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I am submitting herewith a thesis written by Earl D. Brooks II entitled "A Comparison of Anthelmintics in Growing-Finishing Swine." I recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Animal Science.

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A COMPARISON OF ANTHELMINTICS IN GROWING-FINISHING SWINE

A Thesis

Presented for the

Master of Science

Degree

The University of Tennessee, Knoxville

Earl D. Brooks II

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ABSTRACT

Data were collected on twenty-four sows and litters from the October, 1978, farrowing at The University of Tennessee Agricultural Experiment Station (Blount Farm), Knoxville, Tennessee, to determine the effects of various anthelmintics (Atgard, Banminth, Tramisol) administered to pigs raised in confinement and on pasture.

At day 21 post farrowing, one-half of the sows and litters were moved to ½ acre lots on the pasture treatment and the sows and litters on the confinement treatment remained in the farrowing crates. All litters were weaned at 7 weeks of age. The pasture reared pigs remained on pasture and the confinement reared pigs were moved to a pole-type, confinement feeding barn. The pasture reared pigs were moved to the feeding barn at an average body weight of 75 pounds. All pigs were fed until they reached an average market weight of 230 pounds.

There was no measurable difference between treatments on weaning weights. However, a significant difference ($P < .05$) was observed in pig weaning weights due to location with pasture reared pigs weighing 31.52 vs. 25.88 pounds for pigs raised in confinement.

Pasture reared pigs gained more rapidly than the confinement reared pigs (1.50 vs. 1.43) but this was found to be non-significant. Treatment revealed no significant difference among weaning weights.

No significant differences were noted among treatments on final feed efficiency. However, pasture-reared pigs had a significantly ($P < .01$) lower feed efficiency than those raised in confinement (3.08 vs. 3.37).

Total worm egg counts were not significantly different among treatments. However, there were significantly ($P < .05$) more worm eggs in the pasture reared pigs, than in the confinement reared pigs.

Liver scores revealed no significant difference among treatments and location.

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CHAPTER I

INTRODUCTION

With the present trend toward more intensified swine production, much emphasis and concern has been placed on anthelmintics in swine herds. There are many of these products available to the producer with alternative methods of administration.

Tennessee swine producers lose approximately 3.25 million dollars each year to internal parasites (Hall, 1979). These losses are reflected by reduced growth and increased feed costs, increased severity of other diseases and the loss of edible pork due to a high percentage of condemned livers caused by scarring from roundworm migration.

There is a deficiency of available information with respect to anthelmintics now on the market for growing finishing swine. However, a great deal of research has been conducted using anthelmintics in sows. Generally, Tennessee swine producers are utilizing available research information. Additional information on anthelmintics in the area of growing finishing swine would add to the pool of knowledge already available through commercial routes.

The objectives of this study were to compare pigs raised in confinement and on pasture using Atgard, Tramisol, and Banminth wormers versus a control group. This was accomplished by comparing (a) feed consumption and average daily gain, (b) composite fecal samples taken

from each litter at various time intervals, and (c) liver abcesses from pigs were noted by random selection as they were slaughtered.

CHAPTER II

LITERATURE REVIEW

I. INCIDENCE OF INTERNAL PARASITES AND METHOD OF INFESTATION

Jaggers (1965) points out that there is a seasonal (high in autumn and winter and low in summer) and age variation in the incidence of lungworm infection. This, no doubt, accounts in part for the wide difference in incidence reported. Jaggers also concluded that pigs become immune to lungworms and their infection. Manifestations of immunity were the elimination of existing parasites and an absence of an increase in egg counts on reinfection. Spindler (1938) found that lungworm eggs are resistent to temperatures below the freezing point and larvae can survive in earthworms for at least five years. Pigs acquire lungworm infestation primarily by swallowing infected earthworms.

Natural lungworm infestations have been reported in pigs reared indoors with no access to soil containing earthworms according to Taffs (1967); however, until proven otherwise experimentally, the ingestion of earthworms should be regarded as the normal method of transmission. Other research by Taffs (1958) showed that lungworm infestations are unlikely to be a problem when pigs do not have access to pasture. A method of disinfection was suggested by Rose (1959) as (1) removal of feces, (2) scrubbing with hot water and soda,

(3) steam sterilization followed by disinfection overnight with boiling phenol or lysol solution, and (4) thorough drying.

An experiment conducted by Whittle-Stone (1957) showed that signs of lungworm infection were observed with greater frequency in pigs under six months of age. These signs involved coughing, dyspiroea as well as the general signs of helminthiasis. The necropsies revealed characteristic lesions of pale, raised, square or wedge-shaped areas of emphysema affecting the lobules, particularly those of the diaphragmatic lobe near the posterior tip and free border. Consolidated areas were found in the apical and cardiac lobes and in well-established infections, pulmonary nodules were present. Worms were found in the diaphragmatic lobe of the lung about one inch from the posterior tip.

There is no doubt that pigs develop an acquired immunity to lungworms. Dunn (1956) suggests that the older pig is more resistant, either because fewer larvae develop into adults, or because more adults are expelled, or for both reasons. Research by Kelley and Nayak (1964) showed that repeated infection confers a high degree of immunity to reinfection. Infections with Ascaris suum are more common in pigs under five months old and the number of ascarids at post-mortem may or may not bear a direct relationship to the extent of growth retardation. Routine worming does not always affect growth and feed consumption (Gotink, 1965). Underdahl and Kelley (1957) found that pigs infected with virus pneumonia two weeks after infection with lungworms develop pneumonia that is more severe and more extensive than the disease produced by either agent alone. Furthermore, pigs which were innoculated with virus pneumonia, while

Ascaris larvae are migrating through the lungs, exhibited lung consolidation ten times as extensive as that in pigs which received virus pneumonia only.

Taffs (1958) found pigs develop an acquired immunity to Ascaris infection. This is manifested by (1) a reduction or absence of clinical signs such as coughing and increase temperature and respiration, (2) an inhibition of larval growth and migration, (3) an increased cellular response with the immobilization and death of the larvae, and (4) following reinfection, a depression of the fecal egg count, an increase in the number of infertile eggs and the elimination of intestinal worms.

Roneus (1963) found at post-mortem examination that the liver may show "milk spot" lesions and small lymphoid nodules about 2 mm in diameter which may contain Ascarid larvae. Kelley et al. (1969) stated that damage to the liver and lungs of baby pigs during the migratory phase of infection with Ascaris suum is probably more harmful to the pig than the intestinal phase. It is thus more important to keep pigs from eating infective Ascaris eggs than it is to treat them to remove the parasite in the intestinal stage.

Research done by Batte et al. (1966) shows that swine may become infected with all common species of internal parasite larvae by three avenues: (1) ingestion of infective larvae, (2) penetration of broken skin (threadworm), and (3) by access to infected earthworms serving as transport hosts (lungworms). Regardless of the avenue of infection, the immature worm spends four to nine months in the liver.

Research by Taffs (1969) revealed looseness of the feces or feces containing specks of blood and mucus were produced in specific pathogen free (SPF) pigs infected with 30,000 Oesophagostomum (nodular worm) larvae. Short (1948) observed anorexia, constipation, sometimes diarrhea and emaciation in pigs often terminating in death due to infection of Oesophagstomum larvae.

Porter (1940) observed no difference in growth rates between pigs infected with Hyostrongylus rubidus (red stomach worm) and control pigs. At autopsy, the mucous membrane of the stomach may be covered with a thick layer of clear mucus, particularly in the fundic and pyloric regions, and widespread small ulcerations may cover the whole stomach lining (Shanks, 1965).

Powers et al. (1960) concluded from their studies that the whipworm is not a harmless commensal but rather a pathogen capable of causing severe damage. As in ascariasis, the frequency of infection with trichuris suis declines with increasing age. They found infections to be most numerous in animals eight to twenty-four weeks of age. In summary, they found trichuriasis to be an important infection in young swine and that the immunity shown by older pigs can mask the prevalence and perhaps the actual importance of the infections.

Batte et al. (1966) reported that immature stephanurus dentatus (kidney worm) spend four to nine months in the liver. Those not trapped by encapsulating tissue migrate to regions in the vicinity of the ureters. The long life span of this parasite is indicated by requiring nine to sixteen months to reach potency,

with infection persisting in a sow for at least twenty-four months. The infection results in verminous hepatic and pancreatic absesses, extensive fibrosis and marked eosinophilia.

II. ANTHELMINTICS AND MODE OF ACTION

Dichlorvos (Atgard) swine wormer is a highly effective anthelmintic recommended for the removal and control of the sexually mature (adult), sexually immature, and 4th stage larvae of the whipworm (Trichuris suis) nodular worms (Oesophagostumum), large roundworm (Ascaris suum), and the mature thick stomach worm (Ascarops strongylina) occurring in the lumen of the gastrointestinal tract of pigs, boars, and open or bred gilts and sows (Shell Chemical Division, 1977). The preparation is an uncoated, rice-shaped resin pellet, approximately 1/8 inch in length and 1/16 inch in diameter. The active ingredient of Atgard is dichlorvos (2,2-dichlorovinyl dimethyl phosphate). It is designed to be administered to swine in limited amounts in a meal-type ration. When used according to directions, the active ingredient's release rate is sufficient to provide for high anthelmintic efficiency but not of such magnitude as to exceed the degrading capacity of the pig.

According to Cyanamid (1974), lavamisole hydrochloride (Tramisol) has a broad spectrum control and is effective for worming of hogs of any age. It is available to administer by mixing in drinking water and by feed formulation. It is effective in killing mature roundworms, nodular worms, lungworms, intestinal threadworms as well as 75 to 85% of the whipworm population (Hall, 1979).

Hygromycin B (Hygromix) shuts off the egg producing ability of female worms and reduces the adult worm population by killing mature and immature worms (Elanco Products Company, 1976). It is effective in the control of whipworms, nodular worms and is 95 to 100% effective against ascarids (Hall, 1979). Hygromix (hygromycin B) is a continuous in-feed worm control program that should be discontinued 48 hours prior to slaughter. There is evidence that there may be a hearing impairment to some swine when fed hygromycin B over a period of time (Dunne and Leman, 1958). This is particularly unfortunate when it occurs in sows because it deprives them of reaction to their young pigs' needs.

Pyrantel tartate (Banminth) is also a continous in the feed wormer which stops roundworms in the small intestine before the damaging migration begins (Pfizer Agriculture Division, 1977). Pyrantel tartate (Banminth) is also used as a purge wormer and is effective in killing adult roundworms while preventing the establishment of nodular worm infections. It can be fed with Mecadox (carbadox) which is a chemotherapeutic agent that provides control and treatment of swine dysentery, and it also provides excellent control of bacterial swine enteritis (salmonellosis). Mecadox is an effective growth promotant for starting and growing pigs up to 75 pounds body weight. Banminth (pyrantel tartate) is recommended to be fed at 96 grams per ton and Mecadox (carbadox) is fed at 50 grams per ton.

Piperazine is a simple ring compound that can be administered to hogs by both water and feed. It is effective in removing both

roundworms and nodular worms by causing them to be flushed out in a paralyzed state (Dunn et al., 1958). Hall (1979) states that piperazine compounds are as high as 50% effective against nodular worm infestations. This group is the least toxic of the swine anthelmintics and is metabolized much faster. Piperazine compounds, fed wet or dry, are very palatable with a high percent efficacy. They can be given on a 1-day schedule and repeated if necessary.

Thiabendazole at 50 mg per kg body weight mixed in the feed has been recommended by Enigk and Flucke (1962) for killing threadworms in the intestines of pigs. In their experience egg counts dropped, and at necropsy no worms were found in the intestine. The compound seemed to have no ill effect on treated animals. Thiabendazole has been packaged in a paste form for oral dosing of baby pigs 1-8 weeks of age to provide ease of administration and good efficacy against Strongyloides ransomi adults.

Table 1 summarizes the discussed anthelmintics and their effectiveness.

III. PRESENT RESEARCH

Kelley (1969) used 43 gilts in his study to compare treated and untreated dams for parasitism. Treated gilts received hygromycin B for 48 days while the control gilts received the same ration without hygromycin B. The presence of worms in the pigs was determined by eggs per gram (E.P.G.) of feces and observable damage to the livers. The livers were evaluated by counting so called "ascarid scars." Livers having no scars received a 0; 1-5 scars received a 1; 6-10

TABLE 1

EIGHTEEN PERCENT CRUDE PROTEIN CREEP RATION

Worm Species	Piperazine	Levamisole	Dichlorvos	Pyrantel Tartate	Hygromycin B	Thiabendazole
Roundworms	75-100%	99-100%	99-100%	96-100%	95-100%	0%
Nodular worms	50	80-100	95-100	99-100	95-100	0
Whipworms	0	70-85	90-100	0	85-100	0
Lungworms	0	99-100	0	0	0	0
Threadworms	0	80-95	60-80	0	0	99-100

Data from The University of Tennessee Agricultural Extension Service. Publication 742.

scars received a 2; and more than 10 scars received a score of 3. At the end of the experiment, 48 out of 50 pigs from the untreated dams had Ascaris eggs whereas 43 out of 54 pigs of treated dams had Ascaris eggs as indicated by the E.P.G. There were no significant differences in the number of liver scars in pigs from treated and untreated dams.

Research by Alicata (1961) confirmed those of previous workers that prenatal infection with Ascaris suum is probably not a common occurrence in swine. The feeding of about 1,300,000 infective ascarid eggs to a sow over a period of five weeks and during the last third of her pregnancy produced no ill effect on the animal nor its offspring. After the sow farrowed, no lesions or ascarid larvae were noted in the liver, lungs, or intestinal tract of eight of the newborn pigs examined at necropsy from 1 to 48 hours after birth.

Olson and Gaafar (1963) studied the possibility of prenatal infection with Ascaris suum in swine using 16 sows and their 139 progeny. Sows were administered orally infective Ascaris eggs twice weekly throughout gestation. Pigs were necropsied at 3, 4, and 5 weeks of age and their gastrointestinal tracts were examined for ascarids. No larvae, immature or adult ascarids were recovered from any of these pigs indicating that intrauterine infection with this parasite is highly improbable in swine.

Jaggers and Herbert (1964) found their control pigs to be infected with lungworms after they were housed together with

experimentally-infected pigs. To account for these findings, they suggested three possibilities: (1) that infective larvae are retained in the stomachs of the experimentally-infected animals for some time after their introduction through the mouth, and are later regurgitated and made available to other animals; (2) that infective lungworm larvae are passed through the gut of the infected pigs and become available to other animals from the floors of the pens or in contaminated food and water; (3) that infective larvae having migrated to the lung of the host may then be passed to a second pig in saliva or sputum.

Betts (1954) examined the possibility that Ascaris lumbricoides could cause pneumonia in pigs. He gave six pigs, known to be free from virus pneumonia, 250,000-500,000 infective embryonated Ascaris eggs. Pigs were sacrificed at various intervals of time after dosing and although hemorrhages were abundant throughout the liver substance of the pigs sacrificed at 5, 7, and 10 days after infection, there was no sign of lobar pneumonia. In all six pigs, the main sight of damage was the liver.

Young et al. (1979) determined the effect of late gestation feeding of dichlorvos using 82 crossbred sows either non-parasitized, naturally infected with Ascaris suum, or artificially exposed to Oesophagostomum denatum. Each treated sow was given dichlorvos (4mg/kg body weight/day) from day 80 of gestation until parturition. Parasitism did not affect the number of piglets born alive, but sows treated with dichlorvos produced .5 more live pigs per litter ($P < .05$). The mean birth weight of piglets from dichlorvos treatment

sows was .06 kg heavier than that of controls ($P < .01$), while the litter birth weight was 1.3 kg heavier ($P < .01$). Individual pig weaning weight was not markedly affected by parasite infection of the dam. Treatment of the sows with dichlorvos increased the mean piglet weaning weight .5 kg over that of controls ($P < .05$). Dichlorvos treated sows weaned litters 9.1 kg heavier than controls ($P < .01$).

The effect of late gestation feeding of dichlorvos on individual birth weights, viability score for each pig, number of alive and dead pigs per litter and time interval between birth of pigs was conducted by Siers et al. (1976). He divided 100 lightly parasitized sows into 2 groups with treated sows receiving 1,000 mg dichlorvos from day 80 of gestation to parturition. One-half of the treated and control pigs were reared to market weight. The individual pig weights and the number alive per litter were recorded at 7, 14, 21, 60, 120, and 160 days of age. The dichlorvos treatment increased the number of live pigs born per litter and heavier litters at each observation time.

Ferguson (1966) conducted a study to determine the efficacy of broadspectrum anthelmintic, Atgard V, in removing Trichuris suis in swine. Eight Yorkshire pigs averaging six months of age were infected with whipworms. They were housed together and fed Atgard V mixed into 1 pound of the daily ration at a level of 40 mg/kg body weight. Within 24 hours after treatment, dead whipworms were observed in the feces. Four days after treatment an average of 50 dead whipworms per pig had been recovered. Whipworms were not recovered

from the cecum or large intestine of any of the eight pigs at necropsy. Loose stools were evidenced for 3 days following treatment and the resin pellets containing the drug were observed in the feces for 6 days.

Johnson et al. (1972) recommended levamisole to be an effective anthelmintic for swine at a dosage of 8 mg/kg of body weight. They used three experimental groups of pigs, one as an untreated control group, another as levamisole administered through the water, and a third as levamisole administered in the feed. Individual pig weights were obtained over the two-month post treatment trials at 28 and 56 days and fecal samples were taken 2 to 3 weeks following treatment. Treatment with levamisole caused a 95-99% reduction in fecal E.P.G. counts in all tests. Overall, treatment with levamisole resulted in an 11% increase in mean daily weight gains and a savings of 13-15% in feed required per pound of gain during the period.

Results of research conducted by Lindquist et al. (1971) found that egg counts were markedly decreased one week after pigs were treated with levamisole. Body weight gains of pigs administered levamisole in feed were significant at the 95% confidence level and gains of pigs administered levamisole in water were significant at the 90% level of confidence when compared to controls. Body weight gains between feed and water methods of treatment were not significant.

According to Wescott and Walker (1970) pyrantel tartate was efficacious against natural infections of adult ascaris but was not

efficacious against adult trichuris. Arakaua et al. (1971) found pyrantel tartate highly efficacious in removing established infections of Ascaris and Oesophagostomum. When pigs were treated at the rate of 22 mg/kg of body weight, more than 96% of all ascarids were expelled during the first 48 hours. The percentage of worms expelled after the start of treatment with 96 gm/ton of ration for 3 days was 94% after 48 hours and 99% after 72 hours. Over 98% of nodular worms were removed by treatment at 22 mg/kg body weight. The efficacy of pyrantel tartate was not affected by method of administration.

Substantially fewer liver lesions and larvae per gram of lung were observed among pigs given pyrantel tartate in research conducted by Conway and Arakau (1969). The dose response was greatest among pigs given pyrantel tartate at the rate of 13.7 mg/kg of body weight. Continuous administration of pyrantel tartate via the ration also provided a high degree of protection against Ascaris suum. Pigs fed the ration containing pyrantel tartate at the rate of 55.1 mg/kg of body weight manifested an optimum reduction in the number of Ascaris larvae per gram of lung and the number of liver lesions in 36 square centimeters. Pyrantel hydrochloride was similarly efficacious in reducing the number of migrating larvae of Ascaris suum. Both the number of liver lesions and the number of larvae per gram of lung were very low for pigs given pyrantel hydrochloride in the ration.

In a study reported by the National Hog Farmer (1978), either Banminth-Mecadox (pyrantel tartate-carbadox) or ASP-250 with no

wormer was fed to 59 pigs for 28 days in the same ration. Significant differences in pig performance were observed in the two trials. Wormed pigs gained 1.02 pounds per day and weighed 45.3 pounds at the end of the treatment period. Control pigs on the feed additive combination without wormer gained .88 pounds daily for a final weight of 41.7 pounds. The Banminth-Mecadox pigs were more efficient, converting feed at 1.88 pounds of feed per pound of gain as compared to 2.18 for the control group. The improved efficiency saved a substantial 7 pounds of feed per pig.

In another trial within that same two-year study, 64 pigs fed Banminth-Mecadox had a feed conversion of 1.88 pounds, while 64 pigs on Atgard and ASP-250 converted at 2.01 pounds of feed per pound of gain. Pigs on the Banminth program gained slightly faster, averaging .94 pounds per day than Atgard treated pigs which gained .88 pounds daily. Liver lesions were found in 9 of 24 sacrificed pigs fed the antibiotic alone. No lesions were found in wormed pigs. The second trial using the two wormers revealed liver damage to 16 of 26 pigs treated with Atgard and no damage to Banminth pigs. On the 28th day, 7 of 59 pigs not receiving a wormer had roundworms; otherwise, no eggs were detected.

An additional experiment comparing Banminth-Mecadox with Mecadox alone showed average daily gain and feed efficiency improved 2.9% and 7.7% respectively in the worming combination for pigs up to 40 pounds body weight.

According to Taffs (1969) helminths differ in size, structure, life history and effect on the host. The adult males and females

may be as long as 12 inches (Ascaris) or less than 10 mm. (Hyostrongylus). The immature or larval stages, which are barely visible to the naked eye, often cause damage by invasion of various organs and tissues of the pig. The adult female worms in the digestive tract or lung lay eggs which are then passed out with the feces on to the ground. The egg hatches to form a non-parasitic, free-living larva as in the case of the nodular and stomach worms, or a larva develops and remains within the egg as occurs with the large intestinal roundworm. In the case of the lungworm, the embryonated egg is ingested by an earthworm and the pig becomes infested by ingesting the larva or egg, which has reached the infective stage outside the host. The round, nodular, stomach, and whip worm has a direct life-cycle. The parasite is passed directly from one host to another without the development of a parasitic larval phase in another animal known as the intermediate host. The lungworm has an indirect life-cycle which has to be ingested by an earthworm, the intermediate host, before further development can occur. Pigs become infested with lungworms by ingesting infected earthworms.

CHAPTER III

EXPERIMENTAL PROCEDURE

I. MANAGEMENT

Twenty-four sows and litters were used from the October, 1978 farrowing at U. T. Blount Farm. The sows were divided into two groups and treated with Atgard (dichlorvos) 2 to 3 weeks prior to farrowing. Group I consisted of the confinement pigs and group II was the pasture reared pigs. Litters from both sow groups were further divided into four 6-litter groups that received either Atgard (dichlorvos), Banmith (pyrantel tartate), Tramisol (levamisole) or no anthelmintic treatment. The Atgard, Tramisol and control litters received Terramycin-50 antibiotic in their ration while Mecadox was fed in combination with the Banmith located litters.

All of group II litters were moved to the field at three weeks, weaned at seven weeks of age and fed until they reached 75 pounds body weight. They were then moved to the finishing barn and penned by litter with their respective treatment until market weight. All of the pigs were placed on an 18% crude protein ration (Table 2) at 3 weeks of age with 6 litters (3 in group I and 3 in group II) receiving Banmith-Mecadox continuously to 75 pounds body weight.

All of group I litters stayed in the farrowing house until weaning at seven weeks of age and were then moved to the finishing

TABLE 2

EIGHTEEN PERCENT CRUDE PROTEIN CREEP RATION

Ingredient	Pounds
No. 2 Yellow Corn	681
Soybean Oil Meal (44%)	200
Dehydrated Alfalfa Meal (17%)	100
Dicalcium Phosphate	10
Salt	5
Vitamin Premix[a]	8
Antibiotic[b]	1
Total	1005

[a]Provides an additional to the ration of 400,000 UPS units of vitamin A, 100,00 IC units of vitamin D-3, 500 IU of vitamin E, 400 mg of riboflavin, 1,000 mg of pantothenic acid, 1,500 mg of niacin, 1,500 mg of vitamin B-12, 100 mg of Vit K, and 20,000 mg of chlorine chloride.

[b]Contains 50 gms per pound of Oxytetracycline.

Note: Those pens on the Banmith-Mecadox treatment received 2.5 lbs of Mecadox and 1.0 lbs of Banmith additional to the above ration. Mecadox provides 10 gms per lb of Carbadox; Banmith provides 48 gms per lb of Pyrantel Tartate.

barn and fed until reaching an approximate market weight of 230 pounds. These pigs were fed the same as group II with all pigs receiving a 16% crude protein ration (Table 3) from 75 pounds body weight until they reached market weight.

Pigs on the Atgard and Tramisol treatments were purge wormed at weaning and at 14 weeks of age. Atgard was administered in the feed while those litters treated with Tramisol were orally drenched.

The sows were administered Atgard wormer in the gestation ration (Table 4). They were fed approximately 5 to 6 pounds of feed per day prior to farrowing.

Fecal samples were collected from each sow 12 to 24 hours after farrowing and one composite sample was taken from the pigs of each litter at 3, 5, 8, and 14 weeks of age. Samples were taken before the administering of anthelmintic in each case. The fecal samples were examined for the presence of worm eggs by the flotation technique according to Coffin (1953). This technique was accomplished by placing a 2 gram sample in the collection container and placing a plastic cylinder around it. The cylinder is then half filled with the flotation medium which was a sugar solution. The fecal matter is then stirred and a plastic cylinder around it. The cylinder is then half filled with the flotation medium. The fecal matter is then stirred and a plastic strainer is pushed down into the cylinder to force fecal debris to the bottom. Additional medium is added to form a convex meniscus permitting eggs to float through the strainer to the top. A microslide was then placed over the convex where it could contact the

TABLE 3

STANDARD U. T. 16% FINISHING RATION

Ingredient	Pounds
No. 2 Yellow Corn	760
Soybean Oil Meal (44%)	208
Dicalcium Phosphate	10
Limestone	10
Salt	5
Vitamin Premix[a]	6
Antibotic[b]	1
Total	1000

[a]Provides an addition to the ration of 400,000 USP units of vitamin A, 100,000 IC units of vitamin D-3, 500 IU of vitamin E, 400 mg of riboflavin, 1,000 mg of panthothenic acid, 1,500 mg of niacin, 1,500 mg of vitamin B-12, 100 mg of vitamin K and 20,000 mg of choline chloride.

[b]Contains 50 gm per pound of Oxytetracycline.

TABLE 4

U. T. 14% GESTATION RATION

Ingredient	Pounds
No. 2 Yellow Corn	728
Soybean Oil Meal (44%)	130
Dehydrated Alfalfa Meal (17%)	100
Wheat Bran	100
Limestone	10
Dicalcium Phosphate	20
Salt	5
Vitamin Premix[a]	10
Antibiotic[b]	2
Total	1,105

[a]Provides an addition to the ration of 400,000 USP units of vitamin A, 100,000 IC units of vitamin D-3, 500 IU of vitamin E, 400 mg of ribovlavin, 1,00 mg of pantothenic acid, 1,500 mg of niacin, 1,500 mg of vitamin B-12, 100 mg of vitamin D, and 20,000 mg of chlorine chloride.

[b]Contains 50 gm per pound of Oxytetracycline.

ova and be examined under a microscope approximately 10 minutes later for the presence of various ova and larvae.

All dead pigs were autopsied to note parasitic infestations and exact cause of death. A total of 48 hogs were randomly selected at slaughter (two pigs per litter) to observe and record liver and lung damage. The scoring system devised by Kelley (1969) was used to evaluate liver damage due to parasitic infestations. Livers having no scars received a score of 0; 1-5 scars received a 1; 6-10 scars received a 2; and more than 10 scars received a 3.

Pigs were weighed individually at 7, 10, 12, 14, 16, 18, 20, and 22 weeks of age. Pigs not off test at 22 weeks were weighed as needed at 24, 25, and 27 weeks of age. Feed efficiency (FE) and average daily gain (ADG) were computed at each weigh period.

The sows were washed and placed in farrowing crates about three days prior to farrowing. After farrowing each sow received 10 cc of penicillin for three successive days. If the baby pigs showed signs of starvation, ½ cc of oxytocin was administered twice daily to the sow until these signs were alleviated.

Within 24 hours of birth, needle teeth were clipped, birth weights recorded, and pigs were individually identified with ear-notches. The litters were evened up depending on the number of pigs farrowed per litter and the sow's ability to raise a certain number of pigs. Each sow had the opportunity to raise 9 to 10 pigs per litter. At day three, the pigs received intramuscular iron dextran injections. At 10 days of age, fresh dirt was placed

in the pens to aid in the prevention of anemia. All pigs were vaccinated for erysipelas and the male pigs were castrated at approximately four weeks of age.

II. FACILITIES

The farrowing barn employed the use of 24 farrowing crates that were 7 feet long and 6 feet wide with 2½ feet of ½ inch iron rod slats at the rear of the crate. The crates were 2 feet wide for the sow with an additional 2 feet on each side for the pigs. The slat openings were ½ inch behind the sows. An automatic waterer and feed bowl was located in front of the sow. A four-holed, 25-pound capacity, aluminum creep feeder was nailed to the side partition at the rear of the crate.

The crates were cleaned daily by manual labor to prevent manure buildup on the front concrete portion and rear slat portion. The waterers were cleaned once a week and heat was provided by heat lamps only. The farrowing house was ventilated by using a PVC pipe 6 inches in diameter with holes drilled every foot located beneath the rod slats to allow the fan to pull odor from the pit.

The pastures were ½ acre in size, sowed in fescue, red clover and some bermuda grass. Each sow and litter was assigned to a lot containing an open fronted house. The houses were 10 feet long and 9½ feet wide with concrete floors and walls. The houses were bedded with straw and a four-hole, 25-pound capacity, aluminum creep feeder was placed in one corner for the baby pig creep area behind a partition to keep the sows out. The sows were

feed on a 14 by 9½ foot concrete platform with an automatic float-type waterer at one end.

After weaning, the pigs from group II (pasture treatment) remained in these lots until they reached 75 pounds of body weight. Following weaning, they were fed from 300 pound capacity, three-holed Smidley feeders until moved to the finishing barn at 75 pounds of body weight. The litters from group II (confinement treatment) were moved to the finishing barn after weaning following a three-day adjustment period in the farrowing crate.

The pigs were fed in a pole-type barn open to the south side with the north side closed during the winter. The pens were 5 feet wide and 20 feet long with an automatic waterer in the south end and one, two-holed self feeder under the roof at the north end. The floor was solid concrete with a 2% slope to the outside gutter to provide drainage. The pens were scraped and cleaned daily with a 30-inch hand scraper. The panels between the pens were 1 inch by 6 inches oak boards on the upper half of the pens toward the feeder with aluminum slats used on the other half of the pens. A 3 to 5 inch opening between each board or slat allowed air to circulate. One litter was assigned per pen.

III. FEEDING

All sows were fed the gestation ration prior to farrowing (Table 4). The same ration plus 100 pounds of wheat bran was fed to the sows two weeks prior to and after farrowing. The wheat bran was added to give a laxative effect in order to help prevent MMA.

The sows were not fed 24 hours after farrowing to hold down stress from farrowing and to help prevent MMA. Sow's were started at 3 pounds of feed following farrowing and gradually increased over the next 10 days. At the end of that 10 day period they were receiving 3 pounds plus a pound for each pig they were nursing. Sows in both groups were hand fed the same ration twice daily.

At day 21 the baby pigs had access to an 18% crude protein creep ration described earlier in Table 2, page 19. At least three times a week feed was added to insure that the pigs had access to fresh feed at all times. The feeders were checked daily to remove manure and droppings from the feeders.

The pigs were fed the 18% crude protein creep ration until they reached a body weight of 75 pounds. They were then switched to the standard U.T. 16% ration (Table 3, page 21) for finishing to market weight. The pigs remained on this ration until the experiment was complete.

IV. STATISTICAL ANALYSIS

The experimental data were analyzed by Statistical Analysis System (SAS). Average daily gains, feed efficiency, mean weaning weights, total worm egg counts and liver scores were analyzed by an analysis of variance.

The following model was used to analyze the data on a litter basis (average daily gain, feed efficiency, mean weaning weights, egg worm counts, and liver scores).

$$Y_{ij} = u + t_i + l_j + l_{ij} + e_{ijk}$$

Where Y_{ij} is the mean average daily gain from weaning to market of the K-th litter in the ij-th subgroup,

u is Mu, the overall mean,

ti is treatment or effect of the i-th treatment,

lj is location or effect of the j-th location,

tl_{ij} is the effect of interaction specific to the ij-th subgroup,

e_{ijk} represents the deviation of the K-th litter in the ij-th subgroups.

CHAPTER IV

RESULTS AND DISCUSSION

I. EFFECT OF TREATMENT AND LOCATION ON WEANING WEIGHTS

All pigs were weaned at an average of 7 weeks of age with litters divided into two groups of twelve. Group II was moved to pasture when the pigs reached 3 weeks of age while the other litters remained in confinement. All pigs received the standard U.T. 18% creep ration (Table 2, page 19) with one treatment receiving Banminth-Mecadox in addition.

Treatment had no significant effect on pig weaning weight. However, location had a significant effect ($P < .05$) on weaning weights with pigs on pasture weaning at 31.52 lbs. vs. 25.88 lbs. for confinement reared pigs. These weights are comparable to Ligon (1975) whose pasture reared pigs were also significantly heavier than confinement reared pigs. The mean weaning weights by treatment and location are presented in Table 5. There were significant differences ($P < .05$) between control and Tramisol treatments with respect to location.

TABLE 5

MEAN PIG WEANING WEIGHTS BY
TREATMENT AND LOCATION

Treatment	Location	Mean Weaning Weight
Control	Pasture	33.82[a]
Control	Confinement	26.53
Banminth	Pasture	29.03
Banminth	Confinement	27.41
Atgard	Pasture	31.43
Atgard	Confinement	29.43
Tramisol	Pasture	31.73[a]
Tramisol	Confinement	20.15
Combined Pasture Weights		31.52[a]
Combined Confinement Weights		25.88

[a]Significant at the $P < .05$ level.

Note the differences between locations in the Tramisol and Control treatments.

II. EFFECT OF TREATMENT AND LOCATION ON POST-WEANING WEIGHTS AND GAINS

There was no significant difference in average daily gain due to treatment or location from weaning to market. However, the pasture reared pigs gained more rapidly than did the confinement reared pigs (1.50 lbs./pig/day vs. 1.43 lbs./pig/day).

Daniel (1967), Purdue University (1967), Wilson (1968), and Ligon (1975) are all in agreement with these results and state that pasture reared pigs gained significantly faster throughout their experiments. However, Danielson et al. (1969) and Wahlstrom et al. (1971) disagree with these findings as they found no consistent effect of gain between pasture and confinement reared pigs. Mean average daily gains from weaning to market are presented in Table 6.

III. EFFECT OF TREATMENT AND LOCATION ON FINAL FEED EFFICIENCY

Feed efficiency results (weaning to market) by treatment and location are presented in Table 7. Feed efficiency was calculated using the total feed consumed divided by the total pounds of live pork marketed minus the total pounds of pig weaned.

There were no significant differences among treatments on final feed efficiency. However, pasture reared pigs had a highly significant ($P < .01$) lower feed efficiency than those raised in confinement (3.08 lbs. of feed/lb. of pork marketed vs. 3.37 lbs.

TABLE 6

MEAN AVERAGE DAILY GAIN FROM WEANING TO MARKET
BY TREATMENT AND LOCATION

Treatment	Location	ADG
Control	Pasture	1.47
Control	Confinemnet	1.38
Banminth	Pasture	1.51
Banminth	Confinement	1.43
Atgard	Pasture	1.57
Atgard	Confinement	1.40
Tramisol	Pasture	1.45
Tramisol	Confinement	1.51

TABLE 7

MEAN FEED EFFICIENCY BY TREATMENT AND LOCATION

Treatment	Location	Feed Efficiency
Control	Pasture	2.96
Control	Confinement	3.43
Banminth	Pasture	3.17
Banminth	Confinement	3.24
Atgard	Pasture	3.10
Atgard	Confinement	3.63
Tramisol	Pasture	3.10
Tramisol	Confinement	3.17
Combined Pasture Feed Efficiency		3.08[a]
Combined Confinement Feed Efficiency		3.37

[a]Significant at the $P < .01$ level.

of feed/lb. of pork marketed). This is in agreement with Giesler (1961) and workers at Purdue University (1967) who found that growing-finishing hogs on pasture required less feed per pound of gain. It is difficult to compare present research with these findings because pigs in this experiment were brought into the finishing barn at 75 pounds of body weight. However, Danielson et al. (1969) found no significant difference in feed conversion of growing-finishing hogs on pasture and in confinement.

IV. EFFECT OF TREATMENT AND LOCATION ON TOTAL WORM EGG COUNT AND LIVER SCORE

No significant differences were found among treatments on total worm egg counts. This may be due to the fact that worm eggs were only found in the feces at the 14-week collection, therefore making the results small and undetectable for effects. However, there was a significant difference ($P < .05$) between locations with confinement reared pigs having fewer worm egg counts than pasture reared pigs (1.92/litter vs. 3.43/litter). Although various species of worm eggs were found in the samples, Taffs (1967) stated that pasture reared pigs had access to the ingestion of earthworms which is regarded as the normal method of transmission of lungworms. Also, Rose (1959) stated that lungworm infestations are unlikely to be a problem when pigs do not have access to pasture.

Treatment and location showed no significant difference when comparing liver scores (Table 10, Appendix). This also

may be due to the small number of pigs sampled. Kelley (1969), whose scoring system was employed in this experiment, found no significant difference in the number of liver scars in pigs of treated and untreated dams. In the present work, all sows were wormed and pigs were treated differently making it difficult to compare this work with that of Kelley.

V. A FEW OBSERVATIONS AND EXPLANATIONS

In taking an overall look at this experiment, there were contrasting differences. There were no significant differences among treatments in the traits measured; however, location showed significant differences in pig weaning weights, feed efficiency and total worm egg counts. The pasture reared pigs outperformed the confinement reared pigs but contained more worm eggs as was expected. The performance of the pasture reared pigs is supported by the work of Ligon (1975), Daniel (1967), Purdue University (1967), and Wilson (1968) although none of these workers were concerned with internal parasites as a part of their research.

One possible explanation as to why there were no significant differences in average daily gain may be due to differences in space allottments within the pens (range of 9.5 sq. ft./pig to 23.8 sq. ft./pig). Heitman et al. (1961) found that pigs gained significantly faster ($P < .01$) when allowed 20 square feet of space versus only 5 or 10 square feet of floor space. Noland et al. (1959) stated that pigs furnished 16 square feet of floor

space per pig gained significantly faster ($P < .01$) than those provided only 8 square feet per pig.

Finding no significant difference among treatments on the traits measured, perhaps the best deduction from this trial would be the reinforcement of present recommendations on worming of sows prior to farrowing to keep down worm eggs and their transmission. The possibility also exists that there was not a high degree of parasite infection in the lots where pasture reared pigs were raised. There was also a variation in the general performance of both confinement and pasture reared pigs. Siers et al. (1976) made similar observations as pigs from sows wormed prior to farrowing weighed heavier than those from sows not wormed. This is also in agreement with Young et al. (1979) who stated that dichlorvos treated sows weaned significantly ($P < .01$) heavier litters and at a heavier average weight than the control group.

CHAPTER V

SUMMARY

Data were collected on twenty-four sows and litters from the October, 1978, farrowing at The University of Tennessee Agricultural Experiment Station (Blount Farm), Knoxville, Tennessee to determine the effects of various anthelmintics (Atgard, Banminth, Tramisol) administered to pigs raised in confinement and on pasture.

At day 21 post farrowing, one-half of the sows and litters were moved to ½ acre lots on the pasture treatment and the sows and litters on the confinement treatment remained in the farrowing crates. All litters were weaned at 7 weeks of age. The pasture reared pigs remained on pasture and the confinement reared pigs were moved to a pole-type, confinement-feeding barn. The pasture reared pigs were moved to the feeding barn at an average body weight of 75 pounds. All pigs were fed until they reached an average market weight of 230 pounds.

There was no measurable difference between treatments on weaning weights. However, a significant difference ($P < .05$) was observed in pig weaning weights due to location with pasture reared pigs weighing 31.52 vs. 25.88 pounds for pigs raised in confinement.

Pasture reared pigs gained more rapidly than the confinement

reared pigs (1.50 vs. 1.43) but this was found to be non-significant. Treatment revealed no significant difference among weaning weights.

No significant differences were noted among treatments on final feed efficiency. However, pasture-reared pigs had a significantly ($P < .01$) lower feed efficiency than those raised in confinement (3.08 vs. 3.37).

Total worm egg counts were not significantly different among treatments. However, there were significantly ($P < .05$) more worm eggs in the pasture reared pigs, than in the confinement reared pigs.

Liver scores revealed no significant difference among treatments and location.

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APPENDIX

TABLE 8

MEAN FINAL WEIGHTS, WEANING WEIGHT,
AND WEANING AGE

Pen	Treatment	Location	Final Wt.	Wean Wt.	Wean Age
1	Banminth	Confinement	224.7	31.7	49.9
2	Atgard	Confinement	223.4	26.7	50.0
3	Control	Confinement	235.0	33.4	50.0
4	Banminth	Confinement	237.4	31.0	49.0
5	Control	Confinement	206.4	24.0	50.0
6	Banminth	Confinement	216.6	21.7	50.0
7	Control	Confinement	206.6	23.5	49.0
8	Atgard	Confinement	212.0	29.3	51.0
9	Tramisol	Confinement	216.0	19.3	50.0
10	Atgard	Confinement	247.1	33.1	52.0
11	Tramisol	Confinement	219.3	28	50.0
12	Tramisol	Confinement	220.0	21.2	49.0
13	Tramisol	Pasture	231.3	29.4	51.0
14	Tramisol	Pasture	237.9	36.8	52.5
15	Banminth	Pasture	231.8	30.2	50.0
16	Banminth	Pasture	247.4	33.2	51.0
17	Control	Pasture	233.2	31.2	49.7
18	Atgard	Pasture	231.7	23.0	50.0
19	Tramisol	Pasture	225.0	30.9	49.0
20	Control	Pasture	218.2	33.8	46.0
21	Control	Pasture	223.9	34.9	52.1
22	Atgard	Pasture	232.7	36.7	51.0
23	Banminth	Pasture	230.4	22.8	41.0
24	Atgard	Pasture	212.4	32.0	46.0

TABLE 9

TOTAL FEED CONSUMED, FEED EFFICIENCY, AND AVERAGE DAILY GAIN FROM WEANING TO MARKET

Pen	Treatment	Location	Total Feed Consumed (lbs.)	Feed Eff.	(Wean -Mkt) ADG
1	Banminth	Confinement	5791	3.33	1.54
2	Atgard	Confinement	5596	4.06	1.35
3	Control	Confinement	5316	3.29	1.61
4	Banminth	Confinement	5581	3.00	1.40
5	Control	Confinement	3258	3.57	1.26
6	Banminth	Confinement	6584	3.38	1.33
7	Control	Confinement	6262	3.42	1.25
8	Atgard	Confinement	5160	3.53	1.38
9	Tramisol	Confinement	2617	3.16	1.42
10	Atgard	Confinement	4923	3.29	1.47
11	Tramisol	Confinement	5358	3.11	1.53
12	Tramisol	Confinement	3876	3.24	1.59
13	Tramisol	Pasture	5000	3.10	1.42
14	Tramisol	Pasture	5180	3.21	1.41
15	Banminth	Pasture	5951	3.28	1.56
16	Banminth	Pasture	3517	3.28	1.50
17	Control	Pasture	3495	2.88	1.48
18	Atgard	Pasture	3906	3.12	1.47
19	Tramisol	Pasture	5199	2.98	1.52
20	Control	Pasture	2716	2.95	1.44
21	Control	Pasture	5202	3.06	1.48
22	Atgard	Pasture	3689	3.17	1.83
23	Banminth	Pasture	4882	2.94	1.46
24	Atgard	Pasture	3837	3.03	1.41

TABLE 10

TABLE OF LIVER SCORES BY TREATMENT AND LOCATION

Liver Scores	Control	Banminth	Atgard	Tramisol
		Confinement		
0	4	1	2	1
1	2	3	2	3
2	0	0	2	2
3	0	2	0	0
Totals	6	6	6	6
		Pasture		
0	1	1	0	1
1	2	5	2	3
2	1	0	1	2
3	2	0	3	0
Totals	6	6	6	6

Liver scores based on following system:

0 = 0 liver scars
1 = 1-5 liver scars
2 = 6-10 liver scars
3 = > 10 liver scars and majority were condemned

TABLE 11

TOTAL WORM EGG COUNTS PER LITTER BY TREATMENT AND LOCATION AT 14-WEEKS

Pen	Treatment	Location	Total Eggs
1	Banminth	Confinement	5
2	Atgard	Confinement	0
3	Control	Confinement	1
4	Banminth	Confinement	2
5	Control	Confinement	0
6	Banminth	Confinement	2
7	Control	Confinement	2
8	Atgard	Confinement	1
9	Tramisol	Confinement	1
10	Atgard	Confinement	4
11	Tramisol	Confinement	2
12	Tramisol	Confinement	3
13	Tramisol	Pasture	4
14	Tramisol	Pasture	2
15	Banminth	Pasture	2
16	Banminth	Pasture	3
17	Control	Pasture	3
18	Atgard	Pasture	4
19	Tramisol	Pasture	1
20	Control	Pasture	7
21	Control	Pasture	2
22	Atgard	Pasture	4
23	Banminth	Pasture	4
24	Atgard	Pasture	5

TABLE 12

DEATHS OF PIGS DURING EXPERIMENT WITH
CAUSES AND WEIGHTS

Pen	Pig No.	Treatment	Location	Cause of Death	Last Wt. Taken (lbs.)
2	81-1	Atgard	Confinement	Hiatal hernia	106
5	92-1	Control	Confinement	Peritonitis	90
13	89-9	Tramisol	Pasture	Low grade toxin (due to pine tar)	24
16	91-6	Banminth-Mecadox	Pasture	Peritonitis	112
23	99-6	Banminth-Mecadox	Pasture	Pneumonia (lung-worms present)	124

VITA

Earl D. Brooks II was born in Pineville, Kentucky, on January 11, 1956, to Mr. and Mrs. Earl D. Brooks. He was reared in Claiborne County, Tennessee, and attended Ellen Myers School in Harrogate, Tennessee. He was graduated from Powell Valley High School in Speedwell, Tennessee, in May of 1974.

In September, 1974, he entered The University of Tennessee at Knoxville and received a Bachelor of Science degree in Animal Science in June of 1977.

Following graduation, he entered the Graduate School of The University of Tennessee serving as swine and sheep herdsman at U. T. Blount Farm.

He received the Master of Science degree in Animal Science in August, 1979.