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Observations on Parasitism in Sheep in Northwestern South Dakota

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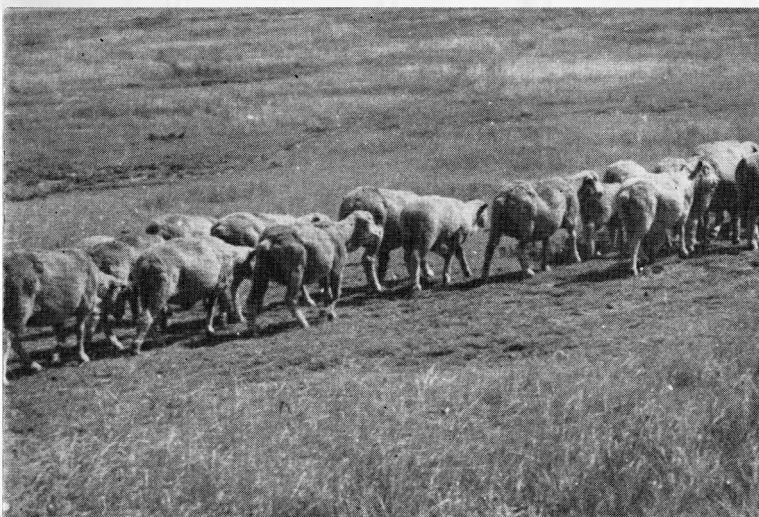
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OBSERVATIONS ON

Parasitism in Sheep

IN NORTHWESTERN SOUTH DAKOTA



VETERINARY DEPARTMENT
Agricultural Experiment Station
SOUTH DAKOTA STATE COLLEGE • BROOKINGS

Contents

Introduction	3
The Dysentery Problem	3
Field and Laboratory Observations, 1944-46	4
Observations on Parasitism in Sheep and Cattle at the Antelope Range Field Station, 1947-54	9
1947-49	10
1950-51	10
1952-54	11
Tapeworms	13
Broad Tapeworms (<i>Moniezia expansa</i>)	13
Fringed Tapeworms (<i>Thysanosoma actinioides</i>)	13
Summary and Conclusions	15
Appendix	18
Life Cycles of the Internal Parasites Found in Sheep in Northwestern South Dakota	18
<i>Haemonchus contortus</i>	18
<i>Ostertagia circumcincta</i>	18
<i>Nematodirus</i> species	18
<i>Trichostrongylus</i> species	19
<i>Moniezia expansa</i>	19
<i>Chabertia ovina</i>	19
<i>Thysanosoma actinioides</i>	19

OBSERVATIONS ON

Parasitism in Sheep

IN NORTHWESTERN SOUTH DAKOTA

G. S. HARSHFIELD, F. N. CARLSON, and T. A. DORSEY¹

THE GRASSLAND in the northwestern region of South Dakota has been used for sheep grazing for many years. According to the U. S. Crop and Livestock Reporting Service, the counties of Harding, Butte, Perkins, Corson, Ziebach, and Dewey, which comprise most of this portion of the state, had a combined sheep population of 336,500 in 1925. This was over half of the sheep in South Dakota.

The 1944 figure was 766,600 sheep for that area, showing more than 100 percent increase in a 20-year period. Between 1944 and 1950 sheep numbers declined in these six counties to 299,000. At least three factors accounted for the decrease after 1944: (1) the difficulty in ob-

taining labor; (2) favorable prices for cattle which could be raised with less labor; and (3) the prevalence of losses of lambs on range from dysentery, a condition that had existed for 5 to 7 years. It was the seriousness of the lamb losses that prompted the work reported here.

THE DYSENTERY PROBLEM

Losses Occur. Between 1937 and 1945 when sheep numbers were high, there were many reports of diarrhea involving lambs on range during the summer months. As a result of the diarrhea there was a serious death loss and many lambs in the affected flocks that lived were light in weight and were not salable as market or feeder lambs. The diarrhea did not affect ewes.

This trouble first appeared in July each year and usually continued until cooler fall weather or until the lambs were removed from range in September or October. Throughout these 2 to 3 months new cases would appear. With the trouble occurring in warm weather and scouring the principal symptom, it was natural for sheepmen to blame internal parasites.

Treatments Given. In many flocks anthelmintic treatments were given to the scouring lambs as well as the lambs not showing symptoms

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Valuable assistance was given to the project in the earlier years by Drs. Benjamin Schwartz, I. H. Roberts, and Robert T. Habermann of the Zoological Division, Bureau of Animal Industry, now Animal Disease and Parasite Branch, Agricultural Research Service, U. S. Department of Agriculture.

which should have been effective in reducing the worm load. Such treatments were generally ineffective in checking the diarrhea in the sick lambs or in preventing the onset of diarrhea in others, so long as the flock was left on range. Some ranchers who moved their flocks from the range to stubble fields were successful in checking the dysentery. Others reported that symptoms of diarrhea were overcome by removing the scouring lambs to a small corral where native hay was fed for several days.

Dysentery in lambs did not appear in all flocks in this range area. There were flockowners who were consistently successful in avoiding the losses on ranges which did not appear to differ in types of soil or grasses from those on which losses occurred.

With the decline in sheep numbers beginning in 1945, dysentery also became less of a problem. From 1946 to 1954 there were few reports of any serious difficulty with scouring lambs.

Field and Laboratory Observations, 1944-46

Field Laboratory. To obtain an appraisal of the sheep parasite and the dysentery problem, a field laboratory was established in 1944 at the U. S. Newell Field Station, Newell, South Dakota. This station served as headquarters for field and laboratory work for 3 years. One of the authors with zoologists of the Zoological Division, U. S. Bureau of Animal Industry, conducted inspections within the area in which the most trouble had been reported.

Inspections were made of flocks in which dysentery was occurring and flocks under different management programs in which scouring did not occur. These visits provided an opportunity to make observations on the quality of sheep in the flocks, management procedures, use and general condition of the ranges, as well as to collect specimens for laboratory examinations for parasites.

Management Problem. Observations made on the inspection trips emphasized the significant fact that the scouring condition in lambs was closely allied with faulty management. Most of the flocks in which

scouring in lambs was seen were small range flocks of 200 to 800 ewes on limited range and without full-time herding.

A few flock owners of 1,000 or more ewes were also experiencing trouble. Scouring among lambs was almost always associated with overstocking on range or a lack of a rotation program to utilize all of the range available. There were instances where carelessness in rotation or moving practices permitted overlapping of grazing areas or excessive length of time on an area.

In a few flocks the quality of the sheep was inferior due to keeping in the breeding flock of light lambs

(cutbacks) which were not salable in prior years. On some ranches summer range was being used for winter and spring grazing, allowing for early range contamination with parasites. The reports that anthelmintic treatments did not provide satisfactory control of dysentery in lambs were verified in the observations during the 1944-46 period.

While there were many factors contributing to faulty management, there was also evidence of freedom from trouble in lambs where the flock management involved regular moving of the flock and the bed-grounds to accomplish uniform grazing of the summer range area.

Two flock histories are cited to provide a more detailed account of the problem which was prevalent in the area.

Flock A. This flock consisted of 450 ewes and 427 lambs of Rambouillet-Corriedale breeding. The ewes had run on the range during the fall and winter but had received supplemental feed for 2 months prior to lambing which started March 25. The summer range consisted of 2,300 acres on gumbo soil with predominately wheatgrass, gramma, and buffalo grass. There was good forage cover on both low and high ground. The water supply was from dams.

The owner reported having had trouble with scouring in lambs since 1938. In 1944 the first evidence of scouring was observed July 7. By July 12 the lambs appeared to have lost their "bloom" and 10 were scouring. An examination of a composite fecal sample

from 9 lambs showed only 390 eggs per gram (e.p.g.)². A parasite egg count on July 22 showed 1,210 e.p.g. Twenty-five lambs were then scouring.

August 3 the owner treated both ewes and lambs with copper sulfate-nicotine drench and reported that many tapeworms were eliminated. Additional lambs developed dysentery, and on August 17 there were about 75 head affected. Two of the affected lambs were autopsied and both revealed a low number of worms. Nevertheless the owner again treated the lambs on August 20 with phenothiazine. The death loss by this time totaled 22 head. Additional cases of dysentery developed following the treatment.

On August 28, a local feeder bought 180 of the lambs including the top lambs and 50 that were then scouring or had scoured. During the 2-weeks these lambs grazed on grain stubble there was only one death, but 20 of the poorest of the group were still scouring. In the original flock some 30 to 35 lambs were still scouring at the last observation September 11. The death loss at that time totaled 73 (17 percent).

Although there were 2,300 acres of range, it became obvious that not over 1,000 acres were being grazed (2.2 acres per ewe). No herder was being employed and the flock was always found near the ranch buildings.

Flock B. This flock consisted of 1,400 ewes and 1,200 lambs of Ram-

²Throughout this bulletin, references to low, moderate, and high levels of parasite infestation designate fecal egg counts of less than 700, 700 to 1,500, and over 1,500 eggs to the gram, respectively.

bouillet-Corriedale breeding. The ewes started lambing May 1 on range. Although 6,500 acres were available for grazing, only about 3,000 acres were grazed in summer (2.1 acres per ewe). A herder was employed and bedgrounds were changed weekly. There was overlapping onto grazed areas with each move. Parts of the range had a liberal amount of gramma grass but wheatgrass predominated.

Counts of parasite eggs in composite fecal samples from ewes and lambs were made monthly with the highest count on July 19 (1,110 e.p.g.). Inspection of the flock on that date revealed several scouring lambs. Additional cases developed through the remainder of July and the owner decided to treat the ewes and lambs with phenothiazine.

The treatment August 1 did not check the dysentery and soon thereafter 283 lambs, including scouring lambs and the smaller unthrifty lambs, were sorted and turned into a cornfield. The death loss in this group through the rest of the season was 120 head. Additional cases of scouring developed in the main flock through August and September. The total death loss of lambs for the season was 200 head (16.7 percent).

On autopsy of a scouring lamb in September, 200 worms (*Haemonchus*) were found in the stomach and 2,000 (*Trichostrongylus* species) in the intestine. The average weight of the top lambs from the flock off range about October 1 was 53.3 pounds.

Autopsies. In 1944, post mortem examinations were conducted on over 40 scouring lambs from as many flocks. The worms present in the stomach and intestine of each of the lambs were recovered for identification of species and determination of the number by either direct count or a sampling technique.

The species of parasites found in these lambs were *Haemonchus contortus* (common stomach worm), *Ostertagia circumcincta* (medium stomach worm), *Trichostrongylus* species (bankrupt worm), *Nematodirus* species (thread-necked bowel worm), *Chabertia ovina* (large mouthed bowel worm), *Moniezia expansa* (broad tapeworm), and *Thysanosoma actinoides* (fringed tapeworm). (Brief descriptions of the life cycles of these parasites are given in the appendix.) Of these, only *Haemonchus contortus* and *Trichostrongylus* species were found in the majority of the lambs.

There was a wide range in the number of worms in individual lambs, varying from less than 100 to 9,300 *Haemonchus* and from 50 to 24,000 *Trichostrongylus* species. *Nematodirus* species, in numbers ranging from 100 to 8,000, were identified in 23 of the lambs autopsied. The others were less consistently found and in comparatively small numbers.

There was no apparent relation between the level of parasite infestation, either involving a single species or mixed infestation, and the incidence of scouring in the flocks

from which the lambs came. One parasite species (*Nematodirus*), encountered in about half of the autopsies, had been suspected by sheepmen of the area as a factor in causing the scouring. Since the time these examinations were made, Kates and Turner³ have demonstrated that *Nematodirus* species can cause diarrhea in lambs when experimentally infected with a large number of larvae.

There were lambs from 24 flocks that had received one or more anthelmintic treatments prior to the time of autopsy without the scouring having been checked.

More Data. In 1945 and 1946 additional data pertaining to the trends in parasite infestations in ewes and lambs on summer range were obtained from two small groups of sheep under different management programs.

On June 11, 1945 two fenced range pastures in the vicinity of Castle Rock, South Dakota were stocked at the rate of 6 acres per ewe and lamb. In the larger of the pastures, Lot 1 (620 acres), a plan of rotation of a group of 103 ewes with their lambs at 4-day intervals was undertaken with a caretaker in charge. The pasture was plotted into 8 grazing areas which allowed a 4-week rest period following each 4 days of grazing. In the smaller pasture, Lot 2 (360 acres), 60 ewes and their lambs were permitted to graze at will.

The species of parasites and the level of infestation were determined by examinations of fecal specimens

from each of the ewes and lambs at the beginning of the trial and at intervals through the summer. The number of worm eggs per gram was calculated by counting the eggs in one-tenth of a gram of feces. Only eggs of the *Strongyle* species were recorded, although note was also made of the presence of tapeworm ova.

Infestation Rate. A preliminary examination of a composite fecal sample from the ewes allotted to the rotation group showed a moderately high infestation of parasites. On June 11 when the trial started these ewes were each treated with 40 grams of phenothiazine to reduce this infestation as much as possible. During the summer a high level of infestation was built up in the lambs of the rotation group. These lambs were each treated with 25 grams of phenothiazine on July 18. No anthelmintic treatment was given to ewes and lambs of the free-grazing group.

Tables 1 and 2 show the average of the parasite egg counts of *Haemonchus* and *Trichostrongylus* species and also the total egg counts for the ewes and lambs in the two lots.

If the differences in egg counts on June 11 and July 5 are used to calculate the efficiency of phenothiazine treatment of the ewes of the rotation group, the results are 96.1 percent for *Haemonchus* and 76.1 percent for *Trichostrongylus*. In like manner, differences between the July 18 and August 8 counts in

³Kates, K. C. and Turner, J. H., "Experimental Studies on the Pathogenicity of *Nematodirus spathiger*, a Trichostrongylid Parasite of Sheep," *Am. J. Vet. Res.*, 1953, Vol. 14, pp. 77-81.

Table 1. Average of Parasite Egg Counts in Ewes, 1945

Lot 1				Lot 2			
Date (1945)	Haemonchus e.p.g.*	Trichostrongylus e.p.g.	Total e.p.g.	Date (1945)	Haemonchus e.p.g.	Trichostrongylus e.p.g.	Total e.p.g.
6-11†	1,056	331	1,494	6-18	592	329	1,004
7-5	41	79	159	7-9	1,275	496	1,939
9-4	1,575	294	1,890	8-28	930	305	1,297

*e.p.g.—eggs per gram of feces.

†Anthelmintic Treatment.

the lambs of the rotation group show an efficiency of phenothiazine treatment of 97 percent for *Haemonchus* and 97.6 percent for *Trichostrongylus* species.

It will be noted in Table 1 that the ewes of the rotation group, regardless of the treatment at the start of the trial and the frequent rotation on range, had acquired a relatively high *Haemonchus* infestation by September 4. The lambs of the rotation group (Table 2) also acquired a high level of *Haemonchus* in the first month on range.

There are two probable explanations of the failure of treatment plus rotation to control infestations: (1) early spring grazing of the pasture by other sheep prior to the start of the trial resulting in pasture contamination and (2) inability of the caretaker to keep the flock limited to the small assigned grazing plots, so grazing of adjoining contaminated areas couldn't be avoided.

In the free-grazing group, the parasite infestation in the lambs remained at a low level through the summer, although a comparatively high level was maintained in the ewes.

It was noted that throughout the summer this group moved about to make good use of the entire pasture. There was no difficulty with dysentery in the lambs of either group.

Six-Day Rotation. In 1946, the same 980 acres of pasture were used for a flock of 160 ewes and their lambs. On May 10, each ewe was treated with 40 grams of phenothiazine and the flock started on a 6-day rotation schedule, with five grazing areas allotted. A herder was provided to supervise the flock.

At the start of the trial and at 2-week intervals throughout the season, individual fecal specimens were collected from 50 marked ewes and as many lambs for identi-

Table 2. Average of Parasite Egg Counts in Lambs, 1945

Lot 1				Lot 2			
Date (1945)	Haemonchus e.p.g.*	Trichostrongylus e.p.g.	Total e.p.g.	Date (1945)	Haemonchus e.p.g.	Trichostrongylus e.p.g.	Total e.p.g.
6-18	0	0	0	6-26	0	0	0
7-18†	2,220	507	2,782	7-25	253	59	312
8-8	77	12	121	8-23	219	60	279
9-25	47	16	63	9-24	204	24	228

*e.p.g.—eggs per gram of feces.

†Anthelmintic Treatment.

fication and counts of the parasite ova.

Table 3 shows the average total parasite egg counts for the ewes and lambs throughout the trial extending to September 25. It can be noted that although the ewes start-

Table 3. Average Total Parasite Egg Counts of Ewes and Lambs on a 6-Day Range Rotation Schedule, 1946

Date (1946)	Eggs/gm. Feces	
	Ewes	Lambs
5-10	77	—
5-22	8	—
6-5	18	—
6-19	44	—
7-3	188	165
7-17	626	652
7-31	489	394
8-14	747	191
8-28	1,105	334
9-11	949	430
9-25	447	308

ed the trial at a very low level of infestation, there was a moderate build-up during the summer to slightly over 1,100 e.p.g. on August 28. The last two ewe samples showed a rapid decline. It is apparent that the program of rotation in this trial was effective in controlling range contamination so that the lamb infestation was kept low. The highest level was reached July 17 with 652 e.p.g. Scouring among lambs was not encountered.

During the examination of fecal specimens from the lambs, note was made of the presence of the eggs of the broad tapeworm *Moniezia expansa*. At one or more samplings during the season, 46 of 49 lambs on which records were complete were harboring tapeworms.

Observations on Parasitism in Sheep and Cattle at the Antelope Range Field Station, 1947-54

Grazing Levels. Although dysentery in lambs on range did not present a problem in the northwestern counties after 1945, the establishment of range studies at the Antelope Range Field Station in Harding County offered an opportunity to obtain data on the trends in parasite infestations in sheep on varying levels of grazing.

From 1947 to 1949 the sheep grazed as a single flock without a regularly employed herder and without a definite schedule of rotation. Starting with the 1950 season, fencing had been completed to provide five summer sheep pastures, each to accommodate 100 ewes with their lambs. They were identified as follows:

Lot 1. Low level grazing, 580 acres (5.8 acres a ewe).

Lot 2. Moderate level grazing, 410 acres (4.1 acres a ewe).

Lot 3. High level grazing, 254 acres (2.54 acres a ewe).

Lot 4. Rotation^a grazing at moderate level, 408 acres (4.08 acres a ewe). This pasture was cross fenced to provide four smaller pastures of equal size for weekly rotation.

Lot 5. Sheep with cattle, 936 acres. This pasture was stocked with 100 ewes and their lambs (4.1 acres a ewe) and 25 cows (21 acres a cow). After 2 years, 1950 and 1951, Lot 5 was discontinued.

1947-49. During the grazing seasons of 1947, 1948, and 1949, when the flock was not divided, composite fecal specimens were collected at approximately monthly intervals from ewes and lambs representing from 5 to 10 percent of the flock. The examination of these specimens for parasite eggs indicated certain trends in the parasite level through the season. The peak of infestation in ewes occurred at either the May or June sampling, with a decline on later samplings. The peak average egg count for ewes in eggs per gram was 1,034, 2,152, and 1,270 for the 3 years respectively.

Parasite infestations were not yet established in lambs at the time of the highest level in the ewes, but were detected in late June or early July samplings. The peak was reached in July or August and a decline noted in later samples. During these 3 years the parasite load in lambs remained at a low level, the highest counts being 632, 475, and 557 e.p.g.

There was abundant range and the flock moved about to make use of much of the area. The periods of the year when highest infestations were detected in ewes and lambs in this flock were the same as had been observed previously in privately owned flocks of the surrounding area.

Additional composite fecal specimens from the ewes were collected at intervals throughout the winter months. A very low level of infestation was indicated with total average counts ranging from 75 to 125 e.p.g. from October to March.

During 1948 and 1949 fecal specimens from cattle at the Antelope Range Field Station were also examined for parasite ova at monthly intervals throughout the year. The total number of parasite ova varied from 0 to 162 e.p.g. with the highest average counts obtained in April and May. On the basis of the egg counts, no significant degree of infestation was found.

1950-51. Through the 1950 and 1951 grazing seasons the sheep flock was divided into the five pastures as previously indicated. Egg counts of composite fecal samples from ewes and lambs of each lot were carried out at approximately monthly intervals. The parasite infestation in lambs remained low (less than 600 e.p.g.) with the exception of the weekly rotation lot.

In the weekly rotation group which was on four small pastures, the egg counts in lambs in early August in both years had risen moderately to between 900 and 1,000 e.p.g. This was followed by a sharp decline to 100 to 200 e.p.g. in September. The higher infestation level in this lot indicated that weekly rotation on four pastures, which allows only 21 days that any one pasture is vacated, does not allow time for contaminating worm larvae to be destroyed by natural factors.

Fecal samples from cattle which were pastured with sheep in Lot 5 continued to maintain a very low level of parasite infestation. The egg counts did not average any higher than samples from cattle pastured separately from sheep at the same station.

1952-54. Changes were made in the experimental procedures in 1952 which resulted in eliminating the sheep-cattle group. The other lots were continued. Ewes ranging in age from 2 to 7 years were allotted to summer pastures to provide a balance in their ages and also in their winter feeding. The same ewes were returned to the same lots in 1953 and 1954 with the exception of those lost by death or by culling due to age or pathological conditions. Replacements were made from 2-year-old offspring of ewes which had received the same management.

At 4-week intervals, both ewes and lambs were individually weighed and fecal specimens collected from 10 to 12 percent of the animals. These individuals, representing the age and winter management variations in each lot, were sampled throughout the season.

The trends in parasite levels in ewes and lambs through the grazing seasons of 1952, 1953, and 1954 are illustrated in Tables 4, 5, and 6. Table 4 shows that the ewes maintained a moderate parasite level through July 1. Following that date, the level declined gradually in the light grazing group but dropped sharply in the other three

lots. The infestation in all four lots remained at a low level throughout the grazing period.

Table 5 for 1953 also shows a sharp drop in the infestation level in ewes in all four lots, with July sampling following a moderate to high level on the first counts June 2. The lambs were not yet eliminating eggs on first sampling, but infestation was established in July. In comparing the peaks attained by lambs of the four lots it is noted that all occurred on the August 4 sampling, with the heavy grazing lot considerably higher than the others. In fact, the parasite infestation had reached a comparatively high level at the July 14 sampling in that group.

In 1954 (Table 6), the trends in the parasite levels in the ewes followed much the same course as indicated in previous years, the exception being the high level attained in the lot on heavy grazing early in the season. The lambs of the high grazing level again reached the highest parasite level of the four groups, the average counts increasing with each sampling through the summer. The infestation in lambs of the other three pastures had declined by the end of the season.

It should be pointed out that the tables represent an average of the total parasite egg counts of the ewes and lambs sampled in each lot. A wide range was found between individuals of any group, demonstrating variations in resistance or susceptibility to parasite infestation. As examples, in one sampling from ewes with an average to-

tal egg count of 1,794, the lowest individual count was 20 e.p.g. and the highest 6,700 e.p.g. A sampling of lambs from one lot varied from 50 to 1,035 e.p.g.

In the examination of the fecal samples, the parasite ova were classified as to species. Throughout all the trials, eggs of *Haemonchus contortus* predominated. The tables representing total egg counts very largely represent also the trends in

stomach worm infestation through the course of a summer.

Tapeworm infestations are not included in the data of the tables. Note was made of the presence of eggs of *Moniezia expansa* when the fecal examinations of lamb specimens were made. At one or more samplings during the summer 82.6, 86.5, and 81.2 percent of the lambs examined in 1952, 1953, and 1954, respectively, were eliminating tapeworm ova.

Table 4. Average Total Parasite Egg Counts of Ewes and Lambs on Different Grazing Levels, 1952

Date (1952)	Eggs per Gram Feces							
	Light Grazing Lot 1		Moderate Grazing Lot 2		Heavy Grazing Lot 3		Weekly Rotation Lot 4	
	Ewes	Lambs	Ewes	Lambs	Ewes	Lambs	Ewes	Lambs
6-5	1160	7	1100	95	1025	207	820	32
7-1	950	57	1213	38	1059	12	1150	12
7-29	743	290	272	181	251	290	530	205
8-26	506	262	201	293	389	448	455	239
9-23	414	226	208	257	136	230	213	263

Table 5. Average Total Parasite Egg Counts of Ewes and Lambs on Different Grazing Levels, 1953

Date (1953)	Eggs per Gram Feces							
	Light Grazing Lot 1		Moderate Grazing Lot 2		Heavy Grazing Lot 3		Weekly Rotation Lot 4	
	Ewes	Lambs	Ewes	Lambs	Ewes	Lambs	Ewes	Lambs
6-2	1067	—	1856	—	1161	—	1180	—
7-14	243	471	123	1013	402	1831	188	709
8-4	82	1131	80	1063	237	1941	544	1480
9-1	90	545	59	953	91	561	101	582

Table 6. Average Total Parasite Egg Counts of Ewes and Lambs on Different Grazing Levels, 1954

Date (1954)	Eggs per Gram Feces							
	Light Grazing Lot 1		Moderate Grazing Lot 2		Heavy Grazing Lot 3		Weekly Rotation Lot 4	
	Ewes	Lambs	Ewes	Lambs	Ewes	Lambs	Ewes	Lambs
5-3	993	—	1038	—	1794	—	1041	—
6-3	1111	—	1246	—	2873	—	1667	—
7-6	56	36	98	26	97	141	371	266
8-3	503	948	636	1242	354	1035	795	1455
9-1	196	700	386	658	289	1606	468	1165
9-20	294	722	746	973	297	1783	418	840

Tapeworms

Broad Tapeworm. One of the species of intestinal parasites that is prevalent in range sheep is the broad tapeworm, *Moniezia expansa*. A high percentage of the lambs of flocks that were checked at intervals throughout the summer during the years covered in this report, showed the presence of tapeworm eggs in fecal specimens at one or more samplings as previously noted.

Both sheepmen and veterinarians have, at various times, attributed scouring in lambs during summer months to tapeworm infestations. During 1945, opportunity was presented to conduct some trials involving treatment with lead arsenate for the removal of broad tapeworms of sheep, and to observe the effect of such treatment on some scouring lambs. The results of those trials have been published by Habermann and Carlson.⁴

In those experiments, lead arsenate in doses of 1 gram removed a high percentage of the tapeworms from 26 infested lambs. The efficiency of treatment was approximately 92 percent, based on the total number of tapeworms passed in the 3 or 4 days after treatment and the number remaining in the intestines at autopsy. Eleven of the treated lambs had evidenced some scouring for from 2 days to 2 weeks prior to the administration of the lead arsenate.

The normal form and consistency of the feces returned following treatment. Since the infestations with the smaller nematode parasites were low in the lambs used in the trials, the improvement following treatment indicated that the

tapeworms accounted for the scouring symptoms in those lambs. At autopsy fringed tapeworms, *Thysanosoma actinoides*, which had not been removed by treatment were found in the intestines of six lambs.

Fringed Tapeworm. The fringed tapeworm (*Thysanosoma actinoides*) has its distribution limited to western states with the eastern limits in the Dakotas. Natural infestations are seen in sheep raised west of the Missouri River but have not been observed in sheep raised in the eastern counties of South Dakota.

Newsom and Cross⁵ state that fringed tapeworms are only slightly, if at all, pathogenic for sheep. They do have some economic importance in that invasion of the bile ducts of the liver accounts for liver condemnations at slaughter amounting to 10 to 60 percent or more in sheep from western states.

Lead Arsenate. Since lead arsenate had shown value for removal of broad tapeworms, a trial was conducted during the winter 1945-46 to

⁴Haberman, R. T. and Carlson, N. F., "Lead Arsenate Relieves Scouring in Lambs Due to Tapeworm Infestation." *Vet. Med.*, 1946, Vol. 41, pp. 306-310.

⁵Newsom, I. E. and Cross, Floyd, *Lamb Diseases in Colorado Feedlots*, 1943, Bull. 474. Colo. Agr. Exp. Sta.

determine whether liver condemnations due to fringed tapeworms could be reduced by administration of this chemical. Approximately half of the lambs that were started on feeding trials at the Newell Field Station were treated with individual doses of 1 gram of lead arsenate early in November 1945. The lambs were slaughtered on March 5 and April 3, 1946. Their livers were inspected for fringed tapeworms. There was no benefit from the treatment, as indicated in the summary data.

Treated lambs slaughtered..	337
Livers condemned	48
Percent condemnation ...	14.24
Untreated lambs	
slaughtered	389
Livers condemned	54
Percent condemnation ...	13.88

"Cunic" Drench. Harshfield and Esplin⁶ in 1943 reported on trials in which "cunic" (copper sulfate and nicotine) drench was used to determine effectiveness in reducing liver condemnations in feedlot lambs. There were three trials. In the first two the drench was administered at the time the lambs were placed on feed. Liver condemnations were 9 and 10.5 percent in the treated lambs as compared to 50 and 42.6 percent in the untreated.

In the third trial, one group of lambs was treated with "cunic" three times and a second group two times on range during the summer prior to a treatment on entering the feedlot. A third group received only the treatment on entering the feedlot and the fourth was not treated.

The liver condemnations were 3.5, 3.6, 20, and 26.7 percent for the four groups respectively. Only small numbers of lambs were included in the three trials.

In view of the promising results in the Colorado trials, "cunic" was used to treat half the lambs placed on feed at the Newell Field Station in the fall of 1946. The drench was mixed to contain 1.5 percent copper sulfate and 1 percent of commercial 40 percent nicotine sulfate concentrate. Each treated lamb received 2 ounces as a drench November 6, 1946. Inspection of the livers was made at slaughter. Fifty-two livers (22.5 percent) were condemned from the 231 treated lambs and 56 (25.1 percent) from 223 untreated. There was no economical advantage of treatment obtained in this trial.

Di-phenthane-70. In the fall of 1947 another chemical was used as treatment of feedlot lambs to determine effectiveness for reducing liver condemnations. The product was Di-phenthane-70 (Pittman-Moore), which has been used as a treatment for tapeworms in dogs and has been recommended for treating sheep for removal of both broad and fringed tapeworms.

The chemical was administered in a dosage of 6.5 grams and the lambs were slaughtered March 5, 1948. There were 29 liver condemnations from 73 lambs which had received treatment (39.7 percent), and 29 condemned livers from 93

⁶Harshfield, G. S. and Esplin, A. L., *Liver Condemnations in Feedlot Lambs Can Be Reduced by Early Treatment for Worms*, Colo. Farm Bull., 1943, Vol. 5, No. 44, pp. 10-12.

untreated lambs (34.9 percent). Thus there was no desirable effect accomplished in this trial.

In an article published since these trials were completed, Olsen⁷ concluded that this chemical had some efficacy in the removal of

fringed tapeworms from sheep, but that results were variable and unpredictable. He reasons that without demonstrable pathogenicity of fringed tapeworms, medication for the salvage of livers alone is not economically feasible.

Summary and Conclusions

IT IS EVIDENT from the foregoing observations and data that a final solution of the cause of the scouring of lambs on range has not been attained. With the reduction in the number of flocks and total number of sheep on range, lamb losses from diarrhea have become insignificant.

Many of the owners of small flocks who were having trouble in the period prior to 1945 quit sheep altogether. Some who still have sheep have reduced the size of their flocks permitting a more favorable sheep number-range area ratio or have instituted better management practices which provide for more vigorous lambs, better nutrition, and a lower level of internal parasites during the grazing season. The observations in the early years of these studies pointed to a close relationship between faulty management and the dysentery problem.

Management. It has long been recognized that management factors, including nutrition, have an important bearing on the acquisition of internal parasites and the injury which will result from parasite infestations. The data obtained from autopsies of scouring lambs and from examinations of fecal specimens did not incriminate internal parasites as the sole factor,

or even the major factor, in the scouring of the lambs as it was observed in 1944 and 1945.

The effect that various range plants may have had when eaten by lambs was not considered in these studies. It is possible that in overgrazing some plants would be eaten that ordinarily would not be touched if desirable grasses were abundant. Many sheepmen in the area included in these studies have stated that sheep eat little or no salt while on range. Apparently the needs for salt are satisfied through salts that are present in soil or in plants. It is possible that some of the plants ordinarily not eaten contain salts in amounts sufficient to be a factor in the scouring of lambs.

Parasite Levels. The observations and data obtained over several years on ranch flocks and controlled groups of sheep on varied

⁷Olsen, O. W., "An Evaluation of Medicants, with Special Reference to Teniatol for Removing Fringed Tapeworms (*Thysanosoma actinioides*) from the Livers of Sheep," *Am. J. Vet. Res.*, 1953, Vol. 14, pp. 616-620.

rates of grazing have helped to establish the trends in parasite levels in ewes and lambs at different periods of the year for the northwestern South Dakota area. There is reason to believe that the same would apply to the remainder of the state. The following seem significant.

1. Ewe flocks wintered either on range or in corrals maintain a parasite infestation at a low level during the colder months.

2. With the beginning of warmer weather (when temperatures reach 45 degrees or more) a gradual increase in the parasite level occurs. The peak level of this rise occurs during May or June.

3. A marked decline, usually rapid but sometimes prolonged over 2 or 3 months, occurs in the infestation level in ewes soon after the peak is reached. In this area, the decline occurs soon after the flock is turned to summer range. This has been referred to as "self cure."

4. Although a slight rise in parasite level in ewes is common in the latter part of the summer, the peak is not as high as in the spring, nor does the rise persist into the winter months.

5. Worm infestations in lambs are not detected before June. This observation has applied regardless of the lambing dates.

6. The development of parasite infestation in lambs is rapid in late June and early July with the peak usually about August 1.

7. Towards the end of summer the level in lambs has declined or is declining.

Control Methods. On the basis of these observations, recommendations can be made regarding the time that anthelmintics should be administered to accomplish the best results. Since parasite infestations are at a low level during the winter, treatment during that period can be expected to accomplish little towards a year-round control program.

Because of the increased infestation in spring months, individual treatment of ewes just prior to turning to summer range should greatly reduce range contamination by mature sheep. If the flock has been kept off summer range during the winter and spring, pastures should then be relatively clean for the start of grazing. With sufficient summer range, infestations usually do not develop to a level requiring treatment.

The observations reported here indicate that at least 4 acres to the ewe and lamb are necessary for summer range in the northwestern counties of the state. Should limitation of range, failure to treat the ewes, or spring contamination of range occur, it might become necessary to treat the lambs during the summer. This date should coincide with the rapid rise in the infestation of the lambs in early July.

An alternative practical control of parasite infestations for smaller flocks on pasture during the summer months is the use of phenothiazine-salt mixture made readily accessible from the time of turning to summer pasture, assuming that salt



A representative group of the ewes that were used in the grazing level trials at Antelope Range Field Station. These ewes are being weighed and fecal specimens collected.

requirements are not met through the soil or forage.

Egg Counts. No definite number of worm eggs in fecal counts can be given as indicative of clinical parasitism. The injurious effects of parasites on the host animal depends on such factors as species of parasites, rate at which the infestation was acquired, and general nutrition of the host animal throughout the course of the parasitism. In the data presented, reference was made to low, moderate, and high levels of infestation. These designations were arbitrarily used to indicate fecal egg counts of 700 or less, 700 to 1,500, and 1,500 or more eggs to the gram.

Tapeworms. Broad tapeworm infestations, while prevalent in range sheep, did not appear to be responsible for the dysentery problem in the northwestern area of South Dakota. These parasites were present in only a small number of the scouring lambs that were autopsied. In

flocks in which anthelmintics that are at least partially effective against tapeworms were used, diarrhea was not checked.

However, the fact that diarrhea in lambs may be produced by tapeworm infestations cannot be overlooked. Several scouring lambs which were treated with lead arsenate showed improvement following such treatment. The trials involving lead arsenate as a taeniafuge indicate high effectiveness in the removal of broad tapeworms.

Fringed tapeworms are a common parasite in western counties but do not naturally infect sheep raised in the eastern counties of South Dakota. They have little, if any, injurious effects but their presence in the bile ducts requires condemnation of the liver at slaughter. The trials aimed at reduction in liver condemnation from this cause by treatment of feedlot lambs with copper sulfate - nicotine solution, lead arsenate, and di-phenanthrene-70 were unsatisfactory.

Appendix

Life Cycles of Internal Parasites Found in Sheep in Northwestern South Dakota

Haemonchus contortus. Common name: Twisted stomach worm. Eggs are deposited by the female in the stomach (abomasum) and are passed in the feces. At 80 degrees F., embryonation is evident at 6 to 8 hours and most larvae hatch within 19 hours after eggs are passed. During the next 3 days larvae undergo growth and molts to reach the infective larval form about 4 days after eggs are passed. At lower temperatures, down to about 45 degrees F., larval development occurs at a slower rate. The infective larvae of *Haemonchus contortus* are relatively short lived, dying within 2 to 3 months under average pasture conditions.

Under conditions of sufficient moisture, dull light, and above minimum temperature, *H. contortus* larvae migrate up blades of grass. They migrate to the ground in cool weather, in bright light, or when moisture disappears from the grass. Greatest migration and the time most favorable for infestation is in early morning.

Infection occurs by ingestion of infective larvae with the grass. Within the stomach the larvae undergo an additional two molts during development to the adult stage which is reached as early as 15 days after infection.

Ostertagia circumcincta. Common name: Brown or medium stomach worm. Eggs passed in the

feces hatch within 24 hours. The infective larval stage is reached in 5 to 6 days at temperatures of 68 to 80 degrees F. Infection occurs by ingestion. On reaching the stomach, the larvae enter the mucosa where molting occurs, after which they return to the surface to complete development to mature stages. Adult stages may be found as early as 15 to 17 days after infection.

Both the eggs and infective larvae are more resistant to environmental conditions than *H. contortus* and some overwintering can be expected in pastures in South Dakota. However, infective larvae are susceptible to drying and the rate of survival is low in summer months with low rainfall.

***Nematodirus* species** (*N. spathiger*, *N. abnormalis*). Common name: Threadnecked strongyle. Eggs are passed in the feces but even under favorable conditions, larvae do not reach an infective stage for 2 to 4 weeks. The adult stage is reached 3 to 6 weeks after infection. Developmental larval stages outside the body are very resistant to environmental conditions and can survive over winter in pastures.

***Trichostrongylus* species** (*T. colubriformis*). Common name: Bankrupt worm. Eggs which are passed in feces may reach the infective larval stage in a minimum of 60 hours. Infection occurs by inges-

tion with food and water with adult stages reached in 17 to 25 days. Although eggs have been shown to resist drying for an extended period, larvae are destroyed by freezing and by high temperature.

***Chabertia ovina*.** Common name: Large mouthed bowel worm. Eggs passed in the feces hatch within 24 hours and develop into infective larvae in 5 to 6 days at summer temperatures. After ingestion of infective larvae, 5 to 6 weeks are required to reach maturity in the large colon where the adults attach to the mucous membrane. In 7 to 8 weeks after infection, eggs from the mature worms are found in the feces.

***Moniezia expansa*.** Common name: Broad tapeworm. Eggs may be passed either free in the feces or contained within the segments. The

egg contains the onchosphere within a membrane known as the pyriform apparatus. Contents of the eggs, including the onchosphere, are eaten by several species of mites common on grasses and the surface layer of the soil.

In the mite, the onchospheres pass through the gut wall to the body cavity where they develop to a stage infective for sheep, known as cysticeroid. This requires about 6 to 8 weeks in summer. Infection of sheep occurs by ingestion of mites containing the cysticeroids. Mature tapeworms may be found in the intestine of sheep in a little over a month.

***Thysanosoma actinioides*.** Common name: Fringed tapeworm. The life history of this species is unknown. Adult parasites are located in the small intestine and frequently invade the bile ducts of the liver.