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THE HELMINTHOLOGICAL SOCIETY OF WASHINGTON

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PROCEEDINGS OF THE HELMINTHOLOGICAL SOCIETY OF WASHINGTON

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Phenothiazine and nicotine-bentonite as an anthelmintic in turkeys. PAUL D. HARWOOD and DOROTHY I. STUNZ, Dr. Hess and Clark, Inc., Ashland, Ohio.

The efficacy of phenothiazine for the removal of *Heterakis* from chickens is well established. However, its use against this parasite in turkeys appears to be based on reasoning by analogy which may not be correct. Accordingly, the limited data which was collected in this laboratory may be worthy of record.

The turkeys, which were purchased locally, weighed from 8 to 16 pounds each and harbored natural infections of *Heterakis gallinae* and *Ascaridia dissimilis*. They also suffered more or less severely from sinusitis. Flock treatments were carried out by placing before 6 turkeys a mixture composed of 4 pounds of poultry mash, 12 grams of nicotine-bentonite (containing 5 per cent nicotine) and 6 grams of phenothiazine. This mixture was left before the turkeys until totally consumed, which required from 36 to 44 hours. After treatment, all feces were collected, washed in the usual manner, and searched for worms. Efficacy of the treatment was determined by comparing the number of worms recovered from the feces, with the number found at necropsy which was carried out 4 days after dosing.

As may be calculated from data presented in table 1, the mixture of phenothiazine and nicotine-bentonite removed 69.6 and 42.9 per cent of the *Ascaridia*,

TABLE 1.—*Effect of phenothiazine and nicotine-bentonite on Heterakis gallinae and Ascaridia dissimilis in turkeys*[a]

Experiment designation	Number of worms eliminated		Number of worms retained	
	Ascaridia	*Heterakis*	*Ascaridia*	*Heterakis*
1	16	163	7	7
2	12	344	16	1

[a] In each experiment 6 turkeys were given 4 pounds of mash feed containing 6 grams of phenothiazine and 12 grams of nicotine-bentonite.

as well as 95.9 and 99.7 per cent of the *Heterakis*, respectively, in the two experiments. The turkeys received on the average 1 gram of phenothiazine which is the standard dose in birds of this size. However, some birds may have received much less because of inappetence. Therefore, one bird in experiment 1 which harbored 5 *Heterakis*, and which proved at necropsy to be an active case of blackhead, may not have received a full dose of the drug. Possibly the relatively low efficacy of nicotine-bentonite against the *Ascaridia* was due to the dilution of the drug with a large amount of feed since in higher animals, at least, nicotine is rapidly destroyed and fatal results occur quickly or recovery is the rule.

Earlier reports of the nematodes infesting domestic turkeys in this country have stated that *Ascaridia galli* was the species of large roundworm present. For example, Wehr (in *Diseases of Poultry*, Biester and DeVries, Editors, 1943, Ames, Iowa) has stated that *A. dissimilis* "has been found only in wild turkeys in this country." On comparison of our material with the figures given by Wehr (1940, Jour. Parasitol. 26: 373), it was found that all specimens were in very close agreement with the figures for *A. dissimilis* while none agreed with the figures for *A.*

galli (syn. *A. lineata*). Apparently this is the first record of *A. dissimilis* in domestic turkeys. However, the authors are at a loss to understand why the name *A. gallopavonis* (Gmelin, 1790) which has clear priority should be abandoned in favor of *A. dissimilis.*

Tests with carbon tetrachloride, hexachlorethane, and tetrachlorethylene, for removing the fringed tapeworm of sheep. O. WILFORD OLSEN and REX W. ALLEN, U. S. Bureau of Animal Industry.

The fringed tapeworm, *Thysanosoma actinioides,* occurs commonly in the bile ducts and intestines of sheep in the southwestern and western States. The parasite renders the liver unfit for human consumption, thereby resulting in considerable economic loss.

Through the courtesy of a large meat-packing company in Chicago, a number of western sheep, approximately 1 year old, were made available for testing the possible anthelmintic action of carbon tetrachloride, hexachlorethane, and tetrachlorethylene, on the fringed tapeworm.

The experimental sheep were divided into 3 lots and treated as follows: Each of 50 sheep received 1 cc. of carbon tetrachloride in soft gelatin capsules; each of 50 sheep received 2.5 cc. of tetrachlorethylene in soft gelatin capsules placed in No. 12 hard gelatin capsules containing 2.5 grams of magnesium sulphate; and each of 75 sheep received 30 cc. of hexachlorethane-bentonite-water suspension drench containing 15 grams of the drug. The suspension was the same as that used in the treatment of liver fluke infection of cattle (Olsen, 1943, Jour. Amer. Vet. Med. Assoc. 102(795): 433–436). The fattening ration used at the time of treatment was continued until the sheep were slaughtered 3 days later. There were 456 control sheep from the same lot as those used for anthelmintic testing. Of the controls, 96 were examined for both liver and intestinal infections with *T. actinioides,* and 360 were examined only for liver tapeworms.

Fourteen livers (8 per cent) and 20 intestines (11.4 per cent) out of the 175 treated sheep harbored fringed tapeworm. With respect to sheep treated, the tapeworms were distributed as follows: Carbon tetrachloride treatment, 3 infected livers (6 per cent) and 3 infected intestines (6 per cent); tetrachlorethylene treatment, 3 infected livers (6 per cent) and 7 infected intestines (14 per cent); and hexachlorethane treatment, 8 infected livers (10.6 per cent) and 10 infected intestines (13.3 per cent). Of the 96 control sheep, in which both the livers and intestines were examined, there were 7 livers (7.3 per cent) and 12 intestines (12.5 per cent) with tapeworms. Of the remaining 360 control sheep whose livers were examined, 37 (10.3 per cent) were parasitized.

There was no significant difference between the number of worms found in the sheep treated with the 3 drugs named and the control animals, and there were no untoward effects of the treatment except that the livers of the treated sheep appeared somewhat darker in color than those of the untreated animals. The results obtained indicate that the drugs used had no anthelmintic action on the fringed tapeworm in the liver or in the small intestine.

The distribution of *Pseudostertagia bullosa* and some new records of nematodes from pronghorn antelope (*Antilocapra americana*). JOHN T. LUCKER and G. DIKMANS, U. S. Bureau of Animal Industry.

It is an interesting fact that *Pseudostertagia bullosa* (Ransom and Hall, 1912) Orlov, 1933, a trichostrongylin stomachworm described more than 32 years ago from sheep as a new species of the genus *Ostertagia,* has not been found in and reported from that host in the interim, either in the United States or elsewhere, so far as we can ascertain.

Ransom and Hall (1912, Proc. U. S. Natl. Mus. 42(1892): 175–179) found this species in 1911 in several sheep from and on a ranch near Resolis, Colorado, and on a second ranch near Amo, Colorado. They referred also to a single female specimen collected in 1910 from a sheep originating in Montana. Their paper indicates that they had available for study a considerable number of specimens. An examination of the records of the U. S. National Museum Helminthological Collection shows that these investigators deposited in this collection 8 lots of specimens comprising more than 170 individuals obtained from 9 different sheep. They (1912, *loc. cit.*) stated that nearly every sheep examined at the first-mentioned ranch harbored this nematode, but that usually less than a dozen specimens were found.

These facts serve to indicate that Ransom and Hall had not made merely a freakish discovery. The lack of subsequent reports to which we have referred does, however, suggest that their species may have a limited distribution.

In 1929, Price (Jour. Parasitol. 14(3): 197) reported this species from a pronghorn antelope dying at the National Zoological Park, Washington, D. C. In general, we are inclined to view the occurrence of parasites in animals kept under such artificial conditions as an unsatisfactory indication of normal host-parasite relationships. However, in July 1944, we identified as *P. bullosa* several worms collected from the abomasum of a wild antelope killed on June 22, 1944, near Jones Creek, Harding Co., South Dakota. These specimens were collected by Dr. Irving H. Roberts of the Zoological Division, who had been assigned to investigate parasitism in sheep in western South Dakota during the spring and summer of 1944. Roberts had estimated quantitatively that about 810 specimens were present in the abomasum of this antelope. Later we also identified as *P. bullosa* several worms collected by Roberts from the fourth stomach of an antelope killed on August 21, near Redig, South Dakota. Shortly thereafter, we confirmed the identification of specimens of *P. bullosa* which had been collected by Dr. Lee Seghetti from the abomasum of an antelope killed on September 28, 1944, near Hammond, Montana.

These facts, especially the comparatively heavy infection noted by Roberts in one of the antelope, suggested that *P. bullosa* may be primarily a parasite of antelope. It seemed possible, too, that *P. bullosa* infection in sheep may be related to, if not dependent upon, the occurrence of the parasite in antelope, especially since in certain areas antelope and sheep have access to and occupy the same range. Later in examining several lots of parasites collected from sheep by Roberts in the course of his work in South Dakota, we identified as *P. bullosa* a small number of specimens obtained from the small intestine of a lamb on September 6, and tentatively determined as this species some female worms collected from a lamb on August 15 The former lamb apparently was from a ranch near Vale, and the latter from one near Newell, South Dakota.

We do not consider these observations proof that *P. bullosa* is normally a parasite of wild antelope, but they strongly suggest it. They do prove that under natural conditions, the species occurs both in antelope and sheep in the same general area at the same time. They afford one possible explanation of the limited known occurrence and distribution of the species as a parasite of sheep.

As a further result of our study of the 3 mentioned collections of parasites from pronghorn antelope and of 2 others, representing 4 different individuals, examined in 1943, we are able to record for the first time from *Antilocapra americana* the following nematode species: *Cooperia bisonis*, *Nematodirus abnormalis* and *Marshallagia marshalli*. The first 2 species were collected in western South Dakota; the last was collected in Montana and identified by Dr. Lee Seghetti, whose identification has been verified by us. In addition to *Pseudostertagia bullosa* (this species was erroneously listed by Dikmans (1939, Proc. Helm. Soc. Wash. 6(2): 97–101) as reported from non-captive pronghorn antelope), we wish also to record

as found for the first time in wild pronghorn antelope under natural conditions in the United States, the following species: *Trichostrongylus colubriformis, Nematodirus spathiger,* and *Haemonchus contortus;* all were collected in western South Dakota. From the same locality we have a single male *Trichuris* which we tentatively regard as *T. discolor.*

Some chemotherapeutic tests in canine filariasis (*Dirofilaria immitis*). PAUL C. UNDERWOOD,[1] U. S. Bureau of Animal Industry.

The tests described herein were carried out by the Zoological Division at the U. S. Department of Agriculture Beltsville Research Center, Beltsville, Md., during the months that immediately followed the development of fuadin (Wright and Underwood, 1934, Vet. Med. 29: 234–246; 1936, North Amer. Vet. 17: 39–43) as a treatment for infection with the dog heartworm, *Dirofilaria immitis.* Of the drugs tested, none revealed an action comparable with that of fuadin and none seemed to offer significant promise in the treatment of filarial infections. The results are recorded, however, on account of the great amount of experimental work that is currently being done along these and similar lines.

MATERIALS AND METHODS

Most of the dogs used in these experiments were naturally infected mongrels obtained from the pound at Norfolk, Va.; a few were uninfected dogs that were raised at this Station.

The drugs that were tested are well-known substances that have been used in the treatment of syphilis, amebiasis, trypanosomiasis, or schistosomiasis. Most of them contained a heavy metal such as arsenic, antimony, or bismuth and, in most cases, they were obtained from the manufacturers and used according to the directions accompanying them. In the majority of cases, dose rates for dogs were not available and had to be estimated arbitrarily.

Whenever possible the drugs were injected intramuscularly, but in some instances intravenous injections were necessary. The action of the drugs was adjudged by comparing the numbers of microfilariae in the peripheral blood before and after treatment. In most instances, several counts were made of the number of larvae in 0.02 cc. of a mixture of equal parts of venous blood and a 3 per cent solution of sodium citrate.

RESULTS

The pertinent data of these tests are summarized in table 1.

Tryparsamide (sodium n-phenylglycineamide-p-arsonate) and acetarsone (3-acetylamino-4-hydroxyphenylarsonic acid), both pentavalent compounds, were the only arsenicals tested in formal experiments. Sodium cacodylate (sodium dimethylarsonate) was also given a superficial trial but the observations were too casual to be considered an experiment and the results, therefore, are not reported in the table. This drug produced some clinical improvement but there was no evidence that any of several dogs treated with it ever lost their infections. This experience with sodium cacodylate agrees well with the experiences reported by Leonpacher (1930, Jen-sal Jour., May, p. 24) and by Mohler (1934, U. S. Dept. Agr., Bur. Anim. Indus., Rpt. Chief, p. 52). Regarding the trials with tryparsamide, it will be noted from the data presented that the parasites were apparently unaffected. However, the clinical improvement that generally followed the administration of arsenicals to infected animals seemed to have been most marked when tryparsamide was used. A preliminary note on the beneficial effect of this drug, and its lack of anthelmintic action on dog heartworms was published by Mohler (1934, *loc. cit.*).

[1] Transferred to Bureau of Dairy Industry, October 16, 1937.

TABLE 1.—*Data on chemotherapeutic tests aganist Dirofilaria immitis in dogs*

Dog No.	Weight	Drug	Dose		Route	Treatment period	Microfilariae per 0.01 cc. blood		Reaction of host and remarks[a]
			Single	Total			Before treatment	After treatment	
	pounds					*days*			
600	18.5	Tryparsamide	0.2 g.	2 g.	i.v.	21	289	213	Tonic effect. 11.5 lbs. gain. Toxic symptoms none
603	37.0	do.	0.5 g.	5 g.	i.v.	21	279	378	Tonic effect. 1 lb. gain. Toxic symptoms none
749	47.5	Acetarsone	10 to 20 cc.	50 cc.	i.v.	8	994	Positive	Fatal. Died on 8th day, after 3rd inj. Cardiac failure. Heartworms alive
531	17.0	Neostibosan	0.2 g.	4 g.	i.m.	20	141	181	No. clinical effect. Worms not killed.
532	17.0	do.	0.2 g.	4 g.	i.m.	20	1	1	do.
603	50.5	Antimony thioglycollamide	0.04 g.	0.84 g.	i.v.	53	282	256	do.
600	20.5	Antimony sodium thioglycollate	0.0125 g.	0.225 g.	i.v.	53	315	252	do.
722	16.5	Ammonium antimony tartrate	0.617 g.	0.617 g.	i.v.	1	49	Positive	Fatal. Death followed few hours after 1st inj. Heartworms alive
646	60.0	do.	0.544 g.	0.544 g.	i.v.	1	12	Positive	do.
738	29.0	do.	0.131 g.	0.393 g.	i.v.	3	None	None	Swellings and abscesses at inj. sites Dog dull and depressed
754	30.0	do.	0.136 g.	0.816 g.	i.v.	3	None	None	Swellings, phlebitis, depression.
727	41.0	do.	0.0558 g.	0.5022 g.	i.v.	11	49	51	Phlebitis, perivascular swellings. Heartworms unaffected
721	18.0	Bismosol	1 to 2 cc.	29 cc.	i.m.	52	7	11	Muscular swellings at inj. sites. Worms unaffected
603	45.0	do.	1 cc.	9 cc.	i.m.	35	239	286	do.
603	47.5	Bismocymol	0.05 g.	0.5 g.	i.m.	34	246	237	do.
603	55.0	Bismuth sodium tartrate	0.015 to 0.03 g.	0.12 g.	i.m.	65	257	239	No clinical reaction. Heartworms unaffected
650	66.0	do.	do.	do.	i.m.	65	62	48	do.
605	49.0	Ichthargan	0.05 g.	0.05 g.	i.v.	1	57	Positive	Dog died shortly after 1st inj. Heartworms alive at autopsy
603	45.0	do.	0.01 to 0.02 g.	0.35 g.	i.v.	17	284	311	Jugular abscesses. Heartworms unaffected
601	13.0	Emetine HCl	0.00618 g.	0.0884 g.	i.v.	26	Positive	Positive	Dog died on 26th day of treatment. Living heartworms recovered

[a] Necropsy performed only on dogs that died from ef

In the present experiments, one of the treated dogs gained over 11 pounds in 21 days, and the other, smaller dog gained 1 pound during the same period. The other arsenical, acetarsone, was without significant action in the one dog to which it was administered, this result agreeing with the much earlier report of Popescu (1932, Rev. Vet. Mil., Rumania 3: 201–207).

Neostibosan, antimony thioglycollamide, antimony sodium thioglycollate, and ammonium antimony tartrate[2] are the antimonials that were tested. The first of these is a pentavalent compound that has been widely used in the treatment of human and experimental kala azar. Its lack of specific action in canine filariasis has already been reported by Wada (1927, Sci. Rpts. Govt. Inst. Infect. Dis., vol. 6, Tokyo; 1929, Jap. Jour. Med. Sci., pt. 4, Pharm. 3: 102; 1930, Jikken Igaku Zasshi, Tokyo, 11: 1041–1050, abs. Biol. Abs. 4:(11) 2639), by Popescu (1932, *loc. cit.*) and by Mohler (1934, *loc. cit.*). The trivalent compounds were likewise ineffective. None of these appears to have been tested heretofore against *D. imitis*. It is interesting to note, however, that ammonium antimony tartrate proved extremely toxic for dogs in these studies, although it has been reported by Brahmachari (1932, Compt. Rend. Cong. Internatl. Med. Trop. et Hyg., 1928, 4: 769) to be better tolerated by man than the other antimony tartrates.

Three bismuth compounds, namely; bismosol, bismocymol (basic bismuth camphocarboxylate), and bismuth sodium tartrate were given limited trials. As shown by the data of table 1, these were ineffective in the manner employed and appear to offer little promise in the treatment of the condition in question.

A silver compound, Ichthargan (silver ichthyol), had no effect in 2 infected dogs. One of these patients was killed by a dose of 0.05 grams intravenously; the other tolerated doses of 0.01 to 0.02 grams but developed abscesses at the sites of injection.

The only metal-free drug employed in these tests was emetine hydrochloride. Simonelli (1936, N. Ercolani 41: 169–178) reported favorably on the use of this drug in heartworm infection, but the writer was unable to confirm his results.

ABSTRACT SUMMARY

Eleven organometallic drugs (tryparsamide, acetarsone, sodium cacodylate, neostibosan, antimony thioglycollamide, antimony sodium thioglycollate, ammonium antimony tartrate, bismosol, bismocymol, bismuth sodium tartrate, and ichthargan) and one alkaloid (emetine hydrochloride) were given limited trials of their efficacy in canine filariasis (*Dirofilaria immitis*). Fourteen infected dogs were used in 18 formal experiments which comprised all of the tests that were made except those with sodium cacodylate. None of the substances tested showed significant action against either the adult worms or the microfilariae. Some of the drugs proved to be highly toxic (*i.e.*, ammonium antimony tartrate and ichthargan) while others, the arsenicals, produced a tonic effect on the treated dogs (*i.e.*, tryparsamide).

Worm parasites in swine raised under a moderate degree of sanitation. JOHN S. ANDREWS and JAMES W. CONNELLY, U. S. Bureau of Animal Industry.

INTRODUCTION

The only readily available information on the occurrence of worm parasites in swine in the Southeastern States is contained in reports by Nighbert and Connelly (1933), Spindler (1934), and Porter (1939). Nighbert and Connelly, during the period 1926 to 1929, made post-mortem examinations of 592 swine of market size. Of these, 481 had been raised under conditions designed to provide a moderate

[2] Prepared by Mr. J. Schaffer, formerly Chemist, U. S. Bureau of Animal Industry.

degree of protection against worm parasites; the remaining 111 were from farms where little or no attention was paid to the control of these pests. The data are incomplete, however, as attention was paid only to the incidence of those nematodes that normally occur in the small intestine, cecum, and colon. Although Spindler recorded the incidence and intensity of the worm parasites found on post-mortem examination of swine raised in Georgia and northern Florida, no attempt was made by him to distinguish between animals raised under sanitary conditions and those raised without attention to sanitation. Porter investigated the stomach worm burden of swine raised under varying degrees of parasite control in southern Georgia and northern Florida; no attention was given by him to other parasites.

During the period from August 1, 1941, to November 1, 1943, the present authors made post-mortem examinations for worm parasites on 129 hogs from the herd belonging to the Georgia Coastal Plain Experiment Station, Tifton, Georgia. The hogs in question had been farrowed and raised to market size under conditions of management designed to provide a moderate degree of protection against worm parasites. In this paper the post-mortem findings are summarized and compared with the findings of other investigators in order to (1) provide further information on the numbers and species of worms in swine in this region, and (2) to evaluate the effectiveness of the management practices involved in controlling worm parasites of swine.

METHOD OF RAISING THE PIGS

The scheme of management under which the pigs in question were raised has been in use for a number of years at the Georgia Coastal Plain Experiment Station, and is a modification of the procedure recommended by Spindler (1934) and Schwartz (1934) for the control of kidney worms and other parasites of swine in the South. Details of the procedure followed are briefly described below.

Pigs are farrowed and kept until weaning (10 weeks of age) in permanent farrowing lots which are used each year for both the spring and the fall farrowings; these occur approximately 6 months apart. Before the spring farrowing the lots are cultivated and sown to oats; prior to the fall farrowing they are again cultivated and sown to cat-tail millet; these crops serve to provide green forage for the sows and their litters. The number of sows on each lot is adjusted so that all are provided with approximately equal grazing areas, irrespective of the number of pigs farrowed. Each lot is provided with a bare strip along fence lines, and the A-type, or shed-type shelter houses, separate feeding pens for sows and pigs, and watering devices are placed on the areas kept bare of vegetation as originally recommended by Spindler (1934).

During the period covered by this investigation fall pigs were transferred at weaning time to a temporary pasture of green oats. This green forage was supplemented with corn, or other carbohydrate feed, a protein, and a mineral mixture, all of which were supplied to the animals in self-feeders. The spring pigs were transferred at weaning to temporary pastures of small grains (oats in 1942; rye and wheat in 1943) for a period of 4 to 5 weeks; they were then transferred to fields of early dent corn. As soon as the corn crop was exhausted (hogged off) the animals were transferred to fields of peanuts for finishing; no supplemental grain feed was provided. As the pigs reached a market weight of approximately 225 pounds each, they were slaughtered at a local abattoir. In the case of each of the 129 animals examined for parasites, liver lesions caused by ascarids and kidney worms were counted as soon as the carcasses were eviscerated. The lungs and the entire alimentary tract, with the exception of the esophagus, were then taken to the laboratory and examined for worm parasites. The data are summarized in tables 1 and 2. In order to have a basis for evaluation of the effectiveness of the management practices enumerated in controlling worm parasites, the data published by Spindler

(1934) are also included; these data were chosen because they are more complete than any of the other data available at this time. For convenience of designation the pigs from the herd of the Georgia Coastal Plain Experiment Station are herein designated as "experimental pigs," and those examined by Spindler are designated as "farm-raised pigs."

PRESENTATION OF DATA

Table 1 contains data on the incidence of worm parasites in the experimental pigs, together with similar data from Spindler's series. Table 2 contains the data pertaining to the numbers of worms found. The following brief discussion will serve to point out some of the more important facts elicited.

Incidence.—Data with respect to the incidence of the various parasites may be divided into 3 general groups, namely, (1) those parasites which were not found in the experimental pigs but which have been reported from pigs on farms in this region (Spindler, 1934; Porter, 1939); (2) those parasites which occurred less frequently than in the farm-raised pigs; and (3) those which were more prevalent than in pigs from farms. The more important points of the data pertaining to each of the 3 groups in question are summarized below.

The parasites comprising group 1 (those absent from the experimental pigs but present in farm-raised pigs) are the hookworm (*Crassisoma urosubulatum*), one species of lungworm (*Metastrongylus salmi*), the red stomach worm (*Hyostrongylus rubidus*), and adult kidney worms (*Stephanurus dentatus*). The absence of the parasites named from the pigs raised at the Experiment Station is of interest in view of the fact that their incidence in farm-raised pigs was reported by Spindler to be 11 per cent, 12 per cent, 15 per cent, and 51 per cent, respectively; Porter found red stomach worms in from 17 to 51 per cent of the hogs he examined.

Parasites comprising the second group (those occurring less frequently than in farm-raised pigs) are the ascarid (*Ascaris lumbricoides* var. *suis*), the thorn-headed worm (*Macracanthorhynchus hirudinaceus*), 1 species of spirurid stomach worm (*Physocephalus sexalatus*), 2 species of nodular worms (*Oesophagostomum longicaudum*, and *O. brevicaudum*), and 2 species of lungworms (*Metastrongylus elongatus* and *Choecrostrongylus pudendotectus*). The incidence of these parasites was from 6 to 42 per cent less than reported by Spindler (Table 1).

Parasites comprising the third group are 1 spirurid stomach worm (*Ascarops strongylina*), the whipworm (*Trichuris suis*), 1 species of nodular worm (*O. dentatum*), and the intestinal threadworm (*Strongyloides ransomi*). The incidence of these parasites ranged from 3 to 29 per cent higher than in the farm-raised pigs examined by Spindler (Table 1). Certain parasites, namely, ascarids, and one of the spirurid stomach worms (*A. strongylina*), as well as liver lesions caused by ascarid and kidney worm larvae were most common in the fall pigs (Table 1). In contrast to this, thorn-headed worms, the 3 species of nodular worms, the other spirurid stomach worm (*P. sexalatus*), whipworms, and threadworms, were most common in the spring pigs.

In addition certain differences were observed in the incidence of parasites in pigs farrowed in the fall of each of the 2 years covered by this report, and also between the spring pigs of that period. From table 1 it can be seen that nodular worms were much less prevalent in the 1942 fall pigs than in the pigs farrowed the previous fall. No lungworms were found in the spring pigs of either year. Thorn-headed worms were not found in pigs farrowed in the spring of 1942. Other parasites, with the exception of nodular worms and lungworms, were more common in the spring pigs of 1943 than in the pigs farrowed the previous spring. This may be accounted for by the fact that in the spring of 1943, the pigs were placed on land that had been occupied by wormy pigs the previous spring.

TABLE 1.—*Incidence of worm parasites recovered post mortem from swine raised under moderate degrees of sanitation at the Georgia Coastal Plain Experiment Station as compared with that reported previously by Spindler from farm-raised pigs in that area*

Name of parasite	Incidence of infection (percentage)							
	Farm-raised pigs	Pigs raised at Coastal Plain Station						
		Fall 1941[d]	Fall 1942[e]	All fall pigs	Spring 1942[f]	Spring 1943[g]	All spring pigs	Fall & spring pigs
Group 1								
Crassisoma urosubulatum	11[a]	0	0	0	0	0	0	0
Metastrongylus salmi	12[a]	0	0	0	0	0	0	0
Hyostrongylus rubidus	15[a]	0	0	0	0	0	0	0
Stephanurus dentatus (kidney)	51[c]	0	0	0	0	0	0	0
Group 2								
Ascaris lumbricoides var. *suis*	74[a]	72	76	75	53	67	58	68
Macracanthorhynchus hirudinaceus	25[a]	15	16	16	0	38	17	16
Metastrongylus elongatus	69[a]	51	41	46	0	0	0	27
Choerostrongylus pudendotectus	50[a]	33	22	28	0	0	0	16
Oesophagostomum longicaudum	97[b]	82	27[h]	54	100	100	100	73
Oesophagostomum brevicaudum	38[b]	44	8[h]	26	28	52	37	31
Physocephalus sexalatus	47[a]	54	5	30	28	48	36	32
Group 3								
Oesophagostomum dentatum	81[c]	97	51[h]	75	97	100	98	84
Ascarops strongylina	53[a]	92	59	79	50	71	59	71
Trichuris suis	23[b]	15	35	25	16	76	40	31
Strongyloides ransomi	26[a]	8	65	37	72	95	81	55
Ascarids (liver lesions)	.....	97	76	88	41	62	45	70
Stephanurus dentatus (liver lesions)	88[c]	100	84	92	88	95	91	92

[a] Based on 348 pigs. [b] Based on 367 pigs. [c] Based on 1,423 pigs. [d] Based on 39 pigs. [e] Based on 37 pigs. [f] Based on 32 pigs. [g] Based on 21 pigs. [h] The reduction in incidence was due to strict sanitation procedures applied to 17 pigs of this group during suckling period.

TABLE 2.—*Average and maximum numbers of worms recovered from swine raised under moderate degrees of sanitation at the Georgia Coastal Plain Experiment Station as compared with the numbers reported previously by Spindler from farm-raised pigs in that area*

Name of parasite	Average number								Maximum number				
	Farm-raised pigs	Pigs raised at Coastal Plain Station							Farm-raised pigs	Pigs raised at Coastal Plain Station			
		Fall 1941	Fall 1942	All fall pigs	Spring 1942	Spring 1943	All spring pigs	Fall & spring pigs		Fall 1941	Fall 1942	Spring 1942	Spring 1943
Group 1													
Crassisoma urosubulatum	7	0	0	0	0	0	0	0	49	0	0	0	0
Metastrongylus salmi[a]	2	0	0	0	0	0	0	0	18	0	0	0	0
Hyostrongylus rubidus	29	0	0	0	0	0	0	0	164	0	0	0	0
Stephanurus dentatus (kidney)	.....	0	0	0	0	0	0	0	.....	0	0	0	0
Group 2													
Ascaris lumbricoides var. *suis*	8	10	12	10	7	5	6	7	176	63	61	40	12
Macracanthorhynchus hirudinaceus	3	2	2	2	0	2	1	2	20	4	4	0	3
Metastrongylus elongatus	24	12	19	17	0	0	0	17	167	45	235	0	0
Choerostrongylus pudendotectus[a]	17	7	14	14	0	0	0	14	97	34	148	0	0
Oesophagostomum longicaudum[a]	126	13	34	19	67	95	78	50	1820	93	523	511	708
Oesophagostomum brevicaudum[a]	36	8	1	7	2	2	2	5	582	26	1	3	6
Physocephalus sexalatus	21	18	1	16	4	17	11	15	235	133	1	14	98
Group 3													
Oesophagostomum dentatum[a]	76	116	73	82	87	109	96	89	725	854	856	717	545
Ascarops strongylina	18	442	198	349	15	57	35	242	98	3680	1400	83	500
Trichuris suis	3	2	3	2	2	3	3	3	14	4	9	3	7
Strongyloides ransomi	.....	4	10	8	362	406	382	234	.....	6	105	1950	1505
Ascarids (liver lesions)	.....	5	3	4	2	2	2	3	.....	13	7	7	6
Stephanurus dentatus (liver lesions)	.....	26	9	16	13	21	16	16	.....	80	50	100	100

[a] Averages include only female worms.

Numbers of worms found.—An examination of the data in table 2 shows that of the parasites found in the experimental pigs all but 2 occurred in somewhat smaller numbers (average infection) than reported by Spindler in the farm-raised pigs which he examined. One exception was the nodular worm (*O. dentatum*) the average infection of which was found to be 89 worms as compared to 76 from the farm-raised animals. Another was the whipworm (*T. suis*), infections of which were approximately the same in the 2 groups. The third was *A. strongylina* the average infection of which was 242 worms as compared to 18 in the farm-raised pigs.

No comparisons could be made between the infestations of intestinal threadworms and the numbers of kidney worm larvae in the liver and kidneys and the numbers of ascarid larvae in the livers in the 2 groups since these data for the farm-raised pigs are not available.

DISCUSSION

The absence of the hookworm (*C. urosubulatum*), one of the lungworms (*M. salmi*) and the red stomach worm (*H. rubidus*) from 129 pigs of the Coastal Plain Experiment Station indicates that these nematodes either have not been introduced into the herd or have been unable to survive the conditions under which the pigs are raised. The fact that the incidence and degree of infection of the 7 other species of helminths (Group 2) were lower than reported by other investigators from farm-raised hogs in this region indicates that the moderate degree of sanitation practiced at the Experiment Station has helped to control these pests. The 5 other species (Group 3) were not materially affected by the measures in question (Table 2).

The absence of kidney worms from the kidneys and kidney fat of the 129 pigs examined may have been due to the fact that pigs raised at this station are marketed at 5½ to 7 months of age which does not allow sufficient time for kidney worms to reach the kidneys of the host animal. This fact has an important bearing on the control of this parasite, as hogs marketed before the worms reach egg-laying maturity do not contaminate soil with the eggs. In addition, there is no loss resulting from condemnation of edible parts of carcasses under meat inspection procedures because of the presence of worms.

As can be seen in the tables, there were no significant differences between spring and fall pigs in the extent of liver invasion by this parasite. This indicates that the infections with this parasite were probably acquired for the most part during the suckling period, either from larvae already on the soil or from larvae hatched from eggs deposited by infected sows. The data presented in this paper indicate that the use of cultivated land has probably contributed to the control of 2 species of lungworms (*M. elongatus*) and (*C. pudendotectus*) by reducing the number of the earthworm intermediate hosts available to the pigs.

SUMMARY AND CONCLUSIONS

1. Post-mortem examinations were made during the years 1941 to 1943 of 129 hogs from the herd of the Georgia Coastal Plain Experiment Station, Tifton, Georgia. The examinations were made to ascertain to what extent the management practices utilized in raising the hogs were instrumental in controlling the intestinal nematodes common in swine in this region. The findings are briefly summarized in this paper.

2. Hookworms (*Crassisoma urosubulatum*), 1 species of lungworm (*Metastrongylus salmi*), and the red stomach worm (*Hyostrongylus rubidus*), were not found in pigs maintained after weaning on temporary pastures at the Georgia Coastal Plain Experiment Station. The kidney worm (*Stephanurus dentatus*) was not found to have invaded the kidneys and kidney fat of these animals.

3. The incidence of ascarids (*Ascaris lumbricoides* var. *suis*), thornheaded worms (*Macracanthorhynchus hirudinaceus*), 2 species of lungworms (*Metastrongy-*

lus elongatus, and *Choerostrongylus pudendotectus*), a spirurid stomach worm (*Physocephalus sexalatus*) and 2 species of nodular worms (*Oesophagostomum longicaudum,* and *O. brevicaudum*) was lower in the pigs raised at the Experiment Station than has been reported in farm-raised pigs in this region; this indicates limited control of these parasites by the management practices followed.

4. One species of spirurid stomach worm (*Ascarops strongylina*), the intestinal threadworm (*Strongyloides ransomi*), 1 species of nodular worm (*O. dentatum*), the whipworm (*Trichuris suis*), occurred more frequently in the pigs examined than has been reported from farm-raised pigs in this region. This fact indicates that the practices followed at this station are relatively ineffectual as control measures against the parasites in question.

5. The moving of pigs to clean ground at frequent intervals during the process of "hogging-off" crops during the summer season was associated with an absence of lungworms, and with a reduction in the severity of infections with all other species of parasites found, except nodular worm, whipworms, intestinal threadworms, and kidney worms. These exceptions may be explained on the basis of favorable conditions for infection during the suckling period provided by the permanent farrowing lots.

LITERATURE CITED

NIGHBERT, E. M., and CONNELLY, J. W. 1933. Effectiveness of the Swine Sanitation System in the South. U. S. Dept. Agr. Techn. Bull. 374. 14 pp.

PORTER, DALE A. 1939. Effectiveness of the Swine Sanitation System in controlling swine stomach worms in the south. Proc. Helminthol. Soc. Wash. 6(1): 21–23.

SCHWARTZ, BENJAMIN. 1934. Controlling kidney worms in swine in the southern states. U. S. Dept. Agr. Leaflet 108, 6 pp.

SPINDLER, L. A. 1934. Field and laboratory studies on the behavior of the larvae of the swine kidney worm, *Stephanurus dentatus.* U. S. Dept. Agr. Tech. Bull. 405. 17 pp.

————. 1934. The incidence of worm parasites in swine in the southern United States. Proc. Helminthol. Soc. Wash. 1(2): 40–42.

Additional studies on the life cycle of *Capillaria caudinflata,* a nematode parasite of chickens and turkeys. EVERETT E. WEHR and REX W. ALLEN, U. S. Bureau of Animal Industry.

In 1942, Allen and Wehr (Proc. Helminth. Soc. Wash. 9(2): 72–73) reported that the earthworm, *Allolobophora* (*Helodrilus*) *caliginosa,* probably played a role in the transmission of the threadworm, *Capillaria caudinflata.* Because of lack of sufficient material with which to conduct the necessary experiments, the exact nature of the role played by the earthworm in the life cycle of this parasite was not definitely determined at that time. Later, as more material became available, additional work to determine the importance of the earthworm in the spread of *C. caudinflata* was undertaken. However, before these studies were completed, Morehouse (1944, Iowa State Coll. Agr. Jour. Sci. 18(2): 217–253) reported on the life cycle of *Capillaria caudinflata* and concluded that (1) this nematode could not be transmitted to chickens by feeding to them embryonated eggs of the parasite, and (2) the earthworm, *Allolobophora* (*H.*) *caliginosa,* served as a true intermediate host. Morehouse was unsuccessful in his attempts to transmit this species by feeding two other species of earthworms, *Eisenia* (*H.*) *foetida* and *Lumbricus terrestris,* or by feeding various species of grasshoppers, beetles, houseflies, ants and sowbugs.

In the course of their studies on the life cycle of *C. caudinflata,* the present writers were successful in transmitting this parasite by the earthworm, *Eisenia* (*H.*) *foetida* and were also able to differentiate the larvae of the two species of *Capillaria, C. annulata* and *C. caudinflata,* found in the earthworm.

The purpose of this paper is to present data on the earthworm, *Eisenia* (*H.*) *foetida,* as a transmitting agent of *C. caudinflata* as well as information on the comparative morphology of the larval forms of *C. annulata* and *C. caudinflata,* as found in the earthworm.

EXPERIMENTAL PROCEDURE

Live gravid females of *C. caudinflata,* removed from infected turkeys, were used as the source of eggs for experimental infections. The eggs were prepared for embryonation by teasing apart or cutting into very small pieces the female worms in a dish of shallow water. Regardless of the procedure used, many of the eggs remained inside the cut or torn portions of the body, but embryonation proceeded at about the same speed as in eggs completely freed from the worms. The culture dishes were allowed to remain at room temperatures until embryonation was completed.

The earthworms used in the experiments were collected near swine and sheep pens which were located at considerable distances from poultry yards. On a number of occasions prior to this test, earthworms from near these same pens had been examined and found to be free of *Capillaria* larvae. Furthermore, chickens to which many of these earthworms had been fed did not acquire *C. caudinflata.*

EXPERIMENTAL DATA

Infection in the earthworm.—The embryonated eggs were introduced directly into the alimentary tract of the earthworms by means of a capillary glass pipette. By this method it was possible (1) to have exact information on the age of the larvae, and (2) to insure that each earthworm used in the experiment received some eggs.

Prior to feeding the embryonated eggs to the earthworms, a small number were tested for hatchability by immersing them in a few drops of dilute digestive fluid obtained, as described by Morehouse (1944, *loc. cit.*), from the alimentary tract of a live earthworm. Within 5 to 10 minutes after immersion of the eggs in the digestive fluid, some of the embryos became very active and after one-half hour many of them had escaped from the eggs.

Several earthworms, *A.* (*H.*) *caliginosa* and *E.* (*H.*) *foetida,* were inoculated with embryonated eggs which had been cultured for from 18 days to 2½ months. Twenty-seven to 31 days later, the earthworms were dissected and examined for the presence of larvae. None was found in a few of the earthworms while a few to many larvae were recovered from each of the other earthworms.

Description of C. caudinflata larvae from earthworm host.—The larvae (Fig. 1) obtained from infected earthworms are about 180 to 200 μ long and 13 to 15 μ wide. In unstained specimens, the narrow esophagus is visible as far posteriorly as the dark, elongated mass which lies near the center of the body; in some specimens, the esophagus can be seen to turn to one side of the mass which, in all probability, is the undeveloped cell body, and to assume, as it does in the adult, a superficial position with respect to the cell body for the remaining portion of its length. Immediately following what is considered to be the cell body is a lighter colored structure which becomes narrower as it approaches the posterior end of the body; this is probably the undeveloped intestine. The tip of the tail is bipartite and set off from the remainder of the body by a deep constriction.

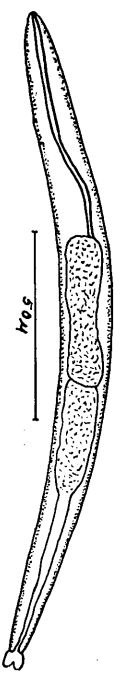

FIG. 1. *Capillaria caudinflata,* larva taken from earthworm.

Differentiation of larvae of C. caudinflata and C. annulata.—The dissection of earthworms, *A.* (*H.*) *caliginosa* and *E.* (*H.*) *foetida,* which were collected from experimental turkey runs at the Beltsville Research Center, disclosed the presence of two types of *Capillaria* larvae. An examination of turkeys which had been removed from these runs earlier revealed the presence of adults of two species of threadworms, namely, *C. annulata* and *C. caudinflata.* Larvae of both of these species were, therefore, suspected as being present in the two species of earthworms. As viewed under the microscope, one type of larva was considerably thicker and somewhat more sluggish in its movements than the other. The thinner larva was relatively more active and possessed a cuticular constriction at the junction of the bifurcated tail with the body; no such constriction was seen in the thicker larva.

In order to identify these larvae with the adults, 56 specimens of the thicker type and 45 of the thinner type were dissected from the earthworms and fed to separate poults. The poults were held for 25 days to allow sufficient time for the larvae to reach the adult stage. At necropsy, the crop, superior and inferior portions of the esophagus, proventriculus, and the first 4 inches of the small intestine of each of the birds were carefully examined for immature and mature worms. Four mature females of *C. annulata* were recovered from the posterior portion of the esophagus, near its union with the crop, in the turkey to which the thicker larvae had been given, and 1 mature female of *C. caudinflata* and 1 unidentifiable immature specimen were recovered from the duodenal region of the intestine of the turkey to which the thinner larvae had been fed.

SUMMARY

1. A study of the life history of the intestinal threadworm of poultry, *Capillaria caudiflnata,* revealed that the earthworm, *Eisenia* (*H.*) *foetida,* as well as *A.* (*H.*) *caliginosa,* served as intermediate hosts of this parasite.

2. The two species of earthworms were experimentally infected with the larvae of *C. caudinflata* by feeding to them embryonated eggs of this nematode; the larvae were recovered from the earthworms several days later by gross dissection.

3. The larvae of *C. caudinflata* and *C. annulata* were morphologically distinguishable on the basis of size, motility, and by the presence of a rather deep constriction which sets off the tail from the rest of the body in the case of the former species.

Some preliminary tests to determine the efficacy of certain substances when used as soil fumigants to control the root-knot nematode, *Heterodera marioni* (Cornu) Goodey. JESSE R. CHRISTIE, Plant Industry Station, U. S. Department of Agriculture, Beltsville, Maryland.

PROCEDURE

The procedure used in these tests has been the result of an effort to devise a quick, simple, and reliable method for testing soil fumigants of unknown efficacy in order that those showing little promise can be separated from those that seem to merit further investigation. Lateral killing range 6 inches below the surface of the soil is used as a basis for evaluation. The principal advantage of the method lies in the fact that information can be obtained on the comparative efficacy of several fumigants when all are acting under nearly identical, and more or less natural, conditions and results can be obtained in a comparatively short time. Briefly stated, the method consists of enclosing root-knot-nematode inoculum in small cheese-cloth bags, burying the bags in the soil of a tilled field at measured distances from the point where the fumigant is injected, then, after a certain interval, removing the bags from the soil and testing the content of each in the greenhouse against an indicator plant.

For each fumigant a narrow trench was dug 6 inches deep and about 3 feet long. A point equidistant from the ends of the trench, where the fumigant was to be injected, was marked with a stake. Ten bags of inoculum were divided into 2 groups of 5 bags each and one group placed at the right, the other at the left, of the stake. The bags of each group were arranged in a row at the bottom of the trench, one 3 inches, one 6 inches, one 9 inches, one 12 inches, and one 15 inches from the stake. The trench was then filled and the soil firmed. Soil temperature and a soil sample for moisture determination were taken about 8 inches from the stake in a direction at right angles to the trench. The stake was then removed and a measured amount of the fumigant injected to a depth of 6 inches. After a certain interval the bags of inoculum were removed from the soil, taken to the greenhouse, and the content of each bag placed near the center of a 6-inch pot filled with steam-treated soil. Squash was used as an indicator plant, the roots being examined after an interval of about 4 weeks.

Soil.—The soil of the plot where the tests were made was Berwyn Loam. A mechanical analysis was not made for this plot but a sample taken from an adjoining plot of similar soil gave the following results (calculated on basis of organic-free oven-dry sample):[1] Fine gravel (2–1 mm.), 1.0%; coarse sand (1–0.5 mm.), 11.7%; medium sand (0.5–0.25 mm.), 15.3%; fine sand (0.25–0.1 mm.), 19.2%; very fine sand (0.1–0.05 mm.), 10.2%; silt (0.05–0.002 mm.), 33.4%; clay (less than 0.002 mm.), 9.2%. Organic matter by H_2O_2, 0.7%.

Materials tested.—Dichloroisopropyl ether, dichlorethyl ether, propylene dichloride, ethylene dichloride, propylene chlorhydrin, and trichlorethane (that used in tests 3, 4, 5, and 6) were provided for testing by Carbide and Carbon Chemicals Corporation; Dowfume G (10 per cent methyl bromide in a mixture of 3 parts ethylene dichloride and 1 part carbon tetrachloride), ethylene dibromide, tetrachlorethane, 1,1,1-trichlorethane, and 1,1,2-trichlorethane (that used in test 7) were provided by the Dow Chemical Company; and DD was provided by Shell Chemical. In test 2 are included 3 mixtures that had been submitted for testing by persons interested in root-knot control. The designations of these mixtures, as given in table 1, were copied from the labels on the bottles and represent all the information available to the writer.

Inoculum.—For test 1 the inoculum consisted of fresh excised galls and root fragments. The root systems of several heavily infected tomato plants were cut into small pieces with scissors. Wads of this root material, each about the size of a walnut, were enclosed in cheesecloth. For test 2 the root systems of several heavily infected tomato plants were ground in a food chopper and the resulting "grist" mixed with 3 or 4 times its volume of sand. This was done to produce an inoculum more comparable to that which occurs in the soil after roots have decayed. For tests 3, 4, 5, 6, and 7 the inoculum was the same as that used for test 1 except that the root fragments were mixed with a small quantity of infested soil.

Dosage.—In all cases the dosage was 10 cc., the only exception being a 20-cc. injection of 1,1,2-trichlorethane (Test 7).

Gas confinement.—A water seal was provided by sprinkling the soil immediately after injection but the soil was not sprinkled again thereafter. In test 7, where the soil was comparatively wet, no water seal was provided.

Time intervals.—The interval between the time when the fumigants were injected and the time when the bags of inoculum were removed from the field were: for test 1, 2, 3, and 4, 7 days; for test 5, 9 days; for tests 6 and 7, 14 days.

Soil moisture.—Soil samples for moisture determinations were taken by pressing into the soil cylindrical metal tubes each about 2¾ inches in diameter and 6

[1] Data provided by Division of Soil and Fertilizer Investigations, Bureau of Plant Industry, Soils, and Agricultural Engineering, Agricultural Research Administration, U. S. Department of Agriculture.

TABLE 1.—*Lateral killing range of certain substances when used as soil fumigants to control the root-knot nematode. Results based on an injection of 10 cc. unless otherwise noted. Tests conducted during the summer of 1944*

Fumigant	Soil at beginning of test		Degree of galling on indicator plants									
	Water by weight	Temp.	15″	12″	9″	6″	3″	3″	6″	9″	12″	15″
	%	°F.										
(Test 1. June 9 to 16)												
Dichloroisopropyl ether	10.1	70	4[a]	4	4	4	4	4[b]	4[b]	4[b]	4[b]	4[b]
Dichlorethyl ether	9.5	71	4	4	4	4	3	3	3	4	4	4
Propylene dichloride	10.5	71	4	4	4	4	4	4	3	3	4	4
Ethylene dichloride	9.7	72	4	4	4	4	2	3	4	4	4	4
Larvacide (chloropicrin)	9.0	71	4	4	4	2	0	1	3	4	4	4
DD	11.0	71	3	1	0	0	0	0[b]	0[b]	0[b]	0[b]	3[b]
(Test 2. July 6 to 13)												
Mixture of DD (450 cc.) & Allyl-isothiocyanate (50 cc.)	9.6	76	3	1	0	0	0	0	0	0	1	4
Mixture of DD (100 cc.) & DDT (258 cc.)	9.8	75	4	3	1	0	0	0	0	0	1	4
Mixture of Ethylene chlorhydrin (100 cc.) & Rotenone (5 grams)	10.9	75	3	3	3	3	3	3	3	3	3	3
Propylene chlorhydrin	9.3	75	3	3	3	3	4	4	3	3	3	3
Larvacide	9.5	75	4	2	1	0	0	0	0	0	1	4
DD	11.4	75	4	2	1	0	0	0	0	0	1	4
(Test 3. July 21 to 28)												
Equal parts Dichloroisopropyl ether & Dichlorethyl ether	14.5	74	4	4	4	4	4	4	4	4	4	4
Equal parts Dichloroisopropyl ether & Propylene dichloride	15.1	71	4	4	4	4	4	4	4	4	4	4
Equal parts Dichloroisopropyl ether & Ethylene dichloride	14.6	70	4	4	4	4	4	4	4	4	4	4
Equal parts Dichloroisopropyl ether & Trichlorethane	12.1	73	4	4	4	4	3	3	4	4	4	4
Equal parts Dichloroisopropyl ether & Propylene chlorhydrin	14.4	74	4	4	4	4	4	4	4	4	4	4
DD	14.0	71	4	4	1	0	0	0	0	0	3	4
(Test 4. July 25 to August 1)												
Equal parts Dichlorethyl ether & Propylene dichloride	10.1	74	4	4	4	4	3	4	3	4	3	4
Equal parts Dichlorethyl ether & Ethylene dichloride	9.4							4	3	4	4	4	4	4

TABLE 1.—*Continued*

Fumigant	Soil at beginning of test		Degree of galling on indicator plants									
	Water by weight	Temp.	15″	12″	9″	6″	3″	3″	6″	9″	12″	15″
	%	°F.										
Equal parts Dichlorethyl ether & Trichlorethane	8.2	73	4	4	4	4	4	0	4	4	4	4
Equal parts Dichlorethyl ether & Propylene chlorhydrin	10.0	73	4	4	4	4	4	4	4	4	4	4
Equal parts Ethylene dichloride & Propylene chlorhydrin	10.5	74	4	4	4	4	4	4	4	4	4	4
DD	10.4	73	4	3	0	0	0	0	0	0	1	4
(Test 5. July 26 to August 4)												
Equal parts Propylene dichloride & Ethylene dichloride	9.0	76	4	3	4	4	2	3	4	4	4	4
Equal parts Propylene dichloride & Propylene chlorhydrin	7.5	75	3	3	4	4	4	4	4	3	3	3
Equal parts Propylene dichloride & Trichlorethane	6.1	75	4	4	3	4	2	1	3	3	3	3
Equal parts Ethylene dichloride & Trichlorethane	8.6	75	4	4	4	4	1	1	2	4	4	4
Equal parts Propylene chlorhydrin & Trichlorethane	8.8	74	3	4	4	4	3	3	4	4	4	3
DD	7.9	74	4	4	0	0	0	0	0	0	1	3
(Test 6. September 11 to 25)												
Trichlorethane	.....[c]	74	4	4	4	4	2	0	4	4	4	4
Trichlorethane (20 cc.)	9.2	73	4	4	4	4	0	0	2	4	4	4
Dowfume G	9.6	73	4	4	2	0	0	0	0	2	4	4
Larvacide	7.9	73	4	4	4	4	0	0	4	4	4	4
DD	7.8	73	4	4	3	0	0	0	0	0	4	4
(Test 7. October 12 to 26)												
Ethylene dibromide	16.0:	64: 50[d]	2	0	0	0	0	0	0	0	0	4
Tetrachlorethane	15.3: 17.0	64: 50	4	4	4	3	4	4	4	4	4	4
1,1,2-Trichlorethane	.....: 16.4	64: 50	4	4	4	3	0	0	2	3	4	4
1,1,1-Trichlorethane	15.7: 18.0	64: 50	4	4	4	4	4	4	4	4	4	4
Larvacide	13.5: 15.7	64: 50	4	4	4	4	1	1	4	4	4	4
Dowfume G	15.8: 17.6	64: 50	3	1	1	0	0	0	2	3	3	4
DD	12.5: 14.4	64: 50	4	2	0	0	0	0	0	0	1	4

[a] See text for explanation of rating.
[b] Roots of indicator plant shown in figure 1.
[c] Sample taken near center of plot at end of test contained 16.5% water.
[d] Soil moisture and temperature determined at beginning and end of test.

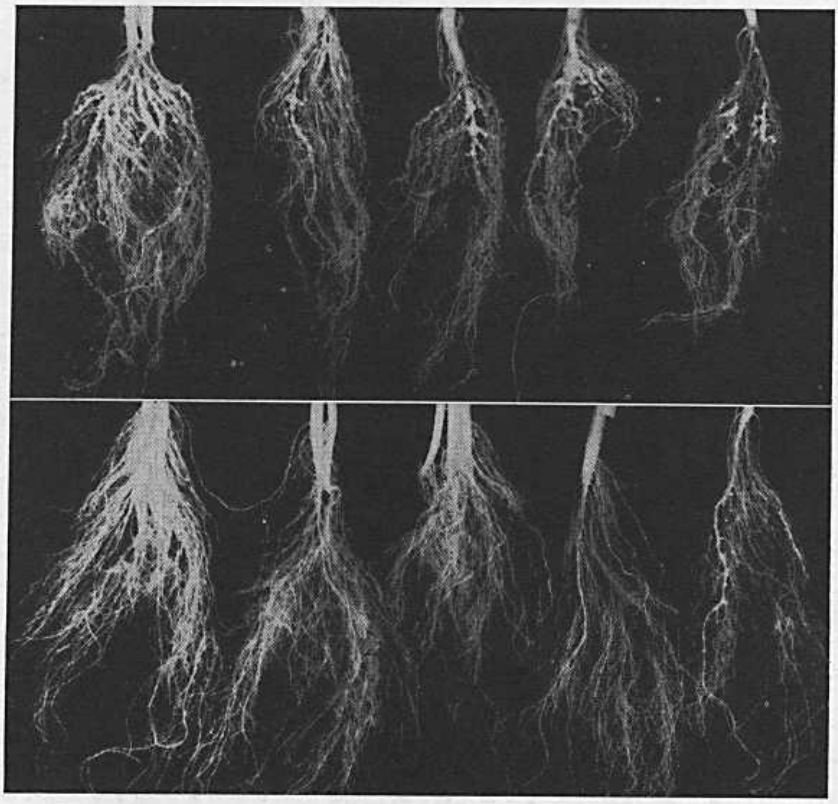

FIG. 1.—Galling on indicator plants produced by inoculum placed (from left to right) 3, 6, 9, 12, and 15 inches, respectively, from the point of injection. Selected from test 1 as showing typical results, upper row with dichloroisopropyl ether, lower row with DD.

inches long. For test 6, the soil at the time the fumigants were injected was relatively dry but rain fell within a few hours and thereafter the soil was relatively wet, hence moisture determinations for this test given in table 1 are misleading. At the end of the test a moisture determination was made on a single sample taken near the center of the plot. For test 7 moisture determinations were made for each fumigant at both the beginning and the end of the test, *i.e.*, when the fumigants were injected and when the bags were removed. Moisture determinations are on an oven-dry basis.

Rainfall.—Precipitation during the test periods was as follows:

Test 1
June 14, 0.11 in.
" 15, 0.12 "
" 16, 0.02 "

Test 2
July 14, 1.51 "
" 20, 1.01 "

Test 3
July 29, 0.15 "

Test 4
July 29, 0.15 "

Test 5
July 29, 0.15 in.
Aug. 2, 4.95 "

Test 6
Sept. 12, 0.34 "
" 13, 1.88 "
" 14, 1.27 "
" 15, 0.09 "
" 18, 0.01 "
" 19, 0.36 "

Test 7
Oct. 13, 0.02 in.
" 14, 0.50 "
" 21, 1.15 "

RESULTS AND COMMENTS

The results are given in table 1. The effect of the fumigants on inoculum placed at varying intervals from the point of injection is expressed in terms of the amount of galling this inoculum produced on the roots of the indicator plants as follows: 0, none; 1, trace; 2, light; 3, moderate; 4, heavy.

In conformity with previous experience, results indicate that Larvacide (chloropicrin) is more effective when infected roots have undergone decay. With DD and Dowfume G this factor does not appear to be so important. The killing range of DD varied slightly from test to test but this does not seem to be correlated with variations in soil moisture or temperature. In test 7, where soil moisture varied from 12.5 to 14.4 per cent the killing range of DD was about the same as in tests where the soil was much drier. In this same test 1,1,2-trichlorethane showed a moderate killing range (to 3 but not to 6 inches) and ethylene dibromide showed a killing range as great as any material in any test (to 12 but not to 15 inches). Excepting these 5 materials noted above, the tests do not indicate that any of the other chemicals, whether used alone or in combinations, possess appreciable killing capacity.

Anthelmintic studies with some thymol-like compounds. FRANK D. ENZIE, U. S. Bureau of Animal Industry.

Thymol has had the status of a useful anthelmintic since it was first used in this capacity some 65 years ago (Bozzolo, 1879, Gior. Internaz. Sci. Med. 2: 1054–1069, 1245–1253). With some physicians it is still the drug of choice for the treatment of hookworm infection of man, although, on the whole, the use of thymol as an anthelmintic fell off significantly after the introduction of carbon tetrachloride by Hall (1921, Jour. Agr. Research 21: 157–175), of tetrachlorethylene by Hall and Shillinger (1925, Amer. Jour. Trop. Med. 5: 229–237) and of hexylresorcinol by Lamson, Ward and Brown (1930, Proc. Soc. Expt. Biol. and Med. 27: 1017–1020). The popularity of thymol in veterinary therapeutics has been especially restricted on account of the involved regimen of therapy as well as for economic reasons.

Since a comparatively simple alteration in the chemical structure of a compound ordinarily has a marked effect upon its toxicologic and anthelmintic actions, it seemed desirable to study a few substances with chemical structures similar to that of thymol, pursuing, in this regard, the comprehensive investigations that were carried out by Lamson and his associates (1934, Amer. Jour. Trop. Med. 14: 467–478; 1935, Jour. Pharmacol. and Expt. Therap. 53: 198–249; 1936, *ibid.* 56: 50–52, 60–68). The specific compounds studied were 8 alkylbenzenes, viz., 6-methyl-m-cresol (4-hydroxy-1,2-dimethylbenzene), 4-isopropyl-m-cresol (thymol), 6-isopropyl-m-cresol (isothymol), 4-tertiarybutyl-m-cresol, 4,6-di-tertiarybutyl-m-cresol, 4-tertiarybutyl-2-chlorophenol, 4-tertiaryamylphenol (''pentaphen''), and 2-amino-p-cymene (carvacrylamine). In addition to thymol, 2 of these compounds (6-methyl-m-cresol and 4-tertiaryamylphenol) had been tested to a limited extent by Lamson *et al.*, and their inclusion in the present study was purely for purposes of comparison. Moreover, Lamson and his associates were searching primarily for a suitable human ascaricide and, as a consequence, their criteria differed in some respects from those employed in this study. Data on a related alkylhydroxybenzene, 4-tertiarybutylphenol (''butylphen''), which showed rather marked anthelmintic action in dogs, have already been reported (Enzie, 1944, this journal 11: 55–58).

The tests were conducted at the station of the Zoological Division, Beltsville Research Center, Agricultural Research Administration, U. S. Department of Agriculture, Beltsville, Maryland. From 1 to 7 days before treatment, the test animals were confined in individual cages and the feces screened daily in order to detect

natural elimination of parasites. The kinds of parasites in each animal were determined by fecal examination prior to treatment. The drugs were given in hard gelatin capsules to dogs after a fasting period of 18 to 24 hours; and 3 to 4 hours after treatment the dogs were returned to regular feed. The feces of each animal were collected individually every 24 hours and examined for parasites. After the elimination of parasites ceased, the test animals were autopsied and the entire gastrointestinal tract examined for parasites and lesions. Representative tissue sections were preserved in the event studies of histopathology become necessary.

RESULTS

The results obtained are shown in tables 1 and 2. It is apparent that iso-thymol, 6-isopropyl-m-cresol, (Table 1), was relatively ineffective against hookworms, 6 per cent (54) of 895, and against whipworms, 13 per cent (137) of 1023, when given to 7 dogs at dose rates of 0.3 to 0.5 gram per pound of body weight. However, at these dose rates the drug removed 93 per cent (142) of 152 ascarids from 8 dogs; and at 0.4 and 0.5 gram per pound, it was completely effective against 109 ascarids in 7 dogs. The efficacy against hookworms was somewhat less than anticipated for compounds of its type. In an attempt to increase the efficacy against this parasite, 3 doses were given at intervals of 3 hours to dogs 144 and 148. At the rate of 0.2 gram per pound of body weight, the drug removed 37 per cent (34) of 92 hookworms but failed to remove 1 whipworm from dog 144. At 0.3 gram per pound, all of 6 ascarids, 31 per cent (33) of 108 hookworms, and 11 per cent (4) of 36 whipworms were removed from dog 148.

Iso-thymol was given in the feed to 2 pigs at a dose rate of 0.5 gram per pound of body weight. The mixture was consumed readily by both animals, and no untoward ractions were observed. In one instance the drug failed to remove any of 31 nodular worms and 17 whipworms, and in the other test, it removed only 7 per cent (2) of 28 ascarids, 1 per cent (1) of 108 nodular worms, 2 per cent (2) of 114 whipworms, and none of 12 stomach worms.

Data obtained from the testing of members of the series other than iso-thymol are shown in table 2. The first member, 6-methyl-m-cresol, was the most toxic of the compounds studied. At a dose rate of 0.1 gram per pound of body weight, the drug was wholly ineffective against 14 ascarids and 23 hookworms in 1 dog. The animal died about 30 hours after treatment, and at autopsy the most significant lesion was a severe hemorrhagic enteritis with considerable free blood in the lumen of the small intestine.

Thymol, 4-isopropyl-m-cresol, removed 100 per cent of 151 ascarids, 97 per cent (178) of 184 hookworms, and 69 per cent (152) of 221 whipworms from 2 dogs at a dose rate of 0.2 gram per pound of body weight. One dog exhibited evidence of intestinal irritation as mucus was found in the feces after treatment.

At dose rates of 0.2 to 0.3 cc. per pound of body weight, 4-tertiarybutyl-m-cresol removed 99 per cent (71) of 72 ascarids, 81 per cent (13) of 16 hookworms, and 34 per cent (32) of 93 whipworms from 3 dogs. A dose rate of 0.3 cc. per pound was ineffective against 1 immature *Dipylidium*. Vomition occurred shortly after treatment in each of the 3 test animals.

At a dose rate of 0.1 gram per pound of body weight, 4,6-di-tertiarybutyl-m-cresol removed only 1 hookworm and was wholly ineffective against ascarids and whipworms in 1 dog. In view of the insignificant anthelmintic action, the dog was treated at an increase dose rate, 0.2 gram per pound, and in this instance the treatment was totally ineffective against ascarids, hookworms, and whipworms. At autopsy after a subsequent test, it was determined by calculation that at the time of treatment with this drug the dog harbored 1 ascarid, 47 hookworms, and 33 whipworms. The only untoward reaction was soft, mushy feces 1 day after treatment.

The chlorinated alkylphenol, 4-tertiarybutyl-2-chlorophenol, removed 100 per cent of 26 ascarids and 67 per cent (4) of 6 hookworms from 1 dog at a dose rate of 0.1 cc. per pound of body weight, and at a dose rate of 0.2 cc. per pound, the drug removed 100 per cent of 54 ascarids, 84 per cent (16) of 19 hookworms, but none of 37 whipworms from 1 dog. No toxic reactions were noted at any time; the compound has, however, a very persistent and disagreeable odor which militates against it as a potential anthelmintic, especially for small animals.

TABLE 1.—*Data on anthelmintic tests with 6-isopropyl-m-cresol in dogs*

Animal No.	Weight	Dose	Worms recovered following treatment	Worms found at autopsy	Efficacy	Effect of treatment on host
	pounds	*grams*			*per cent*	
137	16.0	2.0	Hookworms 2	....	.....[a]	None; retested as dog No. 144
144	16.0	9.6[b]	Hookworms 34 Whipworms 0	Hookworms 58 Whipworms 1	37 0	None
148	19.0	17.1[c]	Ascarids 6 Hookworms 33 Whipworms 4	Ascarids 0 Hookworms 75 Whipworms 32	100 31 11	None
140	28.5	8.55	Ascarids 33 Hookworms 0 Whipworms 24	Ascarids 10 Hookworms 47 Whipworms 301	77 0 7	None; retested as dog No. 142
141	27.0	13.5	Ascarids 29	Ascarids 0	100	None
142	28.5	14.25	Ascarids 10 Hookworms 10 Whipworms 98	Ascarids 0 Hookworms 37 Whipworms 203	100 21 33	None
143	20.0	8.0	Ascarids 40 Hookworms 18 Whipworms 3	Ascarids 0 Hookworms 128 Whipworms 107	100 12 3	None
145	16.5	6.6	Ascarids 8 Hookworms 6 Whipworms 0	Ascarids 0 Hookworms 73 Whipworms 4	100 8 0	None
146	22.5	9.0	Ascarids 5 Hookworms 2 Whipworms 2	Ascarids 0 Hookworms 226 Whipworms 207	100 1 1	None
149	17.0	6.8	Ascarids 2 Hookworms 17 Whipworms 6	Ascarids 0 Hookworms 247 Whipworms 23	100 6 21	None
150	27.0	10.8	Ascarids 15 Hookworms 1 Whipworms 4	Ascarids 0 Hookworms 83 Whipworms 41	100 1 9	None

[a] Since the anthelmintic action was negligible, the dog was not autopsied.
[b] 3.2 grams t.i.d.
[c] 5.7 grams t.i.d.

Pentaphen (4-tertiaryamylphenol), at dose rates varying from 0.2 to 0.3 gram per pound of body weight, removed 94 per cent (90) of 96 hookworms from 3 dogs. The drug, at 0.2 gram per pound, was wholly ineffective against 3 immature ascarids in 1 dog, but at 0.3 gram per pound it removed 99 per cent (127) of 128 ascarids and 23 per cent (9) of 40 whipworms from another dog. There were no untoward reactions to the treatment.

TABLE 2.—*Data on anthelmintic tests with some thymol-like compounds in dogs*

Drug	Animal No.	Weight	Dose	Parasites recovered after treatment		Parasites found at autopsy		Efficacy	Effect of treatment on host
		pounds	*gm. or cc.*					*per cent*	
6-methyl-m-cresol	180	15.5	1.55	None		Ascarids	14	0	Toxic; dog died in about 30 hours
						Hookworms	23	0	
4-isopropyl-m-cresol	170	15.0	3.0	Ascarids	79	Ascarids	0	100	None; 10 ascarids eliminated in 7 days before treatment
				Hookworms	9	Hookworms	6	60	
				Whipworms	9	Whipworms	23	28	
	172	16.0	3.2	Ascarids	72	Ascarids	0	100	Mucus in feces first day after treatment; 1 ascarid eliminated in 4 days before treatment
				Hookworms	169	Hookworms	0	100	
				Whipworms	143	Whipworms	46	76	
4-t-butyl-m-cresol	185	9.0	1.8	Ascarids	34	Ascarids	1	97	Vomition
				Hookworms	0	Hookworms	2	0	
				Whipworms	14	Whipworms	37	27	
	186	25.5	7.65	Ascarids	1	Ascarids	0	100	Vomition; 2 whipworms were eliminated in 3 days before treatment
				Hookworms	10	Hookworms	1	91	
				Whipworms	15	Whipworms	13	54	
				Dipylidium	0	Dipylidium	1	0	
	190	27.5	6.9	Ascarids	36	Ascarids	0	100	Vomition
				Hookworms	3	Hookworms	0	100	
				Whipworms	3	Whipworms	11	21	
4-6-ditertiary-butyl-m-cresol	212	48.0	4.8	Ascarids	0	Ascarids	1[a]	0	Laxative
				Hookworms	1	Hookworms	46[a]	2	
				Whipworms	0	Whipworms	33[a]	0	
			9.6	Ascarids	0	Ascarids	1[a]	0	Laxative; autopsied after subsequent test
				Hookworms	0	Hookworms	46[a]	0	
				Whipworms	0	Whipworms	33[a]	0	
4-t-butyl-2-chloro-phenol	181	16.5	1.65	Ascarids	26	Ascarids	0	100	None
				Hookworms	4	Hookworms	2	67	
	184	14.0	2.8	Ascarids	54	Ascarids	0	100	None
				Hookworms	16	Hookworms	3	84	
				Whipworms	0	Whipworms	37	0	
4-t-amylphenol	160	14.0	2.8	Ascarids	0	Ascarids	3	0	None
				Hookworms	21	Hookworms	2	95	
	165	18.0	5.4	Ascarids	127	Ascarids	1	99	None
				Hookworms	59	Hookworms	1	98	
				Whipworms	9	Whipworms	31	23	
	173	18.5	5.55	Hookworms	10	Hookworms	3	77	None
2-amino-p-cymene	167	18.0	1.35	Ascarids	124	Ascarids	3	98	Vomition
							7	37	
				Whipworms	0	Whipworms	9	0	

[a] Calculated.

The last member of the series, 2-amino-p-cymene, induced vomition when given to 1 dog at a dose rate of 0.075 cc. per pound of body weight. This drug, however, removed 98 per cent (124) of 127 ascarids and 37 per cent (51) of 138 hookworms from the dog; it was wholly ineffective against 9 whipworms.

The constitutional formulae and certain physical properties of the compounds tested are given in table 3. It is apparent that the first 5 substances are meta-cresols, differing only in the position, composition, or number of alkyl substituents. The last 3 substances, on the other hand, differ in the number or composition of radicals in addition to the alkyl substituent. Of the compounds tested, 3 are liquids, 4 are solids, and 1 is a semi-solid. All of the compounds tested are relatively insoluble in water, and their melting points and boiling points vary rather markedly. No correlations between these physical properties and the anthelmintic action were apparent.

DISCUSSION

Thymol (4-isopropyl-m-cresol), the basic compound of this study, exhibited significant anthelmintic action against ascarids and hookworms when given to 2 dogs, but evidence of intestinal irritation was observed in one.

TABLE 3.—*Physical properties of some thymol-like compounds*

Name	Constitutional formulae	Physical state	Water solubility	Melting point	Boiling point
				°C.	°C.
6-methyl-m-cresol	$(CH_3)_2C_6H_3OH$	Solid	1: 450 sl. sol.	63–65	225
6-isopropyl-m-cresol	$CH_3(C_3H_7)C_6H_3OH$	Solid	insol.	116	120 (10 mm.)
4-isopropyl-m-cresol	$CH_3(C_3H_7)C_6H_3OH$	Solid	1: 1100 sl. sol.	50–51	233.5
4-tertiarybutyl-m-cresol	$CH_3(CH_3)_3CC_6H_3OH$	Liquid	insol.	23	230
4,6-di-tertiary-butyl-m-cresol	$CH_3[(CH_3)_3C]_2C_6H_2OH$	Semi-solid	insol.	62.5	285
4-tertiarybutyl-2-chlorophenol	$Cl(CH_3)_3CC_6H_3OH$	Liquid	v. sl. sol.	.....	105–108 (9 mm.)
4-tertiaryamyl-phenol	$CH_3CH_2C(CH_3)_2C_6H_4OH$	Solid	1: 8500 v. sl. sol.	92–93	248–250
2-amino-p-cymene	$(CH_3)_2CH(CH_3)C_6H_3NH_2$	Liquid	v. sl. sol.	−16	113–115 (12 mm.)

Iso-thymol, an isomer in which the alkyl substituent is in the 6 position, exhibited rather marked ascaricidal properties in dogs. Its action against hookworms, however, was relatively insignificant, and multiple doses failed to increase appreciably the efficacy against this parasite. The drug was well tolerated in all tests, and no untoward reactions were observed at any time. At autopsy no lesions were observed which could be attributed solely to the action of the drug. In tests on 2 pigs its anthelmintic action against ascarids, nodular worms, stomach worms, and whipworms was of little consequence.

In substituting a methyl radical for the isopropyl group of iso-thymol, the resultant compound, 6-methyl-m-cresol, proved very toxic and was without anthelmintic action when given to 1 dog. Lamson *et al.* (1935, *loc. cit.*, pp. 227–233), however, reported that the drug exhibited slight ascaricidal action in dogs.

Since the tertiarybutyl radical in the para position gave promising results in tests with alkylphenols (Enzie, 1944, *loc. cit.*), it seemed desirable to substitute this

group for the isopropyl radical of thymol. This compound, 4-tertiarybutyl-m-cresol, demonstrated rather marked anthelmintic action, but in each instance it induced vomition in the test animals. When an additional radical of the same composition was affixed in the 6 position, the resultant compound, 4,6-di-tertiarybutyl-m-cresol, was devoid of anthelmintic activity.

In an attempt to augment the anthelmintic action of butylphen (*ibid.*), a chlorine atom was introduced at the ortho position of the phenol nucleus. At comparable dose rates this compound, 4-tertiarybutyl-2-chlorophenol, was equally effective against ascarids, but its effect on hookworms was somewhat less than that of the unchlorinated alkylphenol. It is known, however, that such a change in the nucleus of a phenol alters the chemical activity of the hydroxyl group and the physical properties of the molecule. The difference in anthelmintic activity with respect to hookworms, therefore, cannot be ascribed solely to the presence of the chlorine atom.

In order to ascertain the effect on anthelmintic action of an alteration in the length of the carbon chain in alkylphenols, 4-tertiaryamylphenol (pentaphen) was tested and the anthelmintic action compared with that of butylphen (Enzie, 1944, *loc. cit.*). This substance demonstrated significant anthelmintic action, but even at larger dose rates its action was not superior to that of the shorter chained compound. Lamson *et al.* (1935, *loc. cit.*, pp. 239–249) tested pentaphen more extensively and obtained similar results. He found, however, that when the drug was pulverized and combined with 2 parts of sodium bicarbonate, the anthelmintic action compared favorably with that obtained with the shorter chained compound at similar dose rates.

The last member of the series, namely, 2-amino-p-cymene, involved the substitution of an amino group for the hydroxyl radical of carvacrol (4-isopropyl-o-cresol), an isomer of thymol. This compound exhibited definite ascaricidal properties, but its action against hookworms was relatively insignificant. Moreover, vomition was induced in the only dog treated.

ABSTRACT SUMMARY AND CONCLUSIONS

In limited anthelmintic studies with a group of thymol-like compounds, namely, 6-methyl-m-cresol, 4-isopropyl-m-cresol, 6-isopropyl-m-cresol, 4-tertiarybutyl-m-cresol, 4,6-di-tertiarybutyl-m-cresol, 4-tertiarybutyl-2-chlorophenol, 4-tertiaryamylphenol, and 2-amino-p-cymene, one, 6-isopropyl-m-cresol (iso-thymol) gave promising results in dogs both with respect to anthelmintic action and apparent lack of toxicity. The anthelmintic properties of this isomer of thymol were rather interesting in that its action against hookworms was relatively insignificant whereas its ascaricidal action was apparently quite marked. At dose rates of 0.4 and 0.5 gram per pound of body weight, given after a fasting period of 18 to 24 hours, the drug was completely effective against 109 ascarids in 7 dogs. On the other hand, dose rates varying from 0.3 to 0.5 gram per pound removed only 6 per cent of 895 hookworms from a similar number of dogs. Moreover, multiple doses of 0.2 and 0.3 gram per pound of body weight failed to increase significantly the action of the drug against this parasite. This substance was of further interest with respect to its apparent lack of toxicity, for at dose rates considerably greater than those of thymol, no evidence of toxicity was manifested in 11 dogs. It is possible, therefore, that isothymol may compare favorably with other canine ascaricides and more extensive testing may show the drug to have particular value in the treatment of ascariasis in puppies.

Methyl chloroform as an anthelmintic. FRANK D. ENZIE, U. S. Bureau of Animal Industry.

Chlorinated hydrocarbons have attained considerable prominence as anthelmintics since the report of Bennett (1885, Med. Rec. N. Y. (776), 28: 319–320) on

the use of chloroform for the removal of tapeworms from man. The first report on the use of this compound against hookworms in dogs was apparently that of Schultz (1911), Jour. Amer. Med. Assoc. 57: 1102–1106), and, a few years later, Hall and Foster (1918, Jour. Agr. Research 12: 397–447), in critical tests, found the drug to be about 57 per cent effective against this parasite. After the significant report by Hall (1921, Jour. Agr. Research 21: 157–175) on the action of carbon tetrachloride as an anthelmintic, similar studies with related compounds by Hall and others resulted in the development of such well known anthelmintics as tetrachlorethylene (Hall and Shillinger, 1925, Amer. Jour. Trop. Med. 5: 229–237), hexachlorethane (Hall and Cram, 1925, Jour. Agr. Research 30: 949–953; Thienel, 1926,

TABLE 1.—*Data on anthelmintic tests with methyl chloroform in dogs*

Dog No.	Weight	Dose	Parasites			Efficacy
				Removed	Left	
	pounds	*cc.*				*per cent*
244	14.0	1.4	Hookworms	83	291	22
			Whipworms	0	3	0
245	17.5	3.5	Hookworms	103	147	41
			Whipworms	1	28	3
246	17.0	1.7	Ascarids	4	0	100
			Hookworms	173	31	85
			Whipworms	0	16	0
247	15.5	3.1	Ascarids	10	0	100
			Hookworms	97	18	84
			Whipworms	4	11	27
248	22.0	6.6	Hookworms	1963	0	100
249	24.5	9.8	Ascarids	10	0	100
			Hookworms	833	0	100
			Whipworms	0	41	0
250	13.0	5.2	Ascarids	5	0	100
			Hookworms	146	0	100
			Whipworms	17	1	94
251	16.0	8.0	Hookworms	778	0	100
253	15.0	4.5	Hookworms	7	0	100
254	11.5	3.5	Ascarids	25	0	100
			Hookworms	243	1	99
			Whipworms	0	37	0

München. Tierarztl. Wchnschr. 77: 771–772) and n-butyl chloride (Wright and Schaffer, 1932, Amer. Jour. Hyg. 16: 325–428).

Apparently the only published report[1] on the anthelmintic action of methyl chloroform is that of Mohler (1934, U. S. Dept. Agr., Bur. Anim. Indus., Rpt. Chief, p. 52). According to the latter report, the drug at a dose rate of 0.3 cc. per kilogram of body weight had an efficacy of 100 per cent for the removal of ascarids and 84 per cent for the removal of hookworms from dogs. There was no record of the number of animals or parasites involved and no statement regarding the toxicity of the drug. Jerstad (unpublished notes) tested the substance against ascarids, hookworms, and tapeworms of cats. At a dose rate of 0.3 cc. per pound of body weight, the drug removed 93 per cent (14) of 15 ascarids from 5 cats, both of 2 tapeworms

[1] In an additional report (Mohler, 1936, ibid., p. 59), noted too late for inclusion in the text, the drug was said to be effective against ascarids and hookworms of cats; no data were given.

from 2 cats, and 1 hookworm from 1 cat. Vomition occurred shortly after treatment in 4 of the 8 cats involved. The only significant pathology was gastritis in 2 of 4 cats that were given theobromine in capsules immediately after treatment.

In order to record additional critical data of the anthelmintic properties of chlorinated hydrocarbons, and, specifically, to provide a more complete record of the anthelmintic action of methyl chloroform, it seemed desirable to conduct a limited number of critical tests with the compound. Methyl chloroform is a clear, colorless liquid with a mild chloroform-like odor. It is insoluble in water and boils at 73 to 75° C.

MATERIALS AND METHODS

The tests were conducted at the station of the Zoological Division, U. S. Department of Agriculture Beltsville Research Center, Beltsville, Maryland. One to two days before treatment, the test animals were confined in individual cages and the feces screened daily in order to detect natural elimination of parasites. The kinds of parasites in each animal were determined by fecal examination prior to treatment. The drug was given in hard gelatin capsules after a fasting period of 18 to 24 hours; and 3 to 4 hours after treatment the test animals were returned to regular feed. The feces of each animal were collected individually every 24 hours and examined for parasites. After the elimination of parasites ceased, the test animals were submitted to necropsy and the entire gastrointestinal tract examined for parasites and lesions. Representative tissue sections were preserved in the event studies of histopathology become necessary.

RESULTS

The results obtained with dogs are shown in table 1. At dose rates of 0.1 to 0.5 cc. per pound of body weight, the compound removed 100 per cent of 54 ascarids from 5 dogs, 90 per cent (4426) of 4914 hookworms from 10 dogs, and 14 per cent (22) of 159 whipworms from 7 dogs. At a dose rate of 0.1 cc. per pound of body weight, it was completely effective against ascarids, but a minimum of 0.3 cc. per pound was required to achieve comparable action against hookworms. There was no significant anthelmintic action against whipworms at dose rates up to 0.5 cc. per pound of body weight. The drug was well tolerated at all dose rates, and no lesions were found at necropsy which could be attributed to the action of the drug.

Under similar conditions of testing, the drug failed to exhibit significant anthelmintic action in chickens. In the aggregate, doses of 1.0 to 3.0 cc. per bird removed 48 per cent (139) of 291 ascarids but none of 286 heterakids from 8 birds; a dose of 2.0 cc. was ineffective against 9 tapeworms in 1 bird.

SUMMARY

These limited tests indicate that methyl chloroform may compare favorably with other anthelmintics for dogs. A dose of 0.1 cc. per pound of body weight appeared to be adequate for the removal of ascarids, but a somewhat larger dose, 0.3 cc. per pound, was necessary to achieve complete success against hookworms. The drug was given in hard gelatin capsules after a fast of 18 to 24 hours, and feed was withheld for an additional 3 or 4 hours after treatment. The drug was well tolerated at dose rates varying from 0.1 to 0.5 cc. per pound of body weight, and it is possible that larger doses could be given with safety.

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