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Practical Tests With Anthelmintics for Grazing Lambs

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ABSTRACT

Two hundred eighty-four lambs were used in six trials over a three-year period in which anthelmintics for lambs were compared under practical grazing conditions. In the first two trials copper sulphate was compared with standard phenothiazine (40 percent concentration and no specifications for particle size). Lambs treated with phenothiazine made slightly faster gains, but the differences were small and not consistent. Copper sulphate was compared with fine particle phenothiazine (average particle size, 3 micron) under two systems of grazing management, continuous grazing versus grazing only during the day. Under the conditions imposed there was no significant difference in gains and the drugs appeared approximately equal in efficiency against stomach worms.

In three comparisons of an organic phosphate, 4-Tert-butyl-2 Chlorophenyl methyl methylphosphoramidate (Ruelene) was compared with phenothiazine. The phenothiazine used in the comparisons was the standard product sold for worming sheep. Fine particle phenothiazine averaging 3 microns in particle size was used in one trial.

Lambs treated with phosphoramidate made faster gains in each of two tests than those treated with phenothiazine. Using fecal worm egg counts as a criteria, the drug was much more effective against *Hemonchus contortus*. The organic phosphate was well tolerated at 100 mg to 200 mg over kg body weight. In a further comparison, lambs treated with 150 mg phosphoramidate per kg body weight made faster (highly significant gains; $P < .01$) than lambs treated with standard phenothiazine.

In a final trial, phosphoramidate was compared with standard phenothiazine and fine particle phenothiazine for lambs grazing lespedeza pasture. Lambs treated with the two phenothiazines grazed together on the same pasture which was adjacent to the one used by lambs drenched with the organic phosphate. Results were prejudiced somewhat in early stages by the apparently greater infestation of parasites in forage of the field grazed by lambs treated with phenothiazine.

Lambs treated with standard phenothiazine were soon in critical condition. Six of 17 died and most of the others had to be removed to dry lot to prevent death. Lambs treated with fine particle phenothiazine were healthier and had a higher survival rate than those treated with the coarser phenothiazine, but in the end they, too, were unable to resist the stomach worms. Lambs treated with phosphoramidate made normal gains and, using worm egg counts and hematocrits as criteria for judging infection, did not encounter critical numbers of internal parasites. A method of treating heavily infected lambs using phosphoramidate drenches and supportive nutrition was effective on heavily infected lambs.

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Practical Tests With Anthelmintics for Grazing Lambs

C. V. Ross and G. C. Shelton

INTRODUCTION

The history of sheep production is replete with accounts of the trials and tribulations of sheepmen with internal parasites in their flocks. Even after the thousands of years of trying to solve the problem, man has evolved no simple, inexpensive and completely effective way of controlling stomach worms in sheep. Today, as in the past, when sheep are used in an intense grazing program and moisture and climate conditions are favorable it is only a question of time until the sheepman can expect to be involved in a deadly battle to save his charges.

Today in Missouri most sheepmen agree their most serious problem is stomach worms. When pasture renovation methods, using new, more productive forages and soil treatments, were developed, they appeared to be a godsend to the sheep raiser. He could anticipate increased production with consequent reduction of expenses from the improvement of carrying capacity per acre of improved pasture. But he did not realize all the implications of stocking pastures heavy enough to fully utilize the forage, and he did not consider how well the shading and other effects of increased leafiness would be adapted to the propagation of nematodes. Many sheepmen have been sadly disillusioned by the discovery that they have intensified their parasite problems by improving pastures.

Sheep tend to develop an immunity or tolerance for stomach worms as they grow older. Young lambs are thus much more susceptible to infestation than adults. The effects are of more economic importance because stomach worms injure all lambs by reducing growth rate and preventing fattening; in the more severe cases, death may result. Summer death losses of lambs in Missouri are to a large extent the result of parasite infections.

One of the oldest treatments for stomach worms in use today is copper sulphate. This chemical is effective, inexpensive, and simple to use, but it has some drawbacks. It is a poison and thus may be fatal if given in incorrect doses. It is only effective against the common stomach worm *(Hemonchus contortus)* and must be given at two to three-week intervals during spring and summer.

Phenothiazine which first became available to sheepmen in 1938 was soon in wide use. It is less toxic than copper sulfate, requires no fasting prior to treatment and is effective against a wider range of internal parasites. It has been used successfully by sheepmen, but there have been many instances when it has failed to control internal parasites.

Reports have indicated that stomach worms may build up immunity to phenothiazine.[1,2,3,4] This information has caused a more concerted search for

other anthelmintics which can be used to control internal parasites in sheep. Attempts have been made to determine whether or not phenothiazine can be improved by changing its physical form. Results of field trials suggest that very fine particle phenothiazine is more effective than the standard product in general use.[5,6,7,8,9] However, none of these reports actually compared the efficiency of the two products as reflected by growth of gains under pasture conditions.

The drug industry is continually testing new anthelmintics in an effort to find products suitable for controlling parasitism. The new drugs are usually tested for toxicity and efficiency but there is seldom evidence under field conditions to indicate how well sheep grow and gain following treatment. Some drugs effectively remove worms but may cause reduction of growth.

The research reported here sought more information on the effectiveness of old and new anthelmintics by comparing gains of lambs on pasture as well as the reductions of parasite populations.

MATERIALS AND METHODS

Spring lambs were used in all of the experiments. With the exception of one test, all lambs ran on pasture during the time on treatments. Most of the pasture was lespedeza. Sudan furnished emergency pasture when lespedeza dried up during the summers of 1958 and 1959.

All lambs were weighed individually and fecal worm egg counts were made on individuals prior to initiation of experiments. Egg counts, body weights, sex, and thrift were used as a basis for dividing lambs into outcome groups. Then lambs from each outcome group were assigned at random to the treatments. All anthelmintics used in this series of experiments were administered as drenches. The initial drench was given the day the experiment began and again at predetermined intervals depending on the original infection of the lambs. Extra drenches were administered when it became obvious that additional treatment was needed to prevent large scale death losses. In cases where frequent drenches were not sufficient to control the parasites, lambs were removed to the veterinary clinic or to hospital quarters and treated with anthelmintics and vitamins and fed dry feed.

Worm eggs were counted in fecal samples taken from each lamb just before it was drenched. Blood samples for hematocrit determinations were drawn at the time fecal samples were taken in experiments where infections were extremely heavy. All data were analyzed by *Analysis of Variance* (Snedecor 1955).

COMPARISONS OF PHENOTHIAZINE AND COPPER SULFATE

Experiment 1 (1958)

The object of Experiments 1 and 2 was to compare gains and condition of lambs treated with phenothiazine and lambs treated with copper sulfate while grazing. The trial began July 3, 1958, with 26 late lambs out of northwest ewes and sired by Hampshire rams. Lot I lambs were drenched with 1⅓ oz. of 40 percent concentration phenothiazine per lamb. They also had access to pheno-

thiazine salt mixture (1 part phenothiazine to 9 parts salt) at all times. Lot II received 1½ ounces of 2 percent copper sulfate solution per lamb and had access to iodized salt at all times. The same treatments were repeated at the end of the seventh and ninth weeks of the test.

The lambs grazed similar Korean Lespedeza pastures, and each lot remained on the original field throughout the experiment. During the early part of the test, moisture was adequate and pastures were excellent. It was necessary to turn dry ewes in with the lambs to prevent excessive growth of lespedeza. In September pastures became dry and grazing was rather sparse.

At the end of the experiment all lambs were graded alive using USDA Standards. Table 1 shows results.

TABLE 1-COPPER SULPHATE VERSUS PHENOTHIAZINE FOR GRAZING LAMBS

Lots	I	II
Treatment	Phenothiazine	Copper Sulphate
Number of Lambs	13	13
Av. Initial Weight (lbs.)	52.69	52.91
Av. Final Weight (lbs.)	76.54	74.69
Av. Gain per Lamb (lbs.)	23.85	21.78
Number Days on Test	84	84
Av. Daily Gain (lbs.)	.281	.S60
Mean Avg. Worm Eggs/Gram Feces		
Initial	3925	2828
28 Days	675	971
56 Days	1000	928
84 Days	475	328
Final Live Grades		
Choice	5	2
Good	8	10
Commercial	0	1

Using worm egg counts as a criterion, the initial infestation was variable. Some lambs appeared to have a rather heavy infection of parasites while others had very few. Lambs on both treatments made satisfactory gains and, according to present day standards, most of them would have graded choice. The lambs which were treated with phenothiazine made somewhat faster gains, graded slightly higher and had a lower worm egg count, but none of the differences were statistically significant. Under the conditions of the experiment there appeared to be little to choose from between the two anthelmintics.

Experiment 2 (1958)

Thirty-six purebred ewe lambs were used in the second experiment. Treatments were the same as in the first experiment with one exception: Since the ewe lambs were being kept for replacements in the purebred flock they were fed approximately ¾ pound of a grain mixture per ewe daily. Composition of the mixture was:

7 parts ground ear corn
2 parts bran
1 part soybean oilmeal

The test began July 25 and was continued for nine weeks. Worm egg counts were made initially, then on the fourth and seventh week and at the end of the test. The ewe lambs were drenched at the beginning of week 1, week 4, and week 7.

The lambs grazed lespedeza pastures located near the sheep barn in Columbia. The stocking rate had been heavy on the fields for years; thus a high level of parasitism was expected. Table 2 gives results.

TABLE 2-COPPER SULPHATE VERSUS PHENOTHIAZINE FOR GRAZING LAMBS

Lots	I	II
Treatment	Phenothiazine	Copper Sulphate
Number of Lambs	18	18
Av. Initial Weight (lbs.)	75.50	74.11
Av. Final Weight (lbs.)	85.17	80.11
Av. Gain per Lamb (lbs.)	9.67	6.00
Number of Days on Test	63	63
Av. Daily Gain (lbs.)	.153	.095
Mean Avg. Worm Eggs/Gram Feces		
Initial[1]	8792	10033
28 Days	3192	4487
49 Days[2]	2667	413
63 Days	433	187
Final Live Grades		
Choice	7	5
Good	9	11
Commercial & Utility	1	2
Cull	1	0

1. Many of the lambs had high worm egg counts.
2. Sample taken one week after the six week drenching of both lots. Most lambs had heavy worm infestations at the beginning of the trial.

Worm egg counts indicated a high level of *Hemonchus Contortus* infestation among some of the ewe lambs. The egg counts suggested a rather wide variation in levels of infection. In spite of the frequent drenching, worm egg counts continued to indicate heavy infection. Poor weight gains were noted for all lambs. Until near the end of this test, pastures were good and should have been adequate for satisfactory gains, but neither group made satisfactory growth. However, some lambs out of each group made very acceptable gains.

Although differences between lots were not statistically significant, lambs treated with phenothiazine had a slight edge in daily gains, thrift, and condition. On the other hand, worm egg counts indicated the level of infestation may have been slightly less in lambs treated with copper sulphate.

Experiment 3

The third comparison between phenothiazine and copper sulphate was made in the summer of 1960. The objectives of the experiment were:

(a) To compare gains and worm egg counts of lambs treated with phenothiazine and lambs treated with copper sulphate.

(b) To compare the efficiency of the two anthelmintics under conditions of continuous grazing with grazing only during daylight hours.

Forty-four purebred lambs from the college Hampshire, Shropshire, and Corriedale flocks were used in the experiment.

The lambs were divided into outcome groups and assigned at random to two groups for the pasture study. Each group was subdivided for the comparison of anthelmintics. Treatments were:

TABLE 3

Lots	I_a	I_b	II_a	II_b
Number of Lambs	11	11	11	11
Grazing Management	Continuous	Continuous	Daylight only	Daylight only
Drench used	2½% $CuSO_4$	Pheno-[1] thiazine	2½% $CuSO_4$	Pheno-[1] thiazine
Dosage/Lamb	1½ ounce	12½ grams	1½ ounce	12½ grams

1. Fine particle phenothiazine had a particle size averaging 3.5 microns as determined by Fisher Sub-Sieve Method.

The lambs were alternated on two lespedeza pastures each week during the trial. All lambs had access to a mixture composed of 90 percent salt and 10 percent phenothiazine. All lambs were weighed biweekly and fecal collections for worm egg counts were made at that time. The lambs which were limited to daylight grazing were penned at night in a dry lot with access to mineral and water. Blood samples were taken on each lamb at the end of the experiment and hematocrit determinations made. Results are shown in Table 4.

A few lambs in each lot had moderately high worm egg counts prior to the experiment, but after the original treatments the lambs appeared free of parasites. This was borne out by the fecal worm egg counts and by hematocrit determinations made at the end of the experiment. The pastures were well drained and the rainfall during the summer was light. Thus, it appears that slight, if any, parasitism developed in either lot. It was interesting to note that severe parasitism with death losses developed in fields on the same farm which were lower and had poorer drainage.

Lambs that were on pasture continuously appeared thriftier and grazed earlier and later in the day than those which were limited to daylight hours. The lambs treated with copper sulphate made somewhat faster gains on both systems of grazing and had slightly higher hematocrit readings, but worm egg counts were approximately the same for lambs on both treatments. Lambs on continuous pasture made faster gains, but none of the differences was statistically significant.

EXPERIMENTS WITH NEW PRODUCTS

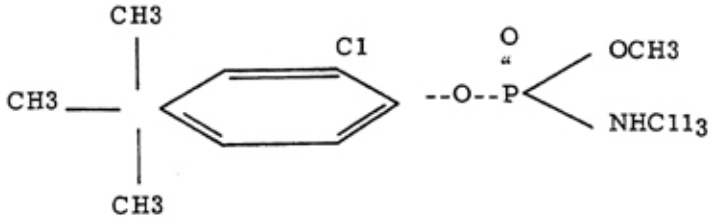
If sheepmen are to wage a winning battle against internal parasites they must be furnished the necessary weapons, perhaps in the form of new or improved drugs or management systems. It was with this in mind that a survey of new drugs with potential value as anthelmintics was made. One of the more promising chemicals appeared to be an organic phosphate compound, 4 tert-

TABLE 4-EFFECT OF ANTHELMINTICS AND TIME ON PASTURE OF LAMBS

Lot Anthelmintic Pasture	$CuSO_4$	Pheno.	I $CuSO_4$ Cont.	III $CuSO_4$ Daylight	II Pheno. Cont.	IV Pheno. Daylight	Cont.	Daylight
Number of Lambs	22	21[1]	11	11	10[1]	11	21[1]	22
Avg. Initial Weight (lbs.)	56.8	56.1	56.8	56.7	54.6	57.5	55.7	57.1
Avg. Final Weight (lbs.)	78.3	74.3	79.7	76.9	73.7	74.9	76.7	75.9
Avg. Gain per Lamb (lbs.)	21.5	18.2	22.9	20.2	19.1	17.4	21.0	18.8
Number Days on Test	56	56	56	56	56	56	56	56
Avg. Daily Gain	.38	.32	.41	.36	.34	.31	.38	.34
Mean Avg. Worm Eggs/Gram of Feces								
Initial	2120	1306	2376	1864	1440	1173	1908	1518
14 Days	32	55	9	55	20	91	15	73
28 Days	41	19	73	9	30	9	52	9
42 Days	46	112	55	37	180	45	118	41
Mean Avg. Hematocrit								
56 Days (Percent)	33.6	30.3	34.4	32.8	27.8	32.8	31.2	32.8

1. One Lamb died two weeks after start of test from pneumonia.

butyl-2-chlorophenylmethyl methyl phosphormidate,[11,12,13,14] which has the following structural formula:



The drug had been used in a number of field trials by Dow Chemical Company, the manufacturer. The trade name is "Ruelene." Using worm egg counts as a criterion, it appeared to be very effective against *Hemochus Contortus* (common stomach worm) in sheep. A quantity of the drug was used in two experiments during the summer of 1959. Dosage levels were based on observations made in field trials. The organic phosphate was compared with a standard phenothiazine solution for drenching sheep. The latter was guaranteed to contain 40 percent by weight of phenothiazine.

Methyl Phosphoramidate

Objectives of the experiment were: To determine the most effective level of methylphosphoramidate for drenching lambs and to compare it with phenothiazine as an anthelmintic.

Fifty-six lambs were chosen from a flock of 280 spring Texas lambs which were to be fattened in dry lot. Several died during the first few days after the lambs arrived at Columbia. An Autopsy revealed very heavy infections of *Hemonchus contortus.* The lambs chosen for the test were the most unthrifty of the carload.

The lambs were divided into outcome groups based on weight, worm egg counts and thrift. They were assigned to four treatments as follows:

Lot	Treatment	Dosage
1	Phenothiazine[1]	1 1/3 oz. 40% concentrate standard
2	Methylphosphoramidate	100 mg/kg body weight as drench
3	Methylphosphoramidate	150 mg/kg body weight as drench
4	Methylphosphoramidate	200 mg/kg body weight as drench

[1]Phenothiazine was a standard product sold for worming sheep. The lambs were treated on the 28th day using the same dosage used on the first treatment.

All lambs were self fed as a group in dry lot on a ground mixed ration composed of the following:

Ground shelled corn	40%
Soybean Oilmeal	5%
Cane Molasses	10%
Alfalfa Hay	45%
	100%

Fecal worm egg counts were made on each individual lamb at the beginning of the test. Individual samples were taken biweekly throughout the trial. After the first sample, counts were made on composited feces of lambs from groups of four and five lambs on each treatment. Lambs were weighed biweekly and graded alive at the end of the experiment.

Since the fecal worm egg counts indicated little or no infestation after 42 days on test and there was little or no chance of reinfestation the experiment was terminated. Results are shown in Table 5.

TABLE 5-PHENOTHIAZINE VS. METHYL PHOSPHORAMIDATE FOR WORMING FATTENING LAMBS IN DRY LOT

Lots	1	2	3	4
Treatment	1 1/3 oz. Pheno.	100 mg/ kg body wt Ruelene	150 mg/ kg body wt Ruelene	200 mg/ kg body wt Ruelene
Av. Number Days on Test	42	42	42	42
Av. Initial Weight (lbs.)	60.4	59.0	60.0	59.5
Av. Final Weight (lbs.)	77.8	82.2	80.4	79.6
Av. Daily Gain (lbs.)	.41	.55	.48	.48
*Av. Live Grade	4.0	4.7	4.7	5.0
Worm Eggs/Gram Feces				
Initial (Drenched)	650	864	557	600
14 Days	43	7.8	0	0
28 Days (Drenched)	43	15.6	0	7.8
42 Days	92	0	0	15.6

*Live Grades were assigned numerical values as follows: Good + = 6; Medium good = 5; Good = 4; Cull = 0

Within 10 days after treatment there was a marked improvement in appearance of lambs treated with the organic phosphate. They were more alert and thrifty in appearance and they had lost the gauntness they had in the beginning. They could easily be picked out of the group up to the last. Most of the lambs treated with organic phosphate could be differentiated in the flock by their better physical appearance.

Gains made by all three lots of lambs treated with phosphoramidate were greater than those which received phenothiazine, but the differences were not statistically significant. The lambs on the phosphoramidate were more uniform and carried more condition than those treated with phenothiazine, but this also was not statistically significant. The average fecal worm egg counts were low initially although it was obvious that many of the lambs were in distress. In later experiments it has been demonstrated that egg counts are not always reliable in cases of extreme parasitism.

Egg counts made after the first treatment with phosphoramidate indicated a remarkable efficiency against *Hemonchus contortus* (stomach worms). At no time was there anything but a scattering of eggs after the first treatment.

Comparison of Phenothiazine Drench and Methyl Phosphoramidate

This experiment was conducted during the summer of 1959. The objective

of the experiment was to compare the effectiveness of standard phenothiazine drench and methyl phosphoramidate for worming lambs on pasture.

Fifty-four weanling lambs out of Northwest ewes and Southdown rams which had been on a wintering trial were used in the experiment. They were placed in outcome groups based on weight, worm egg counts, and previous treatment. They were then assigned at random to two treatments as follows:

1. Control treatment: A drench of 1⅓ oz. of 40 percent concentration of phenothiazine per lamb.
2. Methyl Phosphoramidate treatment: 150 mg per kg body weight.

All lambs were treated at the beginning of the experiment and again 28 days later. They grazed two similar fields of sudan for the first five weeks. Then they were moved to two similar lespedeza pastures for the final three weeks of the experiment. A mineral mixture composed of equal parts of salt and bonemeal was available to lambs at all times.

The lambs were weighed biweekly and individual fecal samples were taken at the time of weighing. The worm egg counts were expressed as the number of stomach worm eggs per gram of dry feces. Results are in Table 6.

TABLE 6-RESPONSE OF GRAZING LAMBS TO PHENOTHIAZINE VERSUS METHYL PHOSPHORAMIDATE AS DRENCHES FOR STOMACH WORMS

	Lot I	Lot II
Treatment per Lamb	1 1/3 oz 40% Phenothiazine	150 mg methyl-phosphoramidate kg body weight
Number of Lambs	27	27
Days on Test	56	56
Inital Weight (lbs.)	63.5	64.2
Final Weight (lbs.)	67.6	71.6
Av. Daily Gain (lbs.)	.073	.132[2]
Worm Eggs/Gram Feces		
Initial	74	15
14 Days	700	63
28 Days	2185	2511
42 Days	844	74
56 Days	3040	1344[3]
Avg. Live Grade[1]	4.9	5.1

[1]Live grades were assigned numerical value as follows: High good = 6; Medium good = 5; Low good = 4
[2]Highly significant ($P<.01$)
[3]Highly significant ($P<.01$)

None of the lambs made good gains due to the shortage of forage which resulted from drouth in July and August of 1959. But the lambs treated with the phosphoramidate gained faster (highly significant $P<.01$) than those on phenothiazine. The difference in appearance was noticeable within the first 10 days after the first treatment. Lambs treated with the organic phosphate were more alert, had more life to their wool, and were somewhat fleshier at the end of the experiment.

Worm egg counts indicated only a few lambs were infested with parasites

at the beginning of the experiment. It is probable that the infestation was quite a lot heavier than egg counts indicated because moderate to heavy parasitism was evident by the 28th day of the trial. They were emaciated, listless, and anemic. The lambs improved in appearance after the drench at 28 days. Lambs drenched with phosphoramidate had approximately one-third the number of worm eggs at 42 days as the phenothiazine treated lambs. This difference was highly significant ($P<.01$).

Comparison of Standard and Finely Ground Phenothiazine and Methyl Phosphoramidate

The objectives of experiment 6 were:

(a) To compare the efficiency of standard and finely ground phenothiazine for treating sheep on pasture for *Hemonchus contortus* (stomach worms).

(b) To compare the two forms of phenothiazine with methyl phosphoramidate (an organic phosphate) as anthelmintics in pasture lambs.

Sixty-eight late spring lambs out of Northwest ewes and Corriedale rams were placed in outcome groups based on body weight, worm egg counts, sex, and thrift. They were then assigned at random to two lots of 34 lambs each. One of the lots was chosen at random and called Lot I. It was further divided into two uniform sublots. The first of these was treated with standard phenothiazine and the other received fine particle phenothiazine.[1]

Lambs in the two sublots grazed together on the same pasture. The other 34 lambs, which comprised Lot II, were treated with methyl phosphoramidate. Treatments and dosage were as follows:

Lots	IA	IB	II
Treatment	Standard Phenothiazine	Fine Phenothiazine	Methyl Phosphoramidate
Number of Lambs	17	17	34
Dosage	12½ gram	12½ grams	150 mg/kg body weight

All lambs grazed lespedeza pastures throughout the test. Two fields which were similar in plant growth were assigned at random at the outset. These fields did differ somewhat in elevation. The field used by lambs treated with phenothiazine was low lying and undoubtedly had a greater concentration of parasites. After three weeks on test, lambs were removed to two other fields which were alike in topography as well as forage growth. It is probable that the initial differences in fields influenced the results.

Lambs were treated initially and at approximately two-week intervals. Table 7 shows results.

Frequent showers, heavy dews and fast growth and shading of the lespedeza made conditions optimum for all lambs to become heavily parasited.

Differences were apparent between groups within a week after the beginning of the test. The lambs treated with the standard phenothiazine drench were dull, listless, emaciated, and unthrifty in appearance. They were often

[1]Particle size averaged 3.5 microns as determined by Fisher Sub-Sieve method.

TABLE 7-COMPARISON OF STANDARD PHENOTHIAZINE, FINE PARTICLE PHENOTHIAZINE AND METHYL PHOSPHORAMIDATE FOR WORMING SHEEP

Lots	IA	IB	II
Treatment	Phenothiazine[1]	Fine Phenothiazine[2]	Methyl Phosphoramidate
Number of Lambs	17	17	34
Days on Test	56	56	56
Initial Weight (lbs.)	53.2	53.0	53.6
Initial Worm Egg Counts/Gram Feces	964	1723	1606
Number of Lambs Dead First 2 Weeks	4	0	0
Number Unthrifty and Anemic	8	5	2
Hematocrits (per cent) Third Week	20.9	20.3	32.9
Number Dead 3 Weeks on Test	6	0	0
No. Removed From Test at End of 25 Days	6	2	0
No. Lambs Removed From Test at 5 Weeks	3	5	0
Hematocrits of Lambs at End of 5 Weeks (%)	26.0	23.8	34.2
No. of Lambs Continuously on Test	4	12	34
Avg. final wt. of Lambs on Experiment (lbs.)	67.8	67.0	72.1
Avg. Gain (lbs.)	16.0	15.0	18.5
Avg. Daily Gain (lbs.)	.28	.27	.33
Hematocrits of Surviving Lambs (percent)	31.1	30.5	31.6

[1]Drenched with 1 ounce 40% concentrate phenothiazine per lamb.
[2]Drenched with 1 ounce 40% concentrate fine particle phenothiazine guaranteed to pass through a 3 micron screen.
[3]Drenched with 2 c.c. of 26% concentrate Ruelene per 10 pounds body weight.

found under shades in spite of the fact that they had apparently grazed very little. Those treated with fine particle phenothiazine had much more life and appeared healthier. They grazed more and always appeared fuller than the ones on standard phenothiazine.

At the end of two weeks on experiment it was obvious that the lambs treated with standard phenothiazine were rapidly being overcome by the parasites. At the end of four weeks four lambs of the group were already dead and several others were moribund. Fecal worm egg counts provided no warning that lambs in that group were in a critical condition; although post mortems on lambs that died indicated *Hemonchus contortus* infection was the cause of death. Visual inspection of the membranes of the eyes and lips appeared to be more reliable since the paleness observed indicated severe anemia. All lambs were treated at the end of two weeks, but those which received the standard phenothiazine continued to fail in condition. Hematocrit determinations made on the twenty-first day of the test indicated a very low red cell count. By that time six lambs were dead and another six had approximately one-half the normal number of red cells. Extremely sick lambs were removed to a hospital pen for treatment. They were drenched with phosphoromidate, given theraputic doses of vitamins A and B complex and fed leafy legume hay, plus a mixture of grain composed of 6 parts corn, 3 parts bran, and one part soybean oilmeal.

All lambs in the hospital pen made an improvement, and within a week most had apparently recovered. However, in most cases it took about six weeks

for blood levels to return to normal.

The lambs treated with fine particle phenothiazine appeared, on the twenty-first day, to be in a much better physical state despite low average hematocrit values. These values were lower than those of lambs treated with standard phenothiazine, primarily because lambs affected worst in the standard phenothiazine treatment group were already dead. It was observed that lambs with hematocrit values from 12 to 14 percent were on the threshold of death if they were not given immediate medication.

Since the infestation was so heavy, all lambs were treated again on the third week of the test. Most lambs treated with fine particle phenothiazine appeared to be helped by the treatment, but two developed edema under the jaw and were so weak they were removed to the hospital pen.

At the end of five weeks only four of 17 lambs treated with standard phenothiazine were still on test compared with 12 of 17 of the group treated with fine particle phenothiazine. Including lambs which had been removed to the hospital pens for treatment, 10 of 17 lambs treated with standard phenothiazine survived and 15 of 17 which received fine particle phenothiazine survived. It was apparent that all of the lambs treated in sick pens would have died had they remained on the pastures.

All lambs treated with methyl phosphoramidate made excellent gains on pasture, none were removed during the experiment and hematocrit measurements were normal at each reading.

This work gave a graphic demonstration of the short-comings of worm egg counts as a criterion for measuring hemonchosis in lambs. Several sheep were near death when worm egg counts failed to indicate even moderate infections. Similar observations have been made by other workers.[15,16] Reasons which might account for the small number of parasite eggs being passed from heavily infected lambs are obscure in this study. Possibly an interaction of host resistance may have been manifested. However, the possibility of an effect from repeated anthelmintic treatments must also be considered.

Hematocrit readings appear to be very good indicators of the degree of *Hemonchus* infection. However, further study is needed to correlate the development of anemia with the worm egg output in the feces of the lamb.

The experiment clearly demonstrated the superiority of fine particle phenothiazine and methyl phosphoramidate over a commercially available phenothiazine product. Methyl phosphoramidate appeared to be more effective against *Hemonchus* in lambs than did fine particle phenothiazine under the conditions of these trials. Further trials which will add additional data on this point are contemplated.

A method of treating heavily infected lambs was found effective. Even lambs which were so anemic that they collapsed from the slightest exercise made rapid recoveries when isolated in dry lots and treated with methyl phosphoramidate and supportive nutrient feeds.

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