesophagostomum*

Table 3. Percent of 'C' group heifers infected with helminth parasites at five seasonal intervals*.

Parasite	Winter 1986	Spring 1986	Summer 1986	Fall 1986	Late Fall 1986
		Sample Period			
Group I[a]	22.0	39.0	45.0	33.0	26.0
Group II[b]	1.0	9.0	10.0	30.0	24.0
Nematodirus spp.	4.0	1.0	1.0	1.0	12.0
Dictyocaulus viviparus		6.0	16.0	7.0	

* Blank space denotes zero value.
a *Cooperia*-*Trichostrongylus*-*Ostertagia*
b *Haemonchus*-*Oesophagostomum*

the late fall and winter sample periods and tapered with the onset of spring. *Dictyocaulus viviparus* larvae were noted in B group heifers only during the summer and fall sampling periods. The number of infected animals was comparable in both periods.

The number of C group heifers infected with group I nematodes was lowest in the winter sample period. The number of group I infected animals rose in spring, peaked in the summer and gradually tapered through the fall and late fall sampling periods. Numbers of C group heifers infected with group II nematodes increased from 1.0% in the winter period to a peak of 30.0% in the fall sample period. The number of *Nematodirus* spp. infected C group heifers was highest in late fall and remained relatively high through the winter period. Very few C group heifers were positive for *Nematodirus* spp. during the spring, summer and fall periods. *Dictyocaulus viviparus* larvae were noted in feces of C group heifers in the spring, summer and fall sampling periods. The number of C group heifers that were passing lungworm larvae reached a peak in the summer sampling period. No lungworm larvae were found in the feces of either B or C group heifers in either the fall or late fall sampling periods.

Tables 4, 5, 6 and 7 list the prevalence of gastrointestinal helminth parasites in each of the four cattle groups on the ten dairy farms.

Table 4. Prevalence of gastrointestinal helminth parasites in 'A' group calves on ten dairy farms. *,a

Farm No.	1	2	3	4	5	6	7	8	9	10	$\overline{X}$[b]
No. of animals examined	25	25	25	25	25	25	25	25	25	25	
Gastrointestinal nematodes combined			8.0				8.0	4.0		32.0	5.2
Cooperia-Trichostrongylus-Ostertagia										20.0	2.0
Haemonchus spp. *Oesophagostomum* spp.										8.0	0.8
Nematodirus spp.							8.0	4.0		16.0	2.8
Trichuris sp.			8.0							4.0	1.2
Strongyloides papillosus											
Moniezia sp.											

* Values represent % positive for the given parasite.
a Blank space denotes zero value.
b Mean prevalence for all farms.

Table 5. Prevalence of gastrointestinal helminth parasites in 'B' group heifers on ten dairy farms. *,a

Farm No.	1	2	3	4	5	6	7	8	9	10	$\bar{X}^b$
No. of animals examined	75	75	75	75	75	75	75	75	75	75	
Gastrointestinal nematodes combined	8.0	34.7	58.7	9.3	52.0	48.0	33.3	14.7	21.3	56.0	33.6
Cooperia-*Trichostrongylus*-*Ostertagia*	2.7	25.3	52.0	5.3	44.0	42.7	13.3	2.7	13.3	41.3	24.3
Haemonchus sp. *Oesophagostomum* spp.		1.3	30.7	2.7	28.0	30.7	4.0		9.3	25.3	14.9
Nematodirus spp.	5.3	5.3	22.7	6.7	6.7	13.3	27.0	12.0	6.7	16.0	12.1
Trichuris sp.	1.3		8.0		4.0				1.3	2.7	1.7
Strongyloides papillosus		1.3	1.3							1.3	0.4
Moniezia sp.				4.0		10.7				8.0	2.3

* Values represent % positive for the given parasite.
a Blank space denotes zero value.
b Mean prevalence for all farms.

Table 6. Prevalence of gastrointestinal helminth parasites in 'C' group heifers on ten dairy farms. *,a

Farm No.	1	2	3	4	5	6	7	8	9	10	$\overline{X}^b$
No. of animals examined	50	50	50	50	50	50	50	50	50	50	
Gastrointestinal nematodes combined	6.0	46.0	46.0	22.0	50.0	54.0	52.0	32.0	32.0	38.0	40.0
Cooperia-Trichostrongylus-Ostertagia	2.0	40.0	42.0	12.0	42.0	52.0	60.0	26.0	24.0	32.0	33.2
Haemonchus spp. *Oesophagostomum* spp.	2.0	12.0	12.0	2.0	20.0	20.0	30.0	18.0	18.0	12.0	14.6
Nematodirus spp.	2.0			8.0	2.0	2.0	6.0	4.0	4.0		2.8
Trichuris sp.			2.0			2.0			2.0	2.0	0.8
Strongyloides papillosus											
Moniezia sp.		2.0	4.0			12.0	8.0			2.0	2.8

* Values represent % positive for the given parasite.
a Blank space denotes zero value.
b Mean prevalence for all farms.

Table 7. Prevalence of gastrointestinal helminth parasites in 'D' group cattle on ten dairy farms. *,a

Farm No.	1	2	3	4	5	6	7	8	9	10	$\bar{x}$[b]
No. of animals examined	50	50	50	50	50	50	50	50	50	50	
Gastrointestinal nematodes combined		32.0	38.0	6.0	26.0	14.0	40.0	8.0	32.0	28.0	22.4
Cooperia-Trichostrongylus-Ostertagia		26.0	26.0	6.0	12.0	8.0	32.0	6.0	24.0	24.0	16.4
Haemonchus spp. _Oesophagostomum_ spp.		14.0	10.0	4.0	16.0	8.0	10.0	4.0	20.0	4.0	9.0
Nematodirus spp.											
Trichuris sp.											
Strongyloides papillosus								2.0			0.2
Moniezia sp.	2.0	6.0	2.0	2.0		2.0	8.0		10.0	4.0	3.6

* Values represent % positive for the given parasite.
a Blank space denotes zero value.
b Mean prevalence for all farms.

Eggs of group I nematodes were found in feces from 21.6% of the cattle examined. Only five calves (2.0%) were infected with group I parasites while 182 (24.3%), 166 (33.2%), and 82 (16.4%) of the B, C and D groups, respectively, were similarly infected. A higher percentage of cattle in each group from each of the ten dairy farms was passing group I eggs than any other helminth egg or larva observed during the study.

In all but the A group, the next most prevalent gastro-intestinal helminth eggs observed were those of the group II complex. Nematodirus spp. were most prevalent in the A group and were found in 2.8% of calves while only 0.8% of all calves were infected with the group II nematodes (Table 4). Group II eggs were found in 11.6% of all fecal samples examined. The B and C groups had comparable infections of group II nematodes with a 14.9% and 14.6% prevalence, respectively, while 9.0% of adult cattle were positive for this group of parasites. Calves from all farms (except farm 10) were negative for group II parasites. Cattle in the B group from all farms harbored group II nematodes with the exception of the heifers from farms 1 and 8. All cattle in the C group were infected with this group of parasites while only farm 1 had adult cattle that were free of this group of nematodes. The highest prevalence for group II parasites was recorded from heifers in the B group at farms 3 and 6 (30.7% positive).

Eggs of Nematodirus spp. were found in 5.6% of all cattle examined. Twelve and one-tenth percent and 2.8% of groups B and C, respectively, were infected with Nematodirus spp. while all adult cattle were negative for this parasite. The B group of heifers at farm 7 showed the highest incidence for Nematodirus spp. (27.0%).

Other gastrointestinal helminth eggs observed and the percentage of positive cattle were: Trichuris sp., 1.0% and Strongyloides papillosus, 0.2%. Trichuris sp. eggs were found in 8.0% of calves at farm 3 and 4.0% of calves at farm 10. All other calves were negative for whipworm. Five of the ten farms harbored Trichuris sp. in the B group with an overall prevalence of 1.7% in this group. Farms 3, 6, 9 and 10 all had 2.0% prevalence of Trichuris sp. eggs in the C group heifers while adult cattle on the ten farms were negative for this parasite. Strongyloides papillosus was not present in either the A or C groups of cattle and was seen only in 0.4% of the B heifers and 0.2% of the D group of cattle.

Two and five-tenths percent of 2000 cattle were passing Moniezia sp. eggs in their feces. These eggs were not found in any of the A group calves but were found in 2.3%, 2.8% and 3.6% of B group heifers, C group heifers and D group cattle, respectively. In the B group, only cattle at farms 4, 6 and 10 were infected with Moniezia sp. Cattle in the C group at farms 2, 3, 6, 7 and 10 were positive for

<u>Moniezia</u> sp. while only on farms 5 and 8 were adult cattle in the D group free of this cestode. Twelve percent of the C group heifers and 10.7% of the B group heifers at farm 6 were infected with tapeworms. Less than 10% of the B group heifers, C group heifers and D group cattle from all other farms harbored <u>Moniezia</u> sp.

<u>Dictyocaulus</u> <u>viviparus</u> larvae were recovered only from B group and C group heifers. All 250 calves and 500 adult cattle were found to be negative for this parasite. Five of the ten farms were positive for lungworms in the C group heifers whereas B group heifers at two of the ten farms harbored <u>D</u>. <u>viviparus</u>. The highest prevalence of lungworm occurred in C group heifers from farm 2 where 16.0% of 50 animals were positive. Of the C group heifers at farms 6 and 7, 12.0% were positive, while 10.0% and 8.0% of these heifers at farms 3 and 5, respectively, were similarly infected. One-tenth percent (1 animal in 75) and 1.3% (9 animals in 75) of B group heifers from farms 3 and 6, respecively, were infected with <u>D</u>. <u>viviparus</u>.

The average number of nematode eggs per gram of feces for all cattle sampled was 3.1 (range 0-222). The intensity of parasite egg production in cattle was compared between dairy farms (Table 8). Heifers in the B group at farm 3 were passing more eggs per gram of feces (avg. 36.5) than animals from any other farm (Table 8). Calves from farm 10 had a mean count of 26.3 EPG while 2.0, 3.0 and 4.0 EPG were

Table 8. Mean gastrointestinal worm egg counts for all cattle sampled during the survey.*

Farm	Group A	B	C	D	Overall Prevalence[a]
1		5.3	4.0		4.9
2		10.6	5.0	9.5	8.3
3	3.0	36.5	8.5	1.7	21.3
4		17.0	3.6	14.7	9.3
5		10.2	5.6	3.5	7.6
6		17.8	6.7	3.1	12.2
7	2.0	4.5	9.1	4.2	6.3
8	4.0	2.5	9.1	2.5	5.9
9		6.5	18.2	6.9	10.0
10	26.3	15.6	6.8	4.7	12.8

a Measured as eggs per gram of feces (EPG).
* Blank space denotes zero value.

the average figures for calves on farms 7, 3, and 8 respectively. All other A group calves at the remaining farms were negative. Heifers in the B group at farms 6, 4, 10, 2 and 5 had mean counts of 17.8, 17.0, 15.6, 10.6, and 10.2 EPG, respectively. Less than 10.0 EPG were recorded for B groups at the remaining 4 farms. Heifers in the C group at farm 9 had an average of 18.2 EPG. Heifers in the C group at the other nine farms had counts of less than 10.0 EPG. None of the adult cattle at farm 1 passed eggs. Milking cows at farm 4 had an average EPG count of 14.7

while 9.5 and 6.7 EPG were the averages for cattle located at farms 2 and 9, respectively. All other farms showed averages of less than 5.0 EPG for the D group cattle.

Calves were passing an average of 0.9 EPG (range 0-146), while B group heifers had a mean count of 5.2 EPG (range 0 to 222). The C group heifers had a mean count of 3.0 EPG (range 0-64) and the adult cattle were passing an average of 1.2 EPG (range 0-24). Analysis of EPG distribution data revealed that 98.2% of the calves, 92.8% of the B group heifers, 97.4% of the C group heifers and 99.2% of the D group cattle had counts ranging from 0 to 20 EPG. None of the calves were passing 21-50 EPG while 5.2%, 2.4% and 0.6% of B, C and D group cattle, respectively, were passing a similar number of eggs. Eight tenths percent of calves, 2.0% of B group heifers, 0.2% of C group heifers and adult cattle were passing 51 or more EPG. Figures 3, 4 and 5 depict the actual EPG distribution in the B, C and D groups, respectively. Because the actual EPG distribution is not normally distributed and follows a negative binominal distribution, most members of a host population have low EPG, and fewer individuals have high EPG counts.

The percentage of cattle showing no eggs in their feces ranged from 94.8% of the calves to 62.2% of the C group heifers, while 66.9% of the B group heifers and 78.0% of adult cattle were negative for worm eggs in their feces.

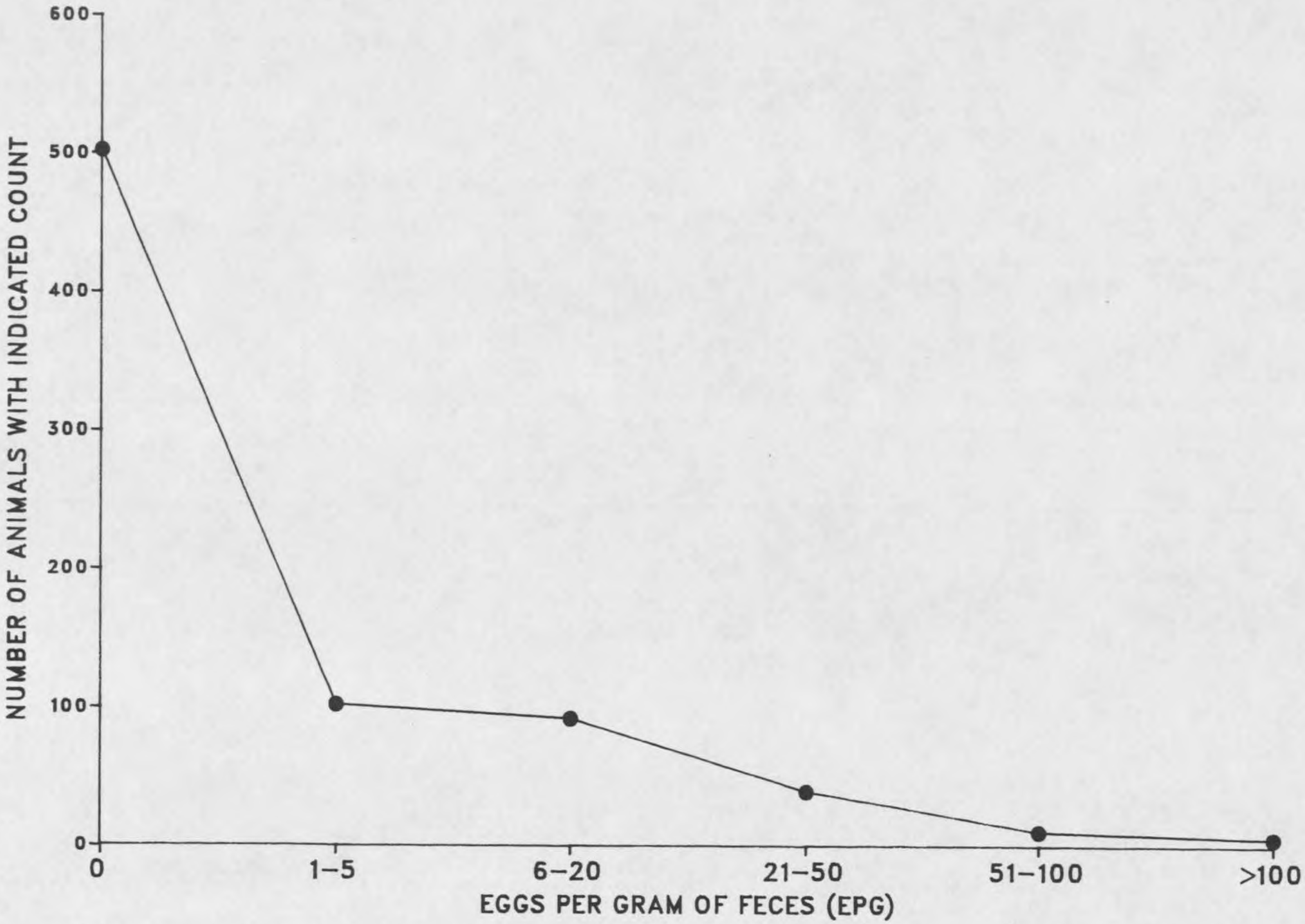

Figure 3. Frequency distribution of gastrointestinal nematode egg counts in ´B´ group heifers.