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SUMMARY

Treating ewes once in December and once the following March with a full dose of liquid phenothiazine and every 28 days thereafter with 1½ per cent copper sulphate until the following December did not control nodular worm infestation even though at the beginning of the experiment the sheep were placed upon clean pasture.

Treating sheep with liquid phenothiazine every four weeks from December to March (giving a total of four treatments) and then giving them 1½ per cent copper sulphate every 28 days did not control nodular worm infestations. The 1½ per cent copper sulphate solution was found very satisfactory in keeping the lambs free from *Haemonchus contortus.*

Treating sheep with liquid phenothiazine every four weeks from December to early April and then allowing them access to phenothiazine-salt mixture (1 part phenothiazine to 10 parts salt) was very satisfactory in controlling nodular worm infestation.

This method of handling sheep held the *Haemonchus contortus* infestation down to an average of about 19 per lamb.

This same method of handling did not satisfactorily control *ostertagia, nematodirus, cooperia,* or tapeworms. Whipworm counts were not materially different in any of the three experiments.

Average weight of the lambs was very much higher in Experiment III when the sheep had access to phenothiazine and salt mixture than it was in Experiments I and II.

Phenothiazine has not been found toxic to sheep either in a 1 to 10 phenothiazine-salt mixture or when the medicine has been given as a drench every 28 days throughout the entire year. The use of phenothiazine has not interfered with breeding efficiency.

Worm egg counts by the flotation method have not contributed any aid in this study, but would be useful in sheep infested with only one species of parasite or with species that can be definitely identified by microscopic examination alone.

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Efficacy of Phenothiazine in the Treatment of Sheep for Control of Internal Parasites

CECIL ELDER, O. S. CRISLER and R. F. GENTRY

Although phenothiazine has been used as an anthelmintic in domestic animals for only a comparatively few years, considerable experimental work has been done with the use of this drug and its efficacy in sheep. Some of the reports showed conflicting results. This has resulted in many different recommendations for the use of phenothiazine in the control of internal parasites of sheep. In general the drug is looked upon as an efficient vermifuge, particularly against *Oesophagostomum columbianum* and *Haemonchus contortus.*

REVIEW OF LITERATURE

Harwood, Habermann, and Jerstad (1), Swales (2), and Thorp and Keith (3) reported good results in worm control from the use of this drug. Elder (4), Gordon and Whitten (5), Gordon (6), and Roberts (7) also looked favorably upon phenothiazine particularly as an anthelmintic for the removal of stomach worms and nodular worms. Whitlock (8) pointed out the efficiency of phenothiazine, particularly when it went directly to the abomasum. Hay (9) reported that a dosage of 25 grams of phenothiazine administered at two week intervals can be tolerated and will effectively remove the intestinal parasites common to sheep. Habermann and Harwood (10) have found phenothiazine effective against nodular worms. Singer and Baker (11) found phenothiazine less effective against infections with *Nematodirus filicollis* and *Haemonchus contortus* and ineffective against *Trichostrongylus* spp., *Strongyloides* spp., and *Trichuris ovis,* but did find this drug effective for the removal of *Oesophagostomum columbianum, Ostertagia ostertagi,* and *Cooperia curticei.*

Wright (12) found six weekly doses of 25 grams of phenothiazine apparently were not harmful to sheep. McNally (13) found that phenothiazine could be given safely to lambs several times during a year without ill effect, but when given oftener than once in two weeks for months at a time, it would cause pathological changes in the kidneys. McCulloch (14) reported that phenothiazine medicated pellets were practical and reasonably efficacious in range sheep which

were infested with *Haemonchus contortus* and *Trichostrongylus colubriformis* in the abomasum.

Thorning, Sampson, and Graham (15) reported *Haemonchus* spp. and *Oesophagostomum* spp. infestations were lowered. They based their opinion on the pre- and post-treatment occurrence of ova in the feces. They did not think the *Strongyloides, Trichuris,* and *Nematodirus* were appreciably affected. In general they look upon phenothiazine as beneficial in the treatment of lambs infested with internal parasites. Habermann and Shorb (16) have shown that in sheep on phenothiazine salt mixture the larval development in the feces was inhibited. Sarles and Foster (17) state that phenothiazine is effective for the removal of adult nodular worms from the large intestine and has the added advantage of effective action against most of the other economically important roundworm parasites of sheep. They have observed no serious symptoms in sheep following treatment with this drug. Martin (18) reported beneficial results in lambs which had access to phenothiazine salt mixtures (1 to 15). Seghetti and Marsh (19) found 10 per cent phenothiazine and salt satisfactory in preventing clinical nematode parasitism in lambs and in reducing worm numbers in ewes.

ANIMALS USED IN EXPERIMENTS

Fig. 1.—Ewes for the experiment were selected from this group.

The sheep used were good grade or better than average native ewes which had been used on another experiment the previous year. All were vigorous and varied in age from two to four years. Replacements were older ewes that were vigorous and in good condition. Micro-

scopic egg counts had shown these ewes to have some parasites, but in no case was the infestation considered heavy. Complete records for one year or longer were available on all of the ewes used. All the animals were bred to a purebred ram and a crop of vigorous lambs resulted. As there was very little twinning, most of the lambs had plenty of milk. They were left with the ewes until they were weaned of their own accord. Water from the city system was available in troughs or galvanized tubs. These animals were allowed freedom of a well-drained pasture during the day, but at night were penned in a small building. This building was open to the south and covered with wire for protection against dogs.

EXPERIMENT I

Many sheep owners have been of the opinion that one dose of phenothiazine would safeguard sheep from internal parasites for an entire season. While this was an erroneous idea, the question of treating sheep with phenothiazine and then putting them on clean ground where sheep had not been run before offered a possibility worth investigating. It was decided to determine if the internal parasites of sheep could be controlled when the sheep were treated with phenothiazine in December, placed on clean ground, treated again with phenothiazine the first of March, and then treated with a full dose of 1½ per cent copper sulphate every 28 days for the remainder of the spring, summer and fall.

Twelve ewes were treated with full doses of the liquid form of phenothiazine and then placed on a clean concrete floor where they were held for 72 hours. They were then placed on a five-acre pasture in which no sheep had been grazed for at least 12 years. These ewes were treated with another dose of phenothiazine during the first week in March. From then until the following December they received a full 4-ounce dose of 1½ per cent copper sulphate solution every 28 days. As soon as the lambs were big enough to nibble grass they were treated with copper sulphate every 28 days at the rate of one ounce of 1½ per cent solution to each 20 pounds of body weight. It was felt that if the ewes were free of nodular worms and that if eggs of this species were not being eliminated in the droppings to contaminate the pasture, the lambs would go through the season without picking up any appreciable number of nodular worm eggs. The copper sulphate solution would control infestations with stomach worms, as demonstrated in previous work at this station.

All of the lambs on the experiment were slaughtered in late November or December and the digestive tract carefully examined

for the presence of any kind of parasites. Special washing technique was used in this examination. The contents of the stomach and small and large intestines were separately washed through an 80-mesh copper screen. Care was taken to wash thoroughly the mucous membrane of all parts of the digestive tract. After the contents were washed through the screen, all parasites were collected and different kinds identified and counted. Examination of these lambs showed that the copper sulphate had been very efficient in controlling stomach worm infestation.

As is shown in Table 1, the two treatments with phenothiazine in December and March had not been sufficient to remove all of the nodular worms from the experimental ewes. The treatment in March

TABLE 1 - FINDINGS IN EXPERIMENT I-LAMBS

Number of lamb	Date Killed	Weights 11/16/43	Haem. Cont.	Oster-tagia	Nemato-dirus	Whip-worms	Nodular worms	Nodules in Small Intestine	Nodules in Large Intestine
454	12/7/43	56#	---	?	Many	1	115	375	310
456	11/26/43	81#	---	Many	Many	2	185	281	394
457	12/13/43	65#	---	---	?	-	114	427	381
458	12/9/43	78#	---	---	?	1	43	378	287
459	12/15/43	81#	---	?	?	3	96	478	327
460	11/23/43	60#	1	Many	Many	2	134	304	162
	Average wt.	70.2#							

# indicates pounds

was given in order to remove any nodular worms which might have been in the larval form and imbedded in the walls of the intestines at the time of the December treatment. It was assumed that the worms which might develop to maturity and produce eggs would not seriously contaminate the pasture during the winter months. Either the two treatments were not efficient or the interval between treatments was too long. It is our opinion that the two treatments were not 100 per cent efficient. As will be seen by the table, the amount of infestation with nodular worms in the lambs was extremely heavy, even though the sheep were on good feed the entire year.

When the grass became short it was supplemented with an excellent grade of alfalfa hay. In spite of the heavy infestation with nodular worms, the sheep made good development and were in fairly good flesh when slaughtered. This was probably due to the abundance of good feed during the season.

Conclusions Drawn in Experiment I.—Treating ewes with phenothiazine in December and again the following March and placing them on clean pasture where sheep had not been run before was not found sufficient to protect the lamb crop from nodular worm infesta-

tion. This was ample proof that the two treatments with phenothiazine so spaced were not sufficient to protect sheep against nodular worm infestation under average Missouri conditions. One and one-half per cent copper sulphate solution given at the rate of one ounce to every 20 pounds of body weight with a maximum dose of four ounces was found efficient in the control of stomach worms. Copper sulphate did not satisfactorily control *ostertagia* and *nematodirus* infestations.

EXPERIMENT II

Nine of the same ewes used in Experiment No. I were used in Experiment II with enough additional ewes to make the total back to twelve. The plan of the experiment was somewhat changed. As clean pasture was not available the second year, it was decided to keep the sheep on the same pasture as used in 1943, but to treat them with phenothiazine every 28 days from December to March (total of four treatments) to determine if it were possible in this manner to free ewes of nodular worms, and to further determine if with this handling of the ewes the pastures would become safe by spring so that young lambs would not become infested. All of the ewes were treated with the liquid form of phenothiazine every four weeks from December to March, as is shown by the accompanying Table 2.

On April 4 all of the ewes were treated with four ounces of 1½ per cent copper sulphate solution and received a like treatment every 28 days thereafter until the following December. All lambs were started on copper sulphate treatment when they became big enough to nibble grass. During the season if the feed became short the grass was supplemented with alfalfa hay. The sheep received no other

TABLE 2 - TREATMENTS WITH LIQUID PHENOTHIAZINE

Number of ewes	Date Treated	Amount given each ewe
12	December 14, 1943	2 ounces
12	January 11, 1944	2 ounces
12	February 8, 1944	2 ounces
12	March 7, 1944	2 ounces

Note: Before dosing the phenothiazine was mixed with an equal quantity of water and four ounces of the diluted material were given to each ewe.

treatment except good care and all of the lambs were slaughtered in November and December 1944. The same washing technique as previously described was used in examining the lambs. Again this year copper sulphate was found efficient in controlling or preventing infestations with stomach worms. No appreciable numbers of oster tagia or nematodirus were found. Every lamb on experiment was

heavily infested with nodular worms, as is shown in the accompanying Table 3.

As shown in Table 3 by the number of nodules and also by the number of adult nodular worms found in the intestines of the lambs, infestation with nodular worms was considered to be very heavy. This proved the method of handling the sheep used that year was not satisfactory for the control of nodular worms.

TABLE 3 - FINDINGS IN EXPERIMENT II-LAMBS

Number of lamb	Date Killed	Weights 12/12/44	Haem. Cont.	Oster-tagia	Nemato-dirus	Whip-worms	Nodular worms	Nodules* in Small Intestine	Nodules* in Large Intestine
461	12/19/44	75#	---	---	---	---	203	175	200
462	1/8/45	78#	---	---	---	---	31	175	150
463	12/18/44	77#	---	---	---	---	68	100	150
464	1/2/45	82#	---	---	---	6	162	100	150
465	12/20/44	74#	---	45	---	11	168	No Count	No Count
466	12/19/44	91#	---	---	---	6	71	125	200
467	12/28/44	74#	---	---	---	4	53	100	125
468	12/20/44	80#	---	---	---	---	103	200	250
469	12/29/44	95#	---	---	---	8	58	100	125
	Average wt. 80.66#								

* Numbers of nodules are estimates.

Conclusions Drawn in Experiment II.—Treating ewes every 28 days from December through March with phenothiazine, then treating every 28 days through the remainder of the year with 1½ per cent copper sulphate solution were not adequate in controlling nodular worm infestation. Either all of the nodular worms in the ewes had not been completely removed by treatment or the temperatures during the winter of 1943-1944 in central Missouri were not severe enough to destroy the eggs that had been deposited on this pasture. The lambs dropped by these ewes became heavily infested with nodular worms during the summer and fall. Copper sulphate solution, 1½ per cent, given at the rate of one ounce for every 20 pounds of body weight was again found to be satisfactory for the control of stomach worms in the lambs.

EXPERIMENT III

Following the findings of Experiments I and II, it was decided to continue the ewes on the same pasture as previously used but to treat them with phenothiazine individually every four weeks from December until April and then put them on a phenothiazine-salt mixture for the balance of the year. Necessary replacements were made and the experiment was started with 12 ewes varying in age from 4 to 9 years. They received a full dose of phenothiazine individually, as is shown in the accompanying Table 4.

TABLE 4 - TREATMENTS WITH LIQUID PHENOTHIAZINE

Number of ewes	Date Treated	Amount given each ewe
12	December 26, 1944	2 ounces
12	January 23, 1945	2 ounces
12	February 20, 1945	2 ounces
12	March 20, 1945	2 ounces
12	April 17, 1945	2 ounces

Note: Before dosing the phenothiazine was mixed with an equal quantity of water and four ounces of the diluted material were given to each ewe.

On the same date the ewes received the fifth dose of phenothiazine they were placed on a phenothiazine-salt mixture made up of one part of powdered phenothiazine and ten parts salt. This mixture was kept before them continuously throughout the spring, summer, and fall. It was protected from the weather and a fresh mixture was put in about every two weeks. The sheep received no other treatment except an abundant supply of alfalfa hay which was fed when the pasture became short. The 1945 season was unusually wet and the grass in the pasture remained fairly good most of the time.

Considerable scouring was noticed during the summer and early fall. Two of the ewes, Nos. 278 and 332, were lost during the year. Ewe No. 332 died 1-29-45 as the result of severe pneumonia. Ewe No. 278 was an eight-year old ewe which died in May, 1945. Her autopsy showed a severe hemorrhagic enteritis. Forty-three tapeworms were found in her small intestine and twenty-six nodular worms were found in her large intestine. There were about 450 nodules in the small and large intestines. Eleven lambs were raised from these experimental ewes and all survived, though at times there was considerable scouring. The lambs were killed between the dates of October 31 and November 21 and the findings are recorded in the accompanying Table 5.

Conclusions Drawn in Experiment III.—It will be seen in Table 5 that the treatments of the ewes with phenothiazine during the winter months and then placing the sheep on phenothiazine-salt mixture (1 part phenothiazine to 10 parts salt) was very satisfactory in controlling infestations with nodular worms. No nodules were found in the small intestine and practically none in the large intestine. Only one adult nodular worm was found in any of the eleven experimental lambs. The *Haemonchus contortus* infestation was held to a rather low figure as only an average of about 19 stomach worms was found in the lambs. As in previous work done at the Missouri Experiment Station, Phenothiazine was not so effective against ostertagia, nematodirus, and cooperia. The average weight of the lambs is very signifi-

cant and was much higher in Experiment III than it was in Experiment I or II even though the weights were taken at a much earlier date. This weight is also significant because the sheep were kept on the same 5-acre pasture and had practically the same feed. In each experiment when the grass became short the pasture was supplemented with a good grade of alfalfa hay.

TABLE 5 - FINDINGS IN EXPERIMENT III-LAMBS

Number of Lamb	Date Killed	Weights 10/31/45	Haem. Cont.	Oster-tagia	Coop-eria	Nema-todirus	Tape-worms	Whip-worms	Nodular worms	Nodules in Small Intestine	Nodules in Large Intestine	Nodules in Liver
494	11/14/45	101#	19	TMTC*	--	--	2	4	--	--	--	--
495	11/16/45	103#	2	TMTC	TMTC	TMTC	--	--	--	--	--	--
496	11/19/45	112#	5	--	--	--	--	--	--	--	15	--
497	11/21/45	69 1/2#	10	--	TMTC	--	--	--	--	--	10	--
498	11/15/45	74 1/2#	7	100 (est)	TMTC	45	--	23	--	--	--	--
499	11/20/45	100#	21	25	TMTC	24	3	2	1	--	10	4
500	11/7/45	96#	8	--	--	400 (est)	14	2	--	--	--	5
527	11/2/45	86#	46	TMTC	--	200	Several	32	--	--	--	--
528	11/1/45	68#	12	--	TMTC	TMTC	9	19	--	--	--	5
529	10/31/45	72#	12	100	TMTC	3	8	36	--	--	--	2
530	11/7/45	92#	64	TMTC	--	TMTC	--	8	--	--	--	--

Average wt. 88.54#

* TMTC means too many to count.

Microscopic Egg Counts.—Microscopic egg counts were made on all ewes and lambs on the experiment every two weeks throughout the experimental period. The technique used was as follows: Individual samples of droppings were collected in small clean bottles and identified by ear tag numbers. Each sample consisted of approximately ten to fifteen pellets, or an approximately equal quantity when the droppings were softer. This was mixed with an equal quantity of water by weight and thoroughly stirred in order to have a good composite sample. One gram of this sample (0.5 gram feces) was mixed with a saturated sodium chloride solution and strained through a single layer of cheesecloth. This was made up to 20 cc. of solution with saturated sodium chloride and eggs were collected on a slide by

TABLE 6 - LAMBS ON EXPERIMENT I-1943
Total Egg Counts of 10 Microscopic Fields Taken at Random

	July			August		September		October		November		December
Number	1	15	29	12	26	9	23	7	21	4	18	2
454	24	0	5	5	12	14	22	2	30	27	26	23
456	15	11	42	40	48	21	28	10	27	35	31	*
457	12	15	22	26	15	7	20	20	16	37	23	18
458	2	4	7	9	5	8	39	6	25	23	23	19
459	20	26	25	16	15	10	17	20	18	24	22	20
460	33	30	10	60	45	53	36	18	33	25	22	*

* Killed before this date.

the flotation method—allowing the slide to remain in place exactly 30 minutes. Comparative egg counts were made throughout the three experiments. Although an attempt was made to differentiate between the different kinds of eggs present, it was found very difficult to always definitely identify the eggs. Therefore, average total egg counts are shown in Tables 6, 7, and 8. Egg counts by this method have been found quite satisfactory in determining infestation with the common internal parasites of sheep.

TABLE 7 - LAMBS ON EXPERIMENT II-1944
Total Egg Counts of 10 Microscopic Fields Taken at Random

	June		July		August		September		October		November			December
Number	14	29	13	27	10	28	7	21	5	19	3	16	30	14
461	7	4	2	8	3	1	4	8	9	10	14	16	5	6
462	2	3	0	7	1	2	2	4	8	2	4	4	9	8
463	3	5	5	4	4	3	4	0	1	9	5	2	3	2
464	7	7	6	9	2	5	9	5	7	7	7	11	3	3
465	13	8	8	3	3	5	6	4	5	24	13	11	5	10
466	1	1	4	1	5	5	5	0	1	2	9	1	9	5
467	0	0	1	2	0	1	1	0	3	1	23	3	2	1
468	5	19	6	7	4	3	8	15	7	7	7	3	6	8
469	0	3	0	5	3	1	3	1	1	1	0	2	3	11

TABLE 8 - LAMBS ON EXPERIMENT III-1945
Total Egg Counts of 10 Microscopic Fields Taken at Random

	May		June		July		August		September		October		November
Number	17	31	14	28	12	26	9	24	6	20	4	18	1
494	9	0	0	8	6	22	7	5	2	9	7	12	6
495	21	4	3	2	3	10	0	3	4	2	0	5	4
496	3	4	2	0		7	4	6	2	3	9	0	1
497				4	12	15	14	10	15	3	19	15	13
498				1	12	27	65	2	4	2	1	2	17
499				0	15	4	8	5	0	1	2	5	6
500				3	3	5	4	2	0	1	7	1	6
527								10	0	9	4	14	0
528								12	11	7	4	5	11
529								12	9	8	6	25	9
530								5	14	0	2	3	7

Fecal samples were not collected until lambs were several weeks old.

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