



Incidence and distribution of helminth parasites and coccidia in Montana cattle
by Richard Hilding Jacobson

A thesis submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree of
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Abstract:

A survey was conducted to determine the identity, incidence and distribution of internal parasites in Montana beef cattle. Fecal samples were collected from 486 calves less than 18 months of age and 479 adult cattle at five intervals during 1965-66 from six sampling stations representing major climatologic and geographic areas of the state.

The results showed that 85.6% of the calves harbored gastrointestinal nematodes, while 59.1% of the adult cattle were similarly infected. The Cooperia-Triastrongylus-Ostertagia group was the most prevalent type of infection (69.7%), followed by Nematodirus (11.3%), Haemonchus (4.8%), Trichostrongylus (2.0%), Strongylus (1.3%) and Capillaria (0.3%). Nematodirus and Haemonchus were about ten times as prevalent in calves as in adult cattle. Ten and one-tenth percent of the calves and 4.2% of the adult cattle were positive for Moniezia.

Nematode egg counts from 0-49 eggs per gram of feces (EPG) occurred in 88.1% of the calves and 98.3% of the adult cattle. Three and four-tenths percent of all animals sampled had counts over 100 EPG.

Seven and one-tenth percent of 422 calves were positive for Dictyocaulus larvae. All of 299 adult cattle similarly examined were negative. Dictyocaulus occurred in calves located in five of the six areas studied, varying from semi-arid sagebrush-grassland range to sub-humid intermountain valley grassland ecosystems.

Fasciola ova were present in feces of 1.7% of 59 calves and 20.2% of 88 adult cattle in western Montana. With the exception of one positive sample from the southwestern station, the remaining 644 fecal samples examined for flukes were negative.

Of 907 fecal samples, 64.9% contained one or more of nine Eimeria species identified during the survey.

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by

RICHARD HILDING JACOBSON

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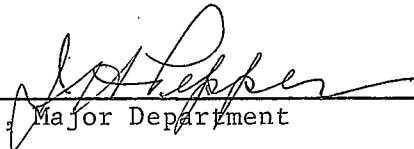
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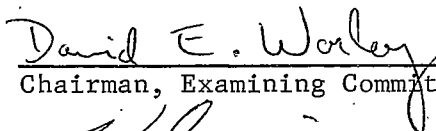
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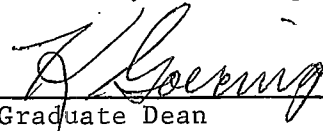
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Approved:


Head, Major Department


Chairman, Examining Committee


Graduate Dean

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ABSTRACT

A survey was conducted to determine the identity, incidence and distribution of internal parasites in Montana beef cattle. Fecal samples were collected from 486 calves less than 18 months of age and 479 adult cattle at five intervals during 1965-66 from six sampling stations representing major climatologic and geographic areas of the state.

The results showed that 85.6% of the calves harbored gastrointestinal nematodes, while 59.1% of the adult cattle were similarly infected. The *Cooperia-Trichostrongylus-Ostertagia* group was the most prevalent type of infection (69.7%), followed by *Nematodirus* (11.3%), *Haemonchus* (4.8%), *Trichuris* (2.0%), *Strongyloides* (1.3%) and *Capillaria* (0.3%). *Nematodirus* and *Haemonchus* were about ten times as prevalent in calves as in adult cattle. Ten and one-tenth percent of the calves and 4.2% of the adult cattle were positive for *Moniezia*.

Nematode egg counts from 0-49 eggs per gram of feces (EPG) occurred in 88.1% of the calves and 98.3% of the adult cattle. Three and four-tenths percent of all animals sampled had counts over 100 EPG.

Seven and one-tenth percent of 422 calves were positive for *Dictyocaulus* larvae. All of 299 adult cattle similarly examined were negative. *Dictyocaulus* occurred in calves located in five of the six areas studied, varying from semi-arid sagebrush-grassland range to sub-humid intermountain valley grassland ecosystems.

Fasciola ova were present in feces of 1.7% of 59 calves and 20.2% of 88 adult cattle in western Montana. With the exception of one positive sample from the southwestern station, the remaining 644 fecal samples examined for flukes were negative.

Of 907 fecal samples, 64.9% contained one or more of nine *Eimeria* species identified during the survey.

INTRODUCTION

Although data on incidence and distribution of parasites are a prerequisite to effective parasite control, relatively few comprehensive surveys on parasitism of North American cattle appear in the literature (Dikmans, 1945, 1952; Becklund, 1964). Only scattered references to outbreaks of verminous gastroenteritis were reported prior to 1942, when Porter published data on incidence of gastrointestinal nematodes in cattle from Alabama, Florida, Georgia, Mississippi and Louisiana. Dikmans (1945) compiled a check list of parasites of domestic animals in North America but data on geographical distribution of the parasites were limited. A preliminary study by Ward (1946) lists results of 133 fecal and eight post-mortem examinations of cattle in Mississippi. Gastrointestinal parasitism of cattle in Oklahoma was surveyed by Cooperrider *et al.* (1948) and found to be a state-wide problem.

A check list of parasites of domestic animals in Georgia was compiled by Cooperrider (1952). Andrews *et al.* (1953) published a paper stressing the economic importance of cattle parasitism in the southeastern United States and listing parasite species recovered from 14 animals. A study by Bailey (1955) revealed clinical parasitism in 11.1% of 422 cattle necropsied at the Auburn University Diagnostic Laboratory. Hitchcock (1956) examined 2,180 fecal samples collected from cattle located in 46 counties of South Carolina and listed the incidence of gastrointestinal parasites. The viscera of 181 North Carolina cattle were examined by Bell (1957) for gastrointestinal parasites.

Surveys of bovine endoparasitism were conducted in Illinois by Levine and Aves (1956), Mansfield (1958) and Szanto *et al.* (1964). Scott (1957)

studied parasitism of cattle from Illinois, eastern Iowa and northeastern Missouri. All of the Illinois studies, including Scott's survey, based their results on fecal egg counts. Another report from the midwest was that of Petri (1958) who studied seasonal fluctuations of gastrointestinal nematodes in 80 Hereford calves imported to Iowa from South Dakota. In a preliminary report on helminths of beef cattle in Arizona, Dewhirst *et al.* (1958) found 94% of 865 fecal samples positive for helminth ova. Becklund and Allen (1958) presented data on worm parasites of cattle in New Mexico and Arizona and in so doing published one of the few surveys on cattle parasites west of the Mississippi River. Becklund (1959), in a survey of Georgia cattle, encountered most of the parasites reported in an earlier study by Porter (1942). Zimmerman and Hubbard (1961) studied gastrointestinal parasitism in 1,750 Iowa cattle representing 19 herds, and found trichostrongyle ova in more than 50% of the fecal samples examined. Twenty apparently healthy calves from northern Florida were examined by Becklund (1961) and found to be infected with 16 species representing nine genera of helminth parasites. Helminthiasis in 32 clinically infected cattle from Georgia was reported by Becklund (1962).

In a survey of gastrointestinal parasitism in Wisconsin dairy cattle, Cox and Todd (1962) found 78.3% and 84.9% of 710 animals positive for nematodes and coccidia, respectively. Intestinal helminths in domestic animals from central Missouri were studied by Sharma and Case (1962). Based on 157 fecal samples, "73.2% were positive for one or more species of parasite". In data gathered between 1955 and 1962, Honess and Bergstrom (1963) listed the intestinal roundworms found in Wyoming cattle. Helminth parasites of

121 cattle were reported by Smith (1967) from necropsy cases at the Texas A&M University Necropsy Clinic.

Although a few of the previously mentioned articles listed data for both helminth and coccidian parasites of cattle (Dikmans, 1945; Ward, 1946; Hitchcock, 1956; Scott, 1957; Cox and Todd, 1962 and Szanto *et al.*, 1964), most of the survey data concerning *Eimeria* species parasitic in cattle has been published separately. Early descriptions of bovine coccidiosis outbreaks in the United States and Canada were reported from Washington (Schultz, 1918), Pennsylvania (Lentz, 1919), Kansas (Dykstra, 1920; Muldoon, 1920; Frank, 1926), British Columbia (Bruce, 1921), Ontario (Gwatkin, 1926), North Dakota (Roderick, 1928) and Nebraska (Skidmore, 1933).

Levine and Becker (1933) published a catalogue and host-index of the genus *Eimeria* in which no incidence or distribution data are listed. Christensen and Porter (1939), and Christensen (1941) published descriptions of three new species of coccidia and listed the nine *Eimeria* species found in Alabama cattle. A host-index and check list (Hardcastle, 1943) brought up to date the earlier work of Levine (*loc. cit.*). Fecal samples from 2,492 cattle located in the southeastern United States were examined for coccidian oocysts by Boughton (1945). Davis and Bowman (1951) listed nine species of coccidia found in cattle from the southeastern states and in 1955, Davis *et al.* found 93% of 102 southeastern cattle infected with *E. alabamensis*.

Hasche and Todd (1959) surveyed 355 bovines from 71 counties in Wisconsin and found 83.5% of the animals infected with one or more of ten species of *Eimeria*. In 1962, Fitzgerald studied coccidiosis in calves on winter and summer ranges and in feedlots in Utah. He listed the species

according to seasonal frequency. Nyberg *et al.* (1967) published data on incidence of bovine coccidia, based on 86 fecal samples from cattle in Tillamook County, Oregon, which is an area representative of other Pacific Northwest dairy regions.

The first technical paper concerning parasites of Montana cattle was published by Marsh (1923). He stated that prior to 1919, coccidiosis had been diagnosed microscopically once and clinically several times by Montana veterinarians. By 1923, ten confirmed cases of bovine coccidiosis had been reported from nine counties representing all sections of the state.

In 1932, a case report by Tunnicliff listed the occurrence of *Cooperia oncophora* and *Nematodirus helvetianus* in two moribund calves from northwest Montana. Marsh (1938) stated that mortality in animals affected with coccidiosis can run from 10 to 25% and thus constitutes a cause of considerable loss in young cattle in the northwestern states. A study of disease problems in range livestock (Marsh, 1952) indicated that intestinal parasites of cattle were less serious in northern range cattle than in the midwest or south. Coccidiosis, however, was considered to be a serious cause of losses in 6 to 10 month calves, particularly in northern range areas which are similar topographically to much of Montana range land.

An outbreak of ostertagiosis occurred in range cattle in central Montana during the winter of 1963-64 (Worley and Sharman, 1966). Mortality was limited to two calves but clinical parasitism was diagnosed in about 300 additional calves.

Although Montana records go back as far as 1915, specific information on identity, incidence and distribution of cattle parasites is very limited.

in scope. The annual report of the Montana State Veterinary Surgeon listed 38 cases of bovine coccidiosis, two of *Dictyocaulus* sp., seven of cysticer-
ciasis, one of nodular disease, one of *Stephanofilaria* sp. and several cases of oesophagostomiasis from 1915 to 1942. Since 1942, more complete data have been available from Livestock Sanitary Board Diagnostic Laboratory records. However, with only a few exceptions, confirmed identification of parasites to the specific level has not been accomplished. Therefore, of 414 cases of endoparasitism diagnosed in Montana cattle from 1942-1964, the following genera and number of infected animals have been catalogued: trichostrongylid group (*Ostertagia*, *Cooperia*, *Trichostrongylus* and *Haemon-
chus* species), 258; *Nematodirus*, 125; *Trichuris*, 11; lungworms, 10; liver flukes, 8; tapeworms, 31; and *Eimeria* species, 221. Other confirmed records of helminth parasites reported in Montana cattle include *Cysticercus bovis*, 4; *Stephanofilaria stilesi*, 2; *Bunostomum phlebotomum*, 1; *Oesophagostomum radiatum*, 2; *Cooperia* spp., 2; *Trichostrongylus axei*, 1 and several cases of the filariid worm *Setaria cervi*. Since the histories of animals in-
cluded in this compilation are mostly unknown, imported cattle could con-
ceivably be responsible for some of these records. As a result, these data may have limited value in enumerating the parasite fauna of native Montana cattle.

Cattle parasite data from 1929 through 1964 have been compiled from records accumulated prior to the onset of this survey at the Montana Vet-
erinary Research Laboratory and are separated into two categories: those originating from post-mortem examinations, and those based upon fecal egg counts. Of 35 animals examined at post-mortem, the parasite species found

and the number of animals infected were: *Cooperia* spp., 3; *C. pectinata*, 3; *C. oncophora*, 2; *Ostertagia* spp., 3; *O. bisonis*, 2; *Nematodirus* spp., 6; *N. helvetianus*, 1; *Dictyocaulus* sp., 3; *D. viviparus*, 3; liver flukes, 3 and *Fasciola hepatica*, 1. Tabulation of 379 fecal egg counts resulted in the following summary of species and numbers of animals infected: trichostrongylid group (*Ostertagia*, *Trichostrongylus*, *Cooperia* and *Haemonchus*), 48; *Nematodirus*, 25; *Trichuris*, 11; *Dictyocaulus viviparus*, 1 and *Moniezia*, 2.

Since the above information on endoparasitism in Montana cattle is limited in scope, a survey was designed to determine the identity, incidence, distribution and intensity of helminth parasites and coccidia in Montana cattle, and to relate climatologic factors to parasite distribution in six ecologically distinct areas of the state.

MATERIALS AND METHODS

Six sampling stations were chosen to represent the major geographic and climatologic regions of the state on the basis of four criteria: 1) geographic location, 2) importance as a center of beef production, 3) stability of cattle management practices and 4) availability of weather data (Fig. 1). The western station was a 320-acre ranch six miles southeast of Stevensville, Ravalli County. The area was classified as intermountain valley grassland and was situated in the Bitterroot drainage on irrigated benchland at an elevation of 3,370 feet. *Agropyron spicatum*, *Stipa comata* and *Poa secunda* were the dominant forage plants. The southwestern station was located five miles northwest of Bozeman, Gallatin County, at an elevation of 4,750 feet. This 180-acre ranch was representative of foothills grassland range found in the southeastern section of the Gallatin Valley. Primary forage plants were *Carex* spp., *Poa* spp., and *Phleum pratense*.

The south central station was located at the Huntley Branch of the Montana Agricultural Experiment Station in Yellowstone County. It was situated on the flood plain of the Yellowstone River at an elevation of 2,988 feet and was primarily an *Agropyron smithii* vegetation system. The site of the eastern station was one mile west of Miles City, Custer County. This 56,000-acre Range Livestock Experiment Station was located at an elevation of 2,731 feet in a badlands grassland biotic community which consisted principally of *Agropyron smithii* and *Stipa comata*. The central station was located along the Sun River between Simms and Augusta (Cascade County) at an elevation of 3,560 feet. Vegetation on this 60,000-acre ranch was classified as central grassland range and consisted of *Stipa comata*, *Bouteloua gracilis* and *Agropyron spicatum*. The northern station was situated at the



Figure 1. Six sampling stations for survey of helminth parasites in Montana cattle.

North Montana Branch of the Agricultural Experiment Station, Hill County, at an elevation of 2,373 feet. This 2,400-acre ranch was characterized by northern grassland vegetation which is found over much of the northern Great Plains region of the United States and Canada, and consists primarily of *Agropyron* spp., *Festuca* spp., *Bouteloua gracilis* and *Stipa comata*.

A summary of the cattle operations at the six sampling stations in Montana appears in Table I. Cattle at the southwestern and northern stations grazed on summer range in the Bridger Mountains and Bear Paw Mountains, respectively. With the exception of marketed animals, cattle from all other stations remained on the home ranch for the entire survey period. Thirty of 147 cattle sampled at the south central station and 166 of 189 cattle at the northern station were on pasture while the remainder were on nutrition studies in feedlots. Cattle at the eastern station were used in crossbreeding studies, and those sampled for this survey were strictly range animals. All range cattle were fed supplemental feed in the winter months as dictated by climatic conditions.

A total of 965 fecal samples was collected at five intervals from calves, yearlings and cows during the period of 3 February, 1965, to 18 July, 1966 (Table II). Five seasonal sampling dates were chosen for all but the central station where the cattle were sampled on four occasions. Calves and yearlings up to and including 18 months of age were treated as a group which hereafter will be designated as calves. Cows and steers over 18 months old were grouped as adult cattle. The mean number of fecal samples collected from calves at each sampling date was 18.0 (range of 8-31), with 67% of the collections having between 16 and 22

Table I. Ranching Practices at Six Sampling Stations in Montana.

	<u>Western Station</u>	<u>Southwestern Station</u>	<u>South Central Station</u>
Breed	Angus	Hereford	Hereford
Type of operation	Commercial	Commercial	Feedlot primarily - Range
Number of cows	175	75	40 mature steers
Number of calves	175	65	60
Calving season	March to May	Mid-March to Mid-May	Calves purchased
Antiparasitic medication program	Co-Ral Pouron in October	Ruelene Pouron late in October	Co-Ral on pastured yearlings in March and April, 1965
	<u>Eastern Station</u>	<u>Central Station</u>	<u>Northern Station</u>
Breed	Hereford	Hereford	Hereford
Type of operation	Range - Experimental	Commercial	Range - Experimental
Number of cows	1300	2500	200
Number of calves	700	2000	180
Calving season	Mid-March to Early May	March to May	March and April
Antiparasitic medication program	Ruelene Pouron in Mid-August and Lindane at weaning	Steer calves treated with Ruelene Pouron in October	Neguvon Pouron* for all cattle in October
*Experimental drug			

Table II. Sampling Dates for Cattle Parasite Survey.

Sampling Station	<u>Season</u>				
	Winter 1965	Spring and Summer 1965	Fall 1965	Winter 1966	Spring and Summer 1966
Western (Stevensville)	15 Feb.	27 July	8 Oct.	1 Feb.	27 June
Southwestern (Bozeman)	3 Feb.	15 June* 28 June**	12 Nov.	25 Feb.	14 June
South Central (Huntley)	17 Mar.	31 Aug.	9 Dec.	24 Mar.	7 July
Eastern (Miles City)	18 Mar.	11 Aug.	10 Dec.	24 Mar.	6 July
Central (Simms)		2 June	23 Sept.	31 Jan.	27 June
Northern (Havre)	28 Mar.	10 Aug.	24 Nov.	23 Mar.	18 July

*Sampling date for calves.

**Sampling date for adult cattle.

fecal samples. All fecal samples were obtained either by direct rectal or more commonly by random lot or pasture sampling methods. The latter were collected within a few minutes after deposition.

Samples were transported to the laboratory where a portion of each (approximately 50 grams) was immediately assayed for lungworm larvae with the standard Baermann technique (Baermann, 1917). Some of the samples were refrigerated for periods of approximately 12 hours before they were baermannized. The remaining portion of the fecal sample was then frozen.

Early in the survey, the Baermann funnels used were long-stemmed (approximately 15 cm.) and had a capacity of about 70 ml. Since the amount of feces one could examine was relatively small, larger 250 ml. funnels were used later. A 20 mesh screen, six cm. in diameter was placed in the funnel approximately four cm. from the top thus allowing the larvae to move more freely toward the bottom of the funnel.

The flotation method of Lane (1928), as modified by Dewhirst and Hansen (1961), was used as an indication of the level of gastrointestinal parasitism in the cattle. This procedure was used for determining the total number of nematode eggs per gram of feces (EPG), the presence or absence of tapeworm ova, and the relative number of coccidian oocysts. Differential worm egg counts were made employing the ovum classification criteria of Dewhirst and Hansen (*loc. cit.*).

Coccidian oocysts were differentiated on the basis of morphologic features. They were ranked according to frequency so that relative fluctuations in total oocyst numbers could be determined between sampling stations and at the same sampling station on a seasonal basis. When one to several

oocysts were present under a 22 mm. coverslip, the infection was designated as +1. If one to three oocysts were observed per low power field (75X), the infection was classified as +2. Four to seven oocysts per field were ranked as a +3 infection and over seven oocysts per field were designated +4. Although total oocyst numbers were estimated, individual species of *Eimeria* were not ranked according to frequency. The species *Eimeria ildefonsoi* and *E. wyomingensis* were not distinguished from *E. auburnensis* and *E. bukidnonensis*, respectively, on the basis that they have been considered synonymous (Levine, 1961).

After a portion of the fecal sample was utilized for the flotation procedure, the remaining fecal material was refrigerated at about 4° C until it was examined for fluke ova by the sedimentation technique of Dennis, Stone and Swanson (1954). Since *Fasciola hepatica* is known to be enzootic west of the continental divide, all fecal samples from the western station at Stevensville were examined for fluke eggs. Since *F. hepatica* is not considered to be generally established in cattle east of the continental divide in Montana, a screening procedure was employed whereby approximately one-third of the samples from the five remaining sampling stations were examined for fluke ova. Later in the survey, composite samples consisting of 5 to 8 individual fecal samples were examined for fluke eggs.

Climatological data for use in correlating macroclimatic conditions with levels of parasitism were collected from weather stations located at a maximum of ten miles from the sampling station. The western weather station, located at the United States Post Office, Stevensville, was the source for all climatologic factors studied except the snow depth information. The

latter was available at Hamilton, approximately 13 miles south of the western sampling station. The southwestern sampling station is about six miles northwest of Montana State University, Bozeman, where all weather data were available except for snow depth information. It was supplied by the Federal Aeronautics Administration Weather Bureau located about six miles north of the sampling station. Weather bureaus at Havre and Miles City served as sources of data used for the northern and eastern sampling stations, respectively. Weather information for central Montana was obtained from records at Sun River. Personnel of the Agricultural Experiment Station at Huntley operate a weather station which was the source for all data for the south central station except snow depth information. No weather station in the immediate vicinity of Huntley recorded snow depth data, so this information is lacking for this location.

Statistical analyses were performed on worm egg counts as an aid in evaluation of the data. Chi-square tests were used to determine if a significant difference existed for adult cattle and calf incidence data between the six sampling stations. An analysis of variance was calculated for calf and adult cattle worm egg counts using a square root transformation. Duncan's multiple range test (Duncan, 1955) was used to determine whether or not statewide parasite populations were homogeneous.

RESULTS

Of 965 bovine fecal samples from all animals examined during the survey, 70.7% were positive for gastrointestinal nematode ova. An analysis of incidence data by sampling station indicates gastrointestinal nematode infections were most prevalent in cattle from central Montana, with 87.8% infected. (Fig. 2). Seventy-eight and one-tenth percent, 76.9% and 76.0% of the cattle from the eastern, south central and northern stations, respectively, were infected with gastrointestinal nematodes, indicating little differences in prevalence of infection from three contiguous regions in the state. Stomach and intestinal nematode eggs were found in 65.7% of bovine fecal samples from the southwestern station, while less than 40% of the animals from the western station were similarly infected.

Incidence data analyzed by age group revealed 82.1% of 486 calves 18 months and younger were infected with gastrointestinal nematodes, while 59.1% of 479 adult cattle harbored similar infections. At the western station, 3.8 times as many calves were infected as adult cattle, while at the south central station a greater percentage of adult cattle (80.6%) were infected than calves (74.1%).

Tables III and IV list the incidence of gastrointestinal helminth parasites in cows and calves from the six sampling stations. The *Cooperia-Trichostrongylus-Ostertagia* group of ova (classified as group I ova) were found in feces from 67.9% of the cattle examined. Three hundred seventy-eight calves (77.8%) were infected with group I parasites while 277 cows (57.8%) were similarly infected. A higher percentage of cattle from each of the six sampling stations was passing group I ova than any other helminth ovum or larva observed during the study.

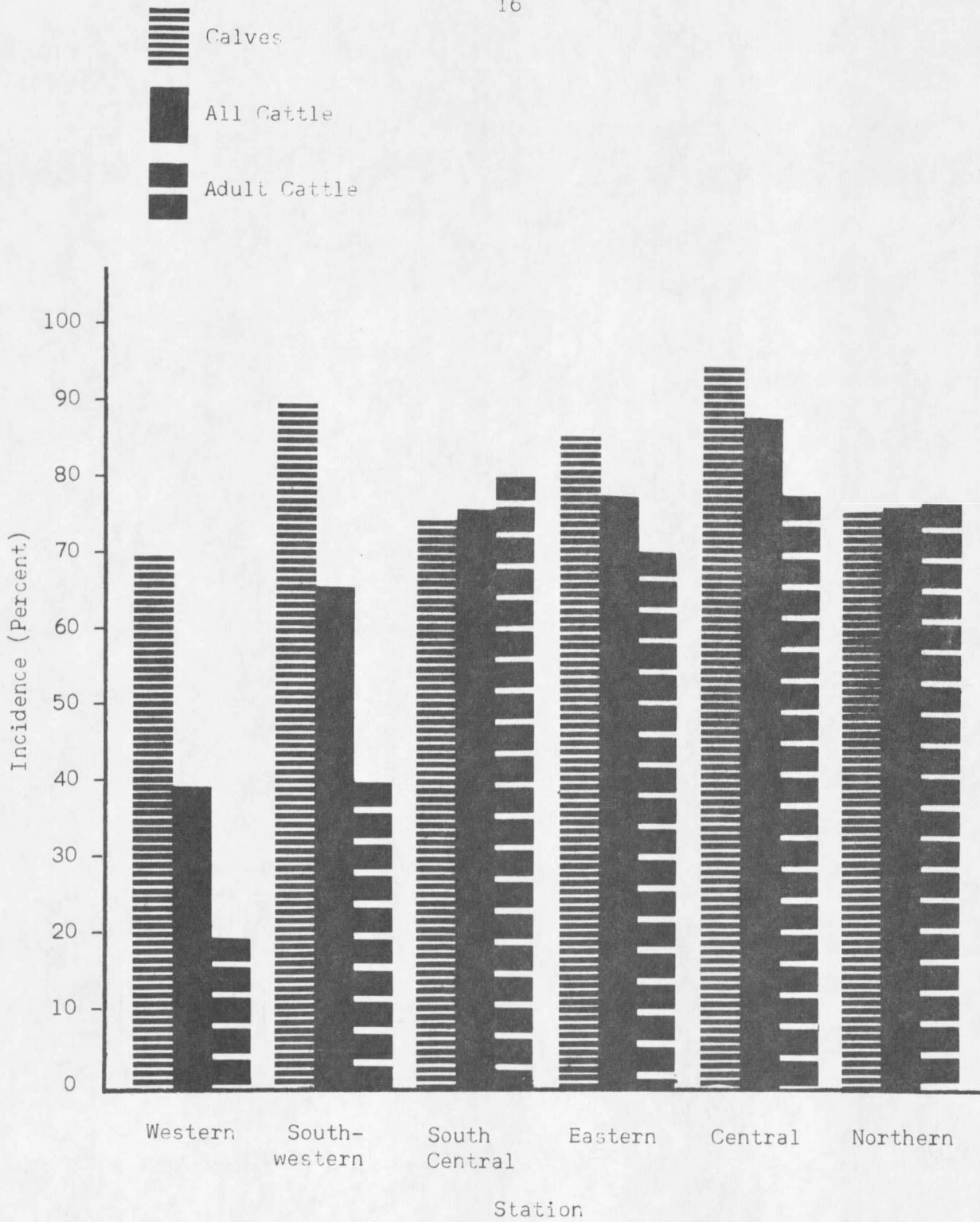


Figure 2. Incidence of gastrointestinal nematodes in Montana cattle.

Table III. Incidence of Gastrointestinal Helminth Parasites of Calves from Six Areas in Montana.

	<u>Station</u>						All Stations
	Western	South- western	South Central	Eastern	Central	Northern	
Number of animals examined	60	90	85	76	86	89	486
Incidence of all nematode genera combined *	70.0	90.0	74.1	85.5	94.2	75.3	85.6
<i>Cooperia-Trichostrongylus- Ostertagia</i> *	65.0	48.9	71.8	84.2	94.2	66.3	77.8
<i>Nematodirus</i> *	15.0	14.4	14.1	18.4	34.9	24.7	20.6
<i>Haemonchus</i> *	0	0	2.4	0	46.5	0	8.6
<i>Trichuris</i> *	1.6	11.1	3.5	0	0	1.1	3.1
<i>Capillaria</i> *	1.6	0	0	0	0	0	0.2
<i>Strongyloides</i> *	0	3.3	0	0	3.5	0	1.2
<i>Chabertia</i> *	0	0.2	0	0	0	0	0.2
<i>Moniezia</i> *	8.3	4.4	4.7	14.5	17.4	11.2	10.1

*Expressed as percentage

Table IV. Incidence of Gastrointestinal Helminth Parasites of Adult Cattle from Six Areas in Montana.

	<u>Station</u>						All Stations
	Western	South- western	South Central	Eastern	Central	Northern	
Number of animals examined	88	85	62	84	66	94	479
Incidence of all nematode genera combined *	18.2	40.2	80.6	71.4	77.3	76.6	59.1
<i>Cooperia-Trichostrongylus- Ostertagia</i> *	15.9	37.6	79.0	71.4	77.3	75.5	57.8
<i>Nematodirus</i> *	0	2.4	9.7	0	0	1.1	1.9
<i>Haemonchus</i> *	0	0	0	0	1.5	3.2	0.8
<i>Trichuris</i> *	0	0	4.8	0	0	1.1	1.3
<i>Capillaria</i> *	2.3	0	0	0	0	0	0.4
<i>Strongyloides</i> *	6.8	1.2	0	0	0	0	1.5
<i>Moniezia</i> *	3.4	7.1	0	7.1	3.0	3.2	4.2

*Expressed as percentage

The next most prevalent gastrointestinal helminth ova observed were those of *Nematodirus* spp. They were found in 11.3% of all fecal samples examined. Nearly 11 times as many calves were infected with this parasite as cows. Cattle from all sampling stations harbored *Nematodirus* spp. with the exception of the cows from the western, central and eastern stations. The highest incidence for this parasite was recorded from calves at the central station (34.9% positive).

Ova of the *Haemonchus-Oesophagostomum* group (classified as group II ova) were found in 4.8% of the cattle examined. Forty-two calves (40 from the central and two from the south central station) and four cows (one from the central and three from the northern station) were infected with group II parasites.

Other gastrointestinal helminth ova observed and the percentage of positive cattle were: *Trichuris* spp., 2.0%; *Strongyloides papillosus* 1.3%; *Capillaria* sp., 0.3% and *Chabertia ovina*, 0.1%. *Trichuris* spp. eggs were found in feces from cows and calves located at the south central and northern stations, and in calves from the western and southwestern stations. *S. papillosus* eggs were present in feces from one of 85 cows and three of 90 calves at the southwestern station. Six of 88 cows from the western station and 3 of 86 calves from the central station were similarly infected. *Capillaria* sp. ova were limited to fecal samples from two cows and one calf at the western station. One animal from the southwestern station was positive for *Chabertia ovina*.

A statistical analysis of gastrointestinal nematode incidence figures, using the chi-square contingency test, indicated a significant difference

($P < 0.01$) between the six sampling stations for infected versus uninfected animals.

Seven and two-tenths percent of 965 cattle were passing *Moniezia* spp. ova in their feces. These eggs were found in 10.1% of all calves and 4.2% of all adult cattle examined. Cattle of all ages from the six sampling stations, except the adult animals at the south central station, were positive for tapeworms. The highest prevalence of *Moniezia* spp. was found in calves from the central station where 16.4% of 86 animals were positive. Fourteen and five-tenths percent of 76 eastern station calves and 11.2% of 89 northern station calves were also infected with tapeworms. Less than 10% of the calves and cows from all other sampling stations harbored *Moniezia* spp.

Dictyocaulus viviparus larvae were recovered from 7.1% of 422 calf fecal samples. Of 299 adult cattle examined, none was found to be positive for lungworms. The highest prevalence of lungworm infection occurred in calves from the central station where 12.9% of 85 animals were positive. Eleven and one-tenth percent of 63 calves from the eastern station were similarly infected. Incidence data revealed 10.9% (6/55), 3.9% (3/76) and 3.5% (3/85) of the calves from the western, southwestern and south central stations, respectively, were infected with *D. viviparus*. All of 75 calves from the northern station were negative for lungworms.

Fasciola hepatica ova were detected in 2.4% of 791 fecal samples examined. The liver fluke was limited to cattle from the western region of the state. One and seven-tenths percent of 59 calves and 20.2% of 84 cows from the western station were infected with *F. hepatica*. One adult cow from the southwestern station was similarly infected. All other animals examined

for liver fluke infection were negative.

The average number of nematode eggs per gram of feces for all cattle sampled was 16.8 (range 0 to 1,268). The intensity of gastrointestinal nematode infections in cattle was compared between sampling stations. Cattle from the central station were passing more eggs per gram of feces (avg. 55.8) than animals from any other area (Table V). Cattle from the northern, eastern and south central stations had mean EPG counts of 12.5, 11.7 and 11.3, respectively. Eight and six-tenths eggs per gram was the average figure for cattle located at the southwestern station, while animals from the western station had a mean worm egg count of 2.4.

Duncan's multiple range test was applied to the egg count data in order that differences between individual stations might be ascertained (Table V). The mean egg count for calves at the central station was significantly greater than for all other stations ($P < 0.01$). The EPG counts for calves at the eastern station were significantly greater than those at the western station ($P < 0.01$), while the egg counts for the southwestern station calves were also significantly different than those at the western station ($P < 0.05$). Egg counts at all other stations were not significantly different at the 5% level. Cows at the western and southwestern stations had egg counts which were not significantly different from each other but were significantly less than all other stations ($P < 0.05$).

Calves were passing an average of 26.7 (range 0-1,268) eggs per gram of feces, while adult cattle had a mean egg count of 6.7 (range 0 to 108). Analysis of EPG distribution data revealed that 88.1% of the calves and 98.3% of the adult cattle had EPG counts ranging from zero to 49. Five and

Table V. Mean Gastrointestinal Nematode Egg Counts* for All Cattle Sampled During the Survey.

Station	Calves	Adult Cattle	All Cattle
Western	5.4 ^a	0.5 ^a	2.4
Southwestern	14.2 ^{ab}	2.7 ^a	8.6
South Central	12.8 ^{ab}	9.2 ^b	11.3
Eastern	16.1 ^b	7.6 ^b	11.7
Central	92.3 ^c	8.2 ^b	55.8
Northern	12.6 ^{ab}	12.5 ^b	12.5

*Expressed as eggs per gram of feces.

a, ab, b, c Refers to Duncan's multiple range test. Any two means not having the same letter superscript are significantly different ($P \leq 0.01$).

six-tenths percent of the calves were passing 50-99 eggs per gram of feces, while 5.1% had egg counts between 100 and 249. Worm egg counts between 250 and 499 were found in feces of 1.0% of the calves while one calf had an EPG count in excess of 500. One and three-tenths percent of the adult cattle had egg counts between 50 and 99, while 0.4% of the cows had counts between 100 and 249 EPG.

A comparison of mean egg counts between adult cattle and calves from each sampling station has been expressed as a ratio. The cow-to-calf mean egg count ratio was highest at the central station (1/11.3) and was followed by the western station (1/10.8), southwestern station (1/5.3), eastern station (1/2.1) and the south central station (1/1.4). The ratio was lowest at the northern station, where adult cattle had a mean EPG figure one-tenth less than the average egg count for calves.

Mean values have considerable defects as indicators of morbidity, and inevitably discard a great deal of information. To alleviate this problem, Figures 3 through 8 graphically present data for nematode egg count distribution and intensity for cows and calves from the six sampling stations. The graphs are constructed according to the log-probability technique of Bradley (1965). The horizontal scale is logarithmic and covers a range from one to 1,000, with units representing nematode egg counts. The ordinate bears a probability scale. It is constructed so that cumulative percentage totals of a normal distribution form a straight line when plotted on it. Each point on the graph represents the percentage of animals having fecal egg counts equal to, or less than the indicated EPG count. The curve is drawn free-hand through the points and portrays the probability with which a given

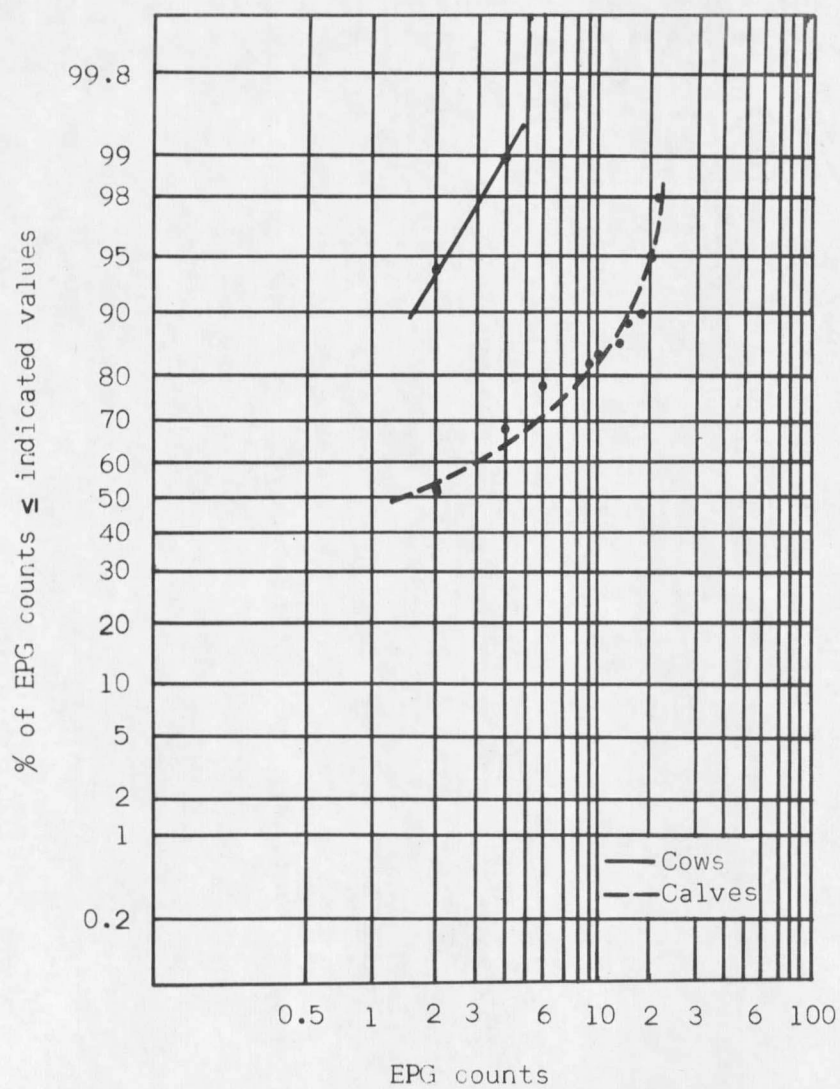


Figure 3. Distribution of gastrointestinal nematode egg counts of cattle at the western station.

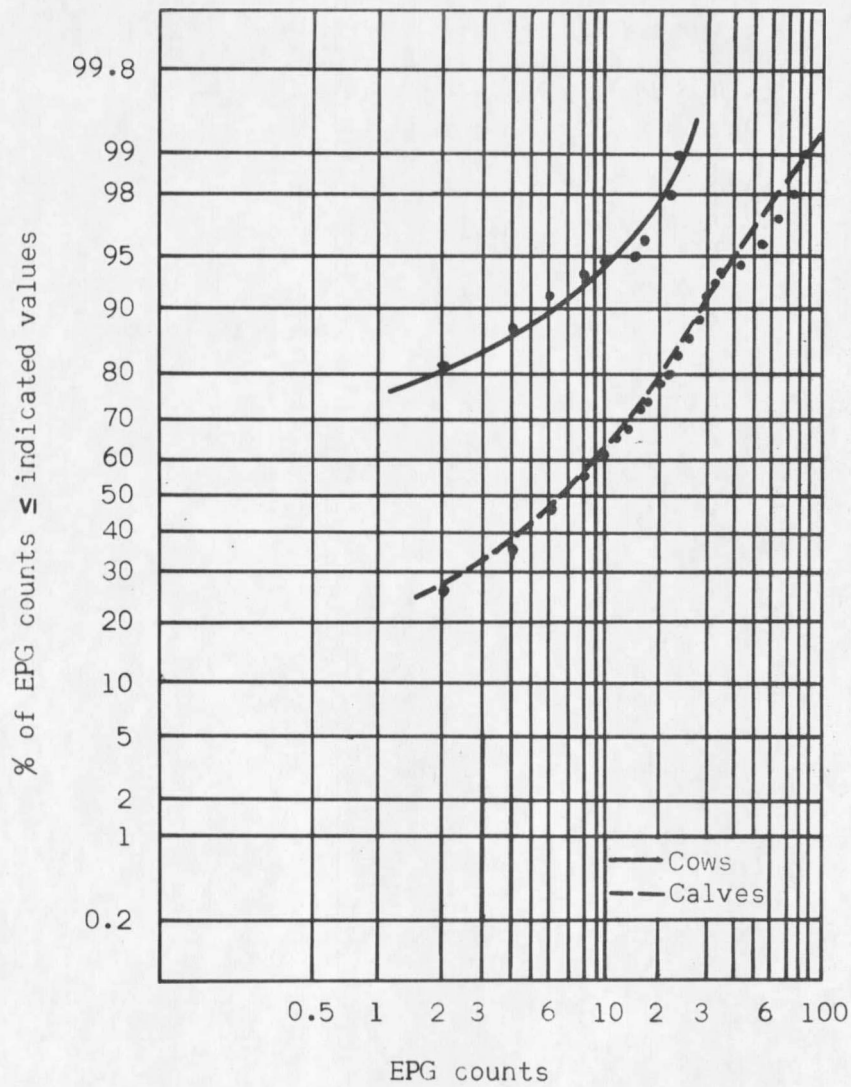


Figure 4. Distribution of gastrointestinal nematode egg counts of cattle at the southwestern station.

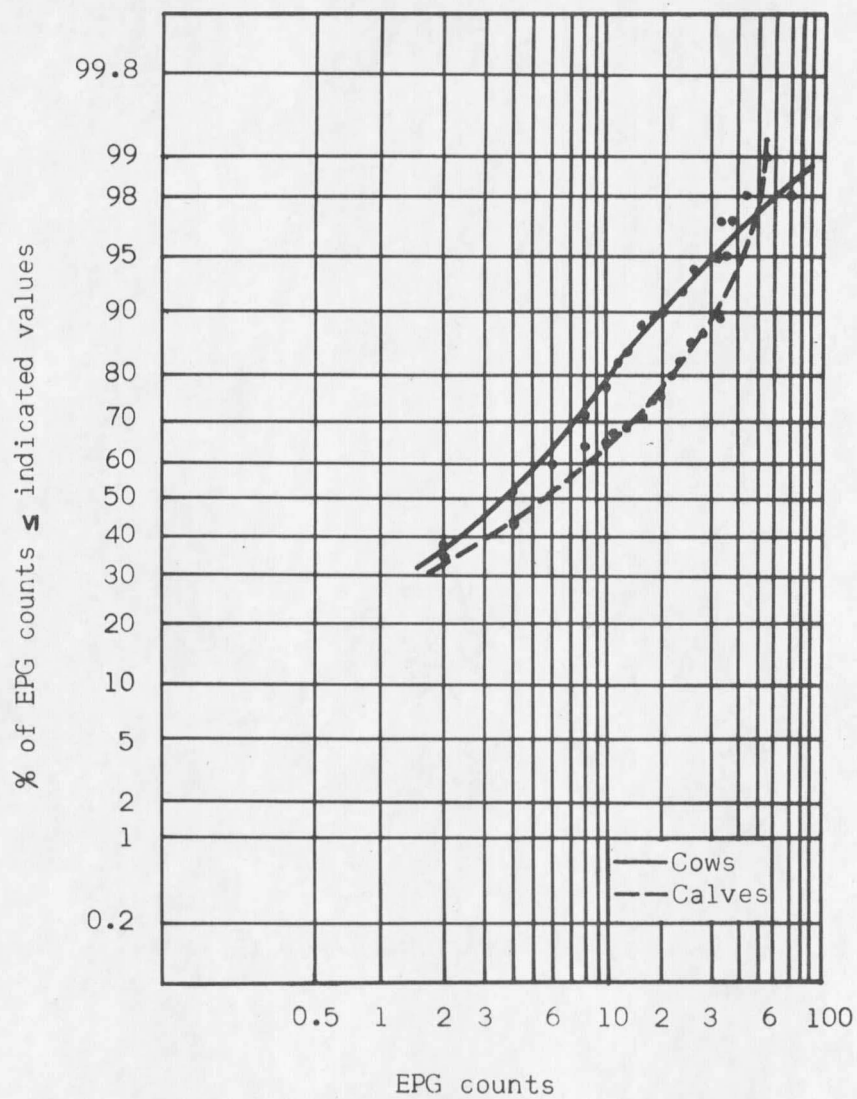


Figure 5. Distribution of gastrointestinal nematode egg counts of cattle at the south central station.

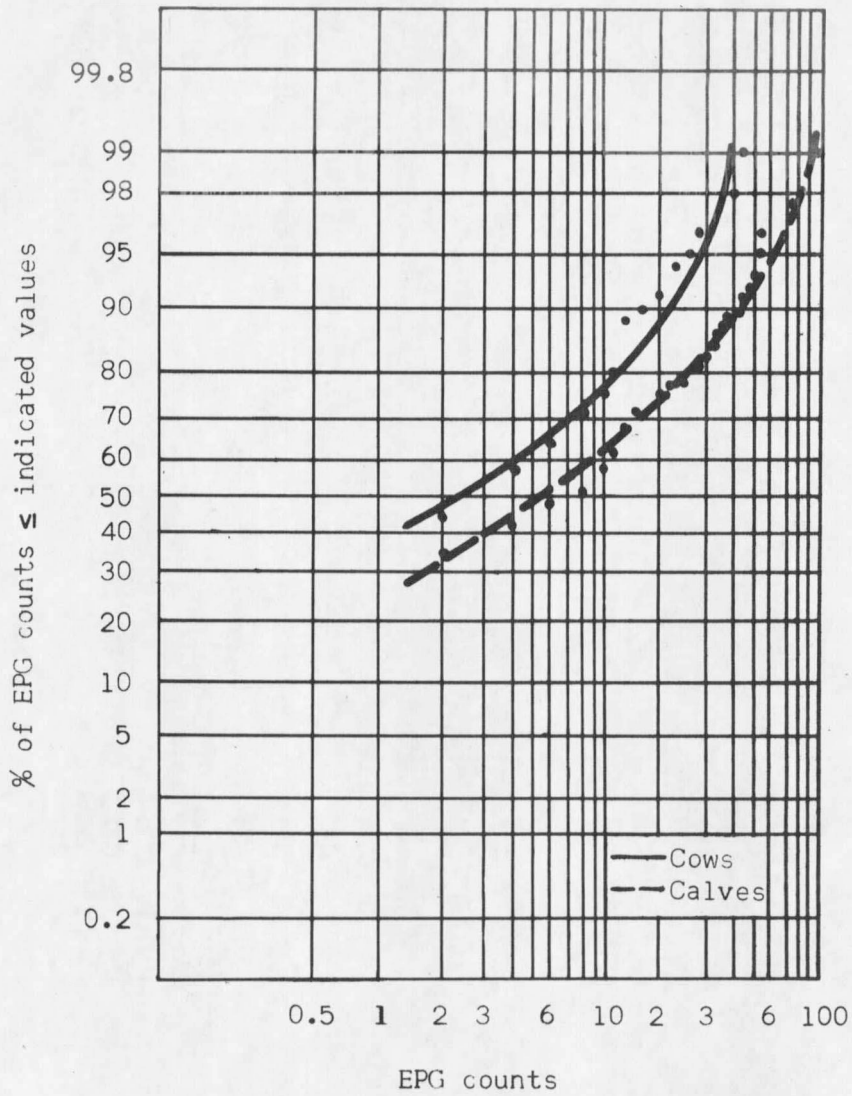


Figure 6. Distribution of gastrointestinal nematode egg counts of cattle at the eastern station.

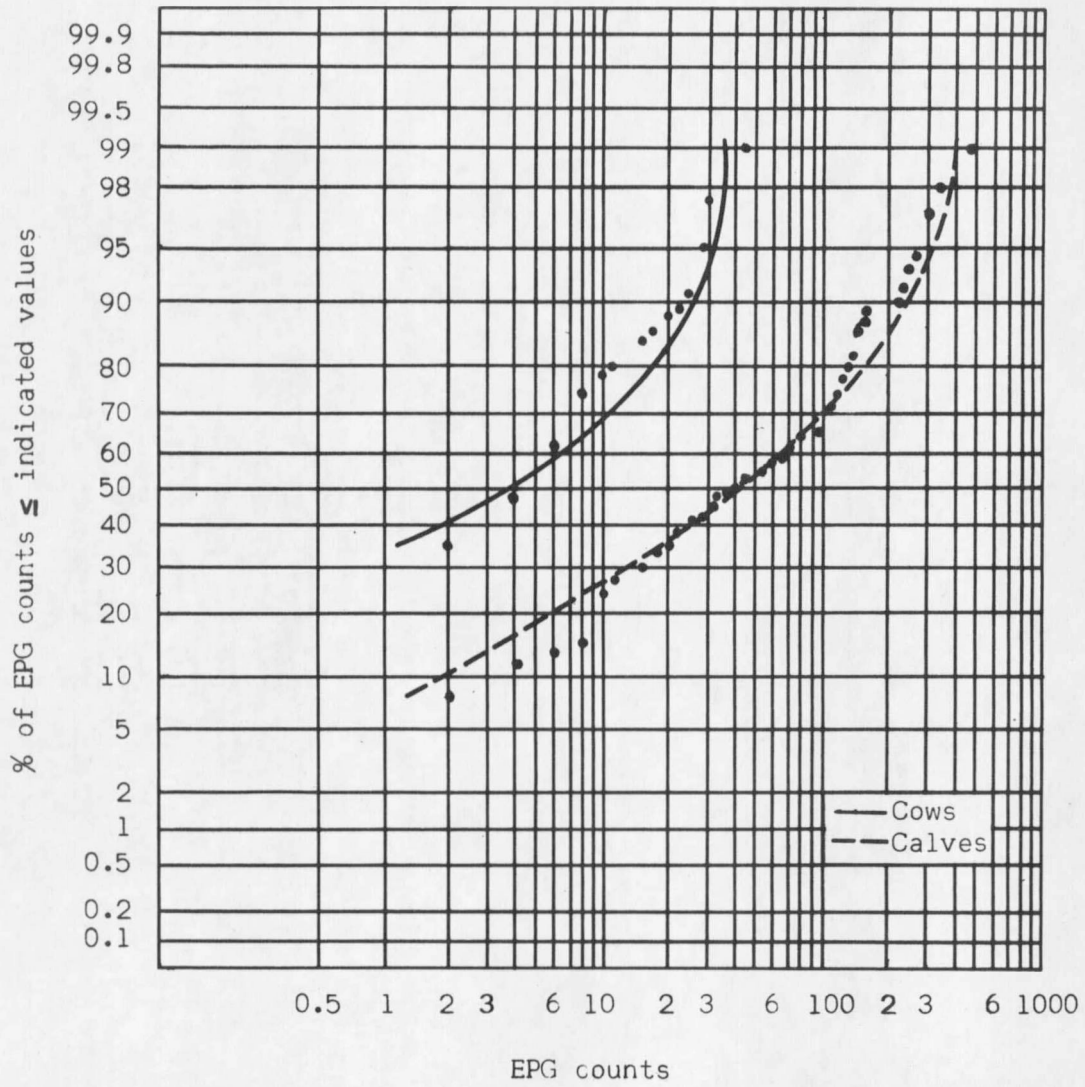


Figure 7. Distribution of gastrointestinal nematode egg counts of cattle at the central station.

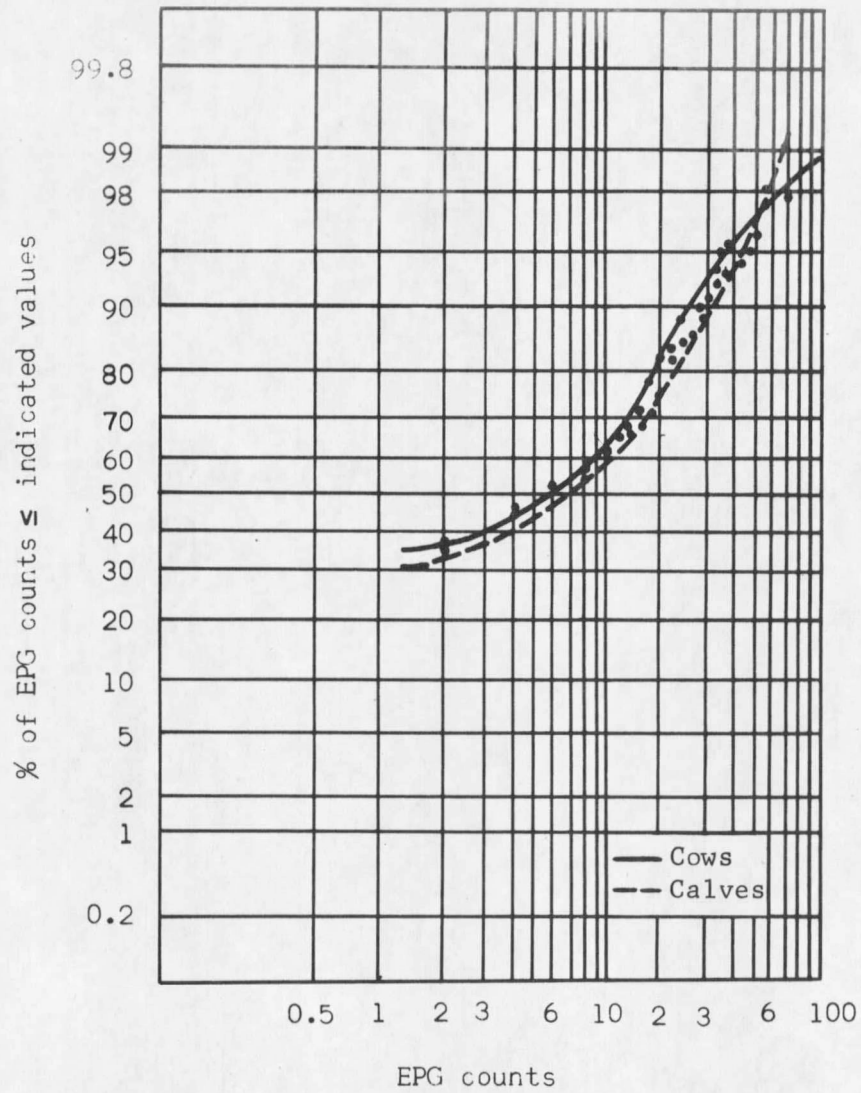


Figure 8. Distribution of gastrointestinal nematode egg counts of cattle at the northern station.

egg count level might occur in fecal samples from cattle at each sampling station.

The percentage of cattle showing no eggs in their feces ranged from 6% in calves from the central station to 82% in the western station cows. At all stations, the curve representing calf EPG levels occurs to the right of the curve representing adult cattle egg counts. Thus, a greater percentage of calves consistently had higher egg counts than cows from the same sampling station even though incidence data indicate a greater percentage of infected adult cattle than calves at the south central and the northern stations.

Ova of group I (*Cooperia-Trichostrongylus-Ostertagia*) occurred with greater abundance than eggs or larvae of any other species or group of helminths. The average intensity of infection with group one ova was about four times as great in calves (Avg. EPG 23.0) as in cows (Avg. EPG 5.9). Mean *Nematodirus* egg counts were 2.2 in calves compared with 0.1 in adult cattle. Fifty-four *Trichuris* ova were seen in 486 calf fecal samples while only eight eggs were observed in 479 adult bovine fecal samples. Group II (*Haemonchus-Oesophagostomum*) and *Capillaria* ova were counted but occurred sporadically, making it impractical to attempt a mean EPG calculation including all animals sampled.

Intensity data for cattle infected with gastrointestinal nematodes (excluding cattle showing no eggs in their feces) revealed a mean group I (*Cooperia-Trichostrongylus-Ostertagia*) egg count of 11.3 in adult cattle feces and 30.1 in calf fecal samples (Fig. 9). Adult cattle and calves infected with *Nematodirus* spp. showed an average of 5.3 EPG and 11.2 EPG;

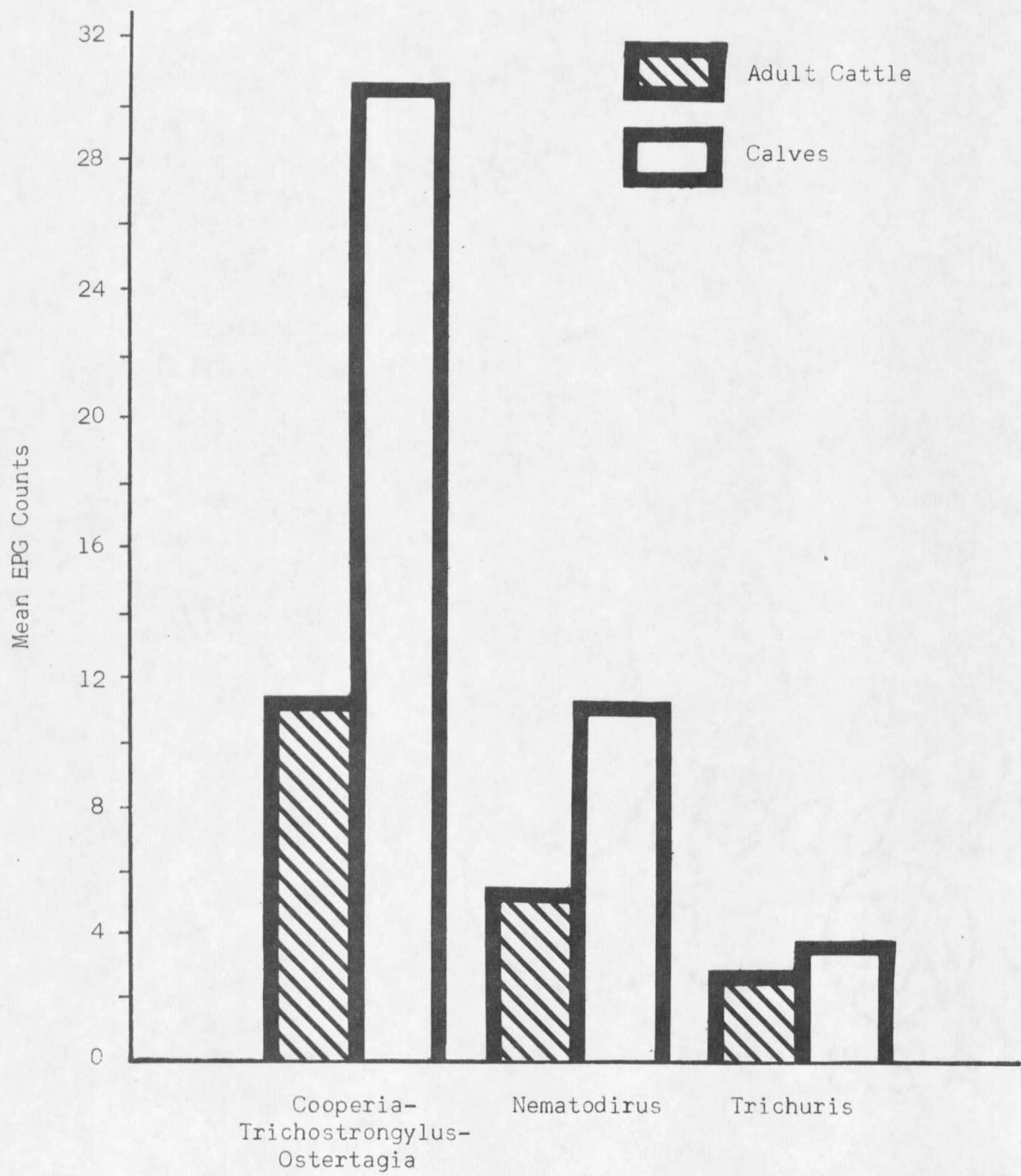


Figure 9. Mean worm egg counts for cattle infected with gastrointestinal nematodes at six Montana locations.

respectively. Mean egg counts for cattle infected with *Trichuris* spp. were 2.7 in adult cattle and 3.6 in calves.

An analysis of mean EPG counts for cows and calves infected with the *Cooperia-Trichostrongylus-Ostertagia* group at each sampling station appears in Figure 10. Calves from the central station had group I egg counts about ten times higher than calves from the western station. Calves from the southwestern, south central and eastern stations had mean EPG counts of 16.0, 16.7 and 17.0, respectively while adult cattle passing group I ova showed average egg counts of 11.6, 10.6 and 10.7 at the south central, eastern and central areas of the state, respectively.

Figure 11 presents mean egg count data for cattle infected with *Nematodirus* spp. None of the cows from the western, eastern and central stations was positive for *Nematodirus* spp. ova. Cows at the southwestern, south central and northern stations were passing fewer *Nematodirus* eggs per gram of feces than group I ova. Mean *Nematodirus* egg counts derived from calf fecal samples were generally about one-fourth (south central station) to four-fifths (northern station) as intense as group I egg counts at the respective sampling stations.

Of 1965 fecal samples examined, 64.9% were positive for coccidian oocysts. An analysis of incidence figures by species indicates *Eimeria bovis* was the most prevalent oocyst observed, followed by *E. auburnensis* which was present in 22.8% of the cattle examined (Table VI). Less than ten percent of the animals harbored one or more of seven additional *Eimeria* species found in the fecal samples. Nearly twice as many calves (80.7% positive) harbored *Eimeria* sp. as did cows



Figure 10. Mean worm egg counts of adult cattle and calves infected with the *Cooperia-Trichostrongylus-Ostertagia* group of nematodes.

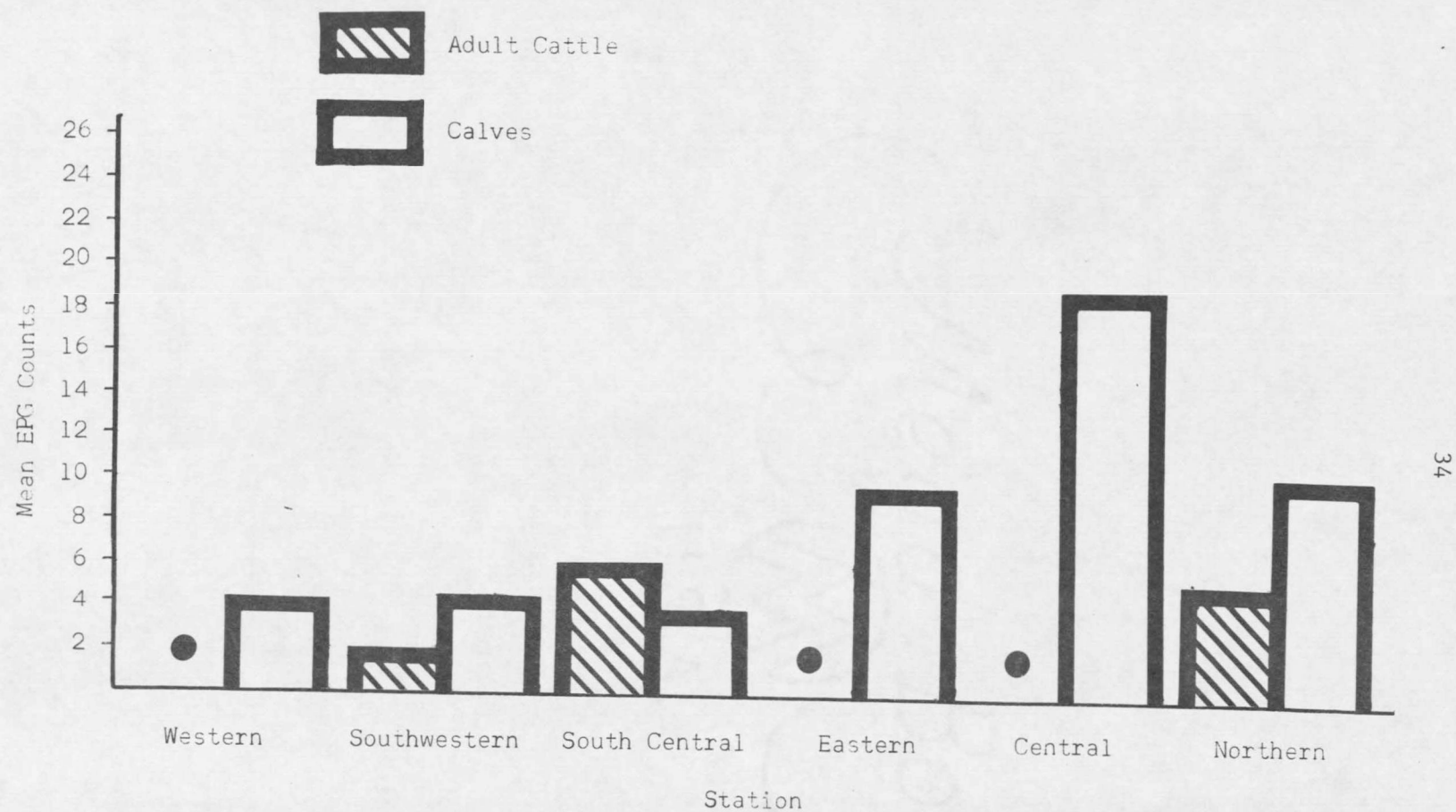


Figure 11. Mean worm egg counts of adult cattle and calves infected with *Nematodirus* spp.

● Indicates all cows were negative.

(48.9% positive).

A comparison of incidence figures for the six sampling stations revealed a relatively uniform infection rate among calves (Table VII). About one-half as many calves from the eastern sampling station were infected as calves from any other station. Incidence figures for calves from the four remaining stations ranged from 80.2% at the south central station to 92.2% at the southwestern station. Infection rates in cows ranged from 39.3% at the eastern station to 60.0% at the southwestern station.

An attempt was made to correlate seasonal trends in bovine endoparasitism with climatological data at the sampling stations. Since there was an inconsistency in the parasite data during corresponding seasons over the two years of the survey, it was concluded that observations over a more extensive period would be necessary for such a correlation.

Table VI. Incidence of *Eimeria* species in Cattle from Six Sampling Stations in Montana.

<i>Eimeria</i> species	Calves	Adult Cattle	All Cattle
<i>E. bovis</i>	61.4	29.6	46.5
<i>E. auburnensis</i>	32.1	12.5	22.8
<i>E. ellipsoidalis</i>	13.8	2.6	8.4
<i>E. bukidnonensis</i>	8.6	4.5	6.7
<i>E. zurnii</i>	6.5	5.0	5.8
<i>E. canadensis</i>	5.4	3.0	4.3
<i>E. cylindrica</i>	1.9	0	1.0
<i>E. alabamensis</i>	0.4	0	0.2
<i>E. brasiliensis</i>	0	0.2	0.1

Table VII. Incidence of Coccidia in Adult Cattle and Calves from Six Sampling Stations in Montana.

Station	Calves	Adult Cattle
Western	88.3	52.3
Southwestern	92.2	60.0
South Central	87.1	58.1
Eastern	47.4	39.3
Central	80.2	43.9
Northern	86.5	41.5

DISCUSSION

Cattle parasite survey data from western states other than Montana have been accumulated in Oklahoma (Cooperrider *et al.*, 1948), New Mexico and Arizona (Becklund and Allen, 1958), Arizona (Dewhirst *et al.*, 1958) and Wyoming (Honess and Bergstrom, 1963). In the four studies, *Ostertagia* spp. were among the more commonly found species of gastrointestinal nematodes. A study currently in progress at the Montana Veterinary Research Laboratory revealed that 88.5% of 26 abomasums from Montana cattle were positive for *Ostertagia* spp. As previously indicated, *Ostertagia bisonis* was responsible, at least in part, for an epizootic in cattle from central Montana (Worley and Sharman, 1966). If the *Cooperia-Trichostrongylus-Ostertagia* group of ova observed in the survey were actually primarily *Ostertagia* spp. eggs, the medium stomach worm likely would be the most prevalent endoparasitic infection in Montana cattle. In studies by Anderson *et al.* (1965) and Martin *et al.* (1957), *Ostertagia ostertagi* was the primary cause of clinical parasitic gastritis in calves. In these studies, large numbers of *Ostertagia* spp. in calves resulted in diarrhea and loss of weight. Therefore, in Montana, indications are that the potential exists for outbreaks of bovine parasitic gastritis attributable to *Ostertagia* spp.

A comparison of *Nematodirus* spp. incidence figures for cattle in the western United States indicated that 52% of the Oklahoma cattle examined were positive for this genus, while infection occurred only occasionally in cattle from New Mexico and Arizona (*v.s.*). *Nematodirus* was considered to be one of the principal causes of clinical parasitism in Wyoming cattle over the past ten years, and was the second most preva-

lent genus of gastrointestinal nematodes present in Montana cattle in the present survey.

Examination of lungs for *Dictyocaulus viviparus* was not made in the Wyoming and Oklahoma studies. Dewhirst *et al.* (1958) reported the presence of this species in Arizona cattle, but Becklund and Allen (1958) found all of 80 cattle they examined from New Mexico and Arizona to be negative for *Dictyocaulus*. This is in contrast to the presence of *D. viviparus* in cattle from five of the six areas studied in Montana.

Moniezia spp. ova were not found in Arizona cattle and were infrequently encountered in New Mexico. No tapeworm data are available from Wyoming, but Oklahoma records indicated that over 50% of the cattle harbored *Moniezia*. The frequency with which this cestode was found in Montana cattle (7.2% positive) was intermediate between that of the Oklahoma and New Mexico studies.

Fasciola ova were observed only in cattle grazing on mountain range known to be enzootic for liver flukes in New Mexico and Arizona. Likewise, liver fluke ova were limited generally to feces of cattle located in the western area of Montana which is also known to be enzootic for hepatic distomiasis.

Haemonchus contortus, *Bunostomum phlebotomum* and *Oesophagostomum radiatum* occur regularly in cattle from New Mexico, Arizona, Oklahoma and Wyoming (*v.s.*), but ova of these species were not commonly found in Montana cattle. With the above exceptions, helminthiasis in Montana cattle generally can be attributed to the same group of gastrointestinal helminths reported from the other western states.

The isolation of *Capillaria* spp. ova from fecal samples of three cattle in western Montana is a new locality record for the northwest region of the United States. According to Becklund (1964), capillarids have been isolated from cattle in Texas, Virginia and the southeastern United States. Dewhirst *et al.* (1958) reported *Capillaria* from cattle in Arizona, and Szanto *et al.* (1964) found *Capillaria* ova in 2.0% of 795 beef calves in Illinois. Other than the above records, *Capillaria* spp. evidently occur infrequently in cattle throughout the United States..

In Montana, calves were more heavily infected with gastrointestinal nematodes than were cows, suggesting an acquisition of immunity with increasing age. The presence of an immune response was strongly suggested by the age distribution of *Dictyocaulus* infections, since only calves up to 18 months of age were found to be infected with lungworms.

Adult cattle in Montana appeared to demonstrate a poor immune response to *Fasciola hepatica*. This is in agreement with similar data presented by Taylor (1964). At the western sampling station, 17 adult cattle were positive for liver flukes, while one calf was similarly infected. Since cows and calves were pastured conjointly, exposure to the metacercaria should have been similar for both age groups. Therefore, on general helminthic immunologic principles, one would expect younger stock to show a higher infection rate than mature cattle.

According to Levine (1963), optimum conditions for pasture transmission of *Trichostrongylus* and *Ostertagia* are a mean maximum temperature of 55°F. to 73°F. and two or more inches of precipitation per month. On this basis, climatographs have been prepared on which total monthly pre-

precipitation is plotted against the mean temperature for the month, and the resultant points are joined by a closed curve. Lines indicating the limits of climatic conditions most favorable for survival of free-living stages (55 F. to 73 F. and two or more inches of precipitation) have been superimposed on these figures. Bioclimatographs were constructed for the western, southwestern, south central and eastern sampling stations, using mean monthly maximum temperatures and mean monthly precipitation data from a 30-year period. Mean figures for each month of the year were not compatible with the prerequisites necessary for optimum transmission of *Trichostrongylus* and *Ostertagia* at the western, south central and eastern sampling stations. During the months of May and June, mean temperature and precipitation data for the southwestern station fell within the limits of climatic conditions most favorable for *Ostertagia* and *Trichostrongylus* transmission. Therefore, according to the bioclimatograph concept, transmission of these two species should be limited in Montana due to climatic factors adverse to the extra-host stages of the parasites.

Weather data were also summarized for two-month periods ending ten to 25 days prior to the sampling dates for each sampling station, in an effort to correlate parasite acquisition with local climatic conditions. Parasites which were acquired during this two-month period would have had time to oviposit, and therefore should have been detected in the ensuing fecal examinations. The average temperature range over four such two-month periods at the central station was 81.5 F., with the greatest range (maximum of 79°F.; minimum of -28°F.) occurring during the period from 17 March to 15 May, 1965. The mean gastrointestinal nematode egg count for calves

immediately following this period (2 June, 1965 sampling date) was 122.6. The maximum and minimum temperatures which occurred during the 18 months of the survey at each of the remaining stations were: western, 94° F. and -31° F.; southwestern, 84° F. and -29° F.; and northern, 93° F. and -29° F.

The relatively wide range in temperatures coupled with the lack of favorable periods for parasite transmission at each of the sampling stations theoretically would tend to limit parasite distribution in Montana cattle. However, the *Cooperia-Trichostrongylus-Ostertagia* group, *Nematodirus*, and *Moniezia* were identified from cattle at all sampling stations at all sampling intervals. The presence of *Dictyocaulus viviparus* in all but the northern area of the state revealed a widespread distribution of lungworms in Montana cattle which was previously unrecognized. Therefore, the helminth parasites most important to the Montana cattle industry are not limited to a specific climatologic area of the state, but are essentially statewide in distribution. Either free-living stages of the parasite are able to survive relatively harsh climatic conditions which characterize Montana throughout most of the year, or the adult parasites perpetuate the life cycle by persisting in the host during environmental conditions adverse to survival of extra-host stages.

The fact that gastrointestinal parasitism is perpetuated through succeeding generations of native stock indicates that conditions necessary for survival of free-living stages exist statewide. The length of time free-living stages survive under Montana conditions is still questionable and dependent upon accumulation of more data. However, it is

probably safe to assume that propagation and transmission occur during several months of the year, otherwise the parasite species would not be perpetuated. A consideration of Montana's macroclimatic conditions, coupled with the general distribution of gastrointestinal and respiratory parasitism in Montana cattle, would tend to indicate that extreme caution must be practiced when relating parasitism to macroclimatic conditions, since the occurrence of established parasite genera during this study was considerably more common than bioclimatographic data theoretically would indicate.

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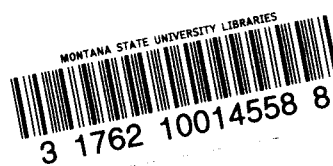
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