A SURVEY OF HELMINTHS AND COCCIDIA OF SWINE IN NORTHEASTERN KANSAS

by

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CHAPTER I.

INTRODUCTION

The swine industry is an important part of Kansas' agriculture. It is expected that Kansas' share of U.S. pork production, which was 2.9 percent in 1968, will increase to 4 percent by 1980, Anon. (1970).

In terms of total Kansas swine production, the growth is forecast to be from 611,000,000 pounds in 1968, to 1,044,000,000 pounds in 1980, Buller et al. (1971). While production of the industry is increasing and has been over the last few years, very little is known about the prevalence of swine parasitism in feeder pigs.

The trend in swine production in Kansas is believed to be toward larger swine enterprises and a narrower margin of profit. As numbers increase in a unit, and profit narrows, the economic effects of clinical, and particular subclinical parasitisms become more important. Such losses have been estimated in the past by Spindler (1956). Confinement feeding, on concrete, of home raised or purchased feeder pigs has become a specialty with some farmers. The benefits of concrete per se in this method of raising swine in preventing parasitism has been seriously questioned, Todd (1960).

It is quite obvious, however, that the majority of swine in Kansas are raised in the general manner as they have been for many years. These herds have been referred to as "conventional." Such herds, usually with less than 10 sows, are farrowed one or more times a year in a central farrowing house. The pigs are with the sows until weaning time, usually

5-8 weeks, at which time the breeding stock is separated from the growing pigs. The pigs are on pasture during the pasture season, at least they are turned out in a lot and are confined during their finishing period. The finishing diet is corn primarily, balanced with protein concentrates containing the remaining essential ingredients and water. The breeding stock is on pasture following weaning, and during the gestation period.

In pigs raised on slatted or on concrete floors, the possibility of infection with swine parasites having intermediate hosts would be minimized. Metastrongylus requires earthworms to complete its life cycle. Earthworms which existed 4 years in an abandoned hog lot in Maryland were reported to be infectious, Spindler (1937). Normally, earthworms would not be found on slatted floors or in enclosed buildings with concrete floors.

The spirurids, Ascarops and Physocephalus, have an indirect life cycle involving several species of beetles, Stewart and Kent (1963). These authors reported 9 of 12 species of beetles, found in hog pastures in southern Georgia contained larvae of spirurids. Without doubt, infected beetles could have found their way into most of the swine facilities in these studies, to become potential sources of infection.

Manure is the principal source of infective eggs and larvae and must be removed from pig pens at frequent intervals. If such infectious material is allowed to accumulate, the probability of host infection would be understood to increase. The newer systems of management, namely use of concrete floors or slatted floors, should reduce time and labor required to remove manure and make it easier to raise large numbers of pigs without associated increase in parasitism.

Because of the changes occurring in Kansas agriculture, more information is needed on swine parasitism, particularly in the newer areas of swine production. Extension specialists, working with the researcher in the development of future parasite control programs, will find this present information useful in determining deficiencies in present management and disease prevention recommendations.

The purpose of this survey was to determine the prevalence of parasitism in samples of Kansas swine and to make observations on certain management practices as they relate to swine parasitism.

CHAPTER II.

REVIEW OF LITERATURE

Ransom and Foster (1920) found that 41 percent of the swine intestines collected from slaughter-houses in Chicago contained Ascaris. These swine ranged in age from one month to four years of age.

Spindler (1934) established the prevalence of worm parasites in southeastern swine. Three-hundred and forty-eight gastrointestinal tracts and lungs were examined. The animals examined ranged from 4 months to several years, the majority being six to 12 months old. Seventy-four percent of these animals were infected with Ascaris.

Andrews and Connelly (1945) examined the viscera of 129 Georgia hogs for worm parasites. These hogs weighed an average of 225 pounds and had been maintained under conditions of moderate sanitation. Sixty-eight percent of the animals harbored Ascaris.

Using the fecal smear technique, Allen and Jones (1949) found that 35 percent of 180 to 225 pound hogs packed in Chicago were infected with Ascaris.

According to Spindler (1947), the number of Ascaris harbored bears a direct relationship to retardation of growth in the pig. He stated that 109 Ascaris are sufficient to destroy the health of the pig and that 20 to 39 Ascaris will decrease the rate of growth to approximately one-half that of noninfected pigs. He was also of the opinion that mature Ascaris as well as the migrating larvae exerted an adverse effect on the health of the animals. Wood et al. (1963a,b) confirmed the adverse effects of ascarid larvae and adults in pigs even when they were fed an adequate diet.

In his 1934 survey, Spindler found 26 percent of southeastern swine infected with the intestinal threadworm, Strongyloides ransomi. Pigs with pure infections of the threadworm had mild to severe symptoms, and some died. Spindler (1944) reported that the threadworm is pathogenic to sows. Leland and Cox (1963) stated that Strongyloides ransomi is associated with considerable mortality or morbidity in young pigs.

Sullivan and Shaw (1953) reported that death occurs in pigs harboring heavy, pure infections of lungworms. In pigs moderately and heavily infected with lungworm, the utilization of feed was less efficient than in non-infected pigs. No difference was observed in the carcasses of these two groups.

Porter (1939) examined 1,467 swine stomachs selected at random from a southern Georgia packing plant. 41 percent were infected with the red stomach worm, Hyostrongylus rubidus. He later described (1940) the gastric ulcers it caused as one result of experimental infection. The ulcers healed 85 days after infection.

Porter (ibid.) noted that 89.2 percent of the swine examined were infected with spirurid stomach worms (Physocephalus sexalatus and Ascarops strongylina). Foster (1912) stated that these worms caused considerable gastric disturbances.

Spindler (1933) in a survey of 367 southern swine found 98 percent of the animals infected with the nodular worm, Oesophagostomum longicaudum and 81 percent with O. dentatum.

Spindler (1951) reported on the damaging effects of mixed roundworm infections. The mixed infections were composed of Ascaris, Trichuris, lungworms, and stomach worms. He found a marked difference in weight between pigs kept comparatively free of parasites and those which were moderately to heavily infected.

Goldsby and Todd (1957) reported helminth infections in Wisconsin market-weight swine based upon abbatoir collections made in 1955-56. The percentage of swine infected with Ascaris was 65.4 percent, spirurids 36 percent, Strongyloides 14 percent, nodular worms 77 percent.

Powers et al. (1959) found the prevalence of Trichuris in young swine in Wisconsin to be 75.5 percent.

Ames et al. (1973) detected Strongyloides ransomi in 9.1 percent of 493 litters in Missouri in 1970-71.

There is less known about the coccidia of swine than about the coccidia of any other species of domestic animal. Coccidiosis is a serious disease of poultry, lambs and calves; however, knowledge of the prevalence, life cycles, pathogenicity, species and economic importance of coccidia in swine is so scant that it is impossible to assess their role in swine production.

Hagen and Bruner (1961) and Levine (1961) reported seven species of coccidia. Vetterling (1965) reported the species in six localities in the United States to be Eimeria neodebliecki, E. scabra, E. suis, E. perminuta, E. debliecki, E. porci, E. cerdonis, E. spinosa, and Isospora suis.

In the Wisconsin survey conducted by Powers, et al. (1959), oocysts were found in 62.8 percent of 199 swine, ranging in age from 8 weeks to adult breeding stock.

Eimeria spinosa has been found in Georgia, Maryland, Michigan, California, and Hawaii, according to Andrews and Spindler (1952). Novicky (1945) found that 27.4 percent of 62 pigs surveyed in Venezuela were infected with *E. debliecki*.

Eight species of *Eimeria* and one species of *Isospora* are known to exist in the United States, Vetterling (ibid.). Prevalence studies in foreign countries were reported by Levine (1961) and Vetterling (1965).

The relative use of sanitary procedures and success in swine raising, as measured by mortality, morbidity, weight gains, and length of time in preparation for market, have been the basis of many of the early field observations on parasitism, Anon. (1926), Robbins (1926), Gibson (1931), Spindler (1933, 1937). The relationship between parasitism and sanitary practices, which involve different kinds of swine raising facilities was partially described by Hall (1964).

Ransom (1918) summarized the facts, known at that time, concerning *Ascaris*, including investigations conducted by scientists in various countries of the world. As a result, a system of swine sanitation was devised to protect pigs from parasite infections during the first few weeks of life.

The plan was tried in McLean County, Illinois, beginning in the spring of 1920. The field trial lasted six years and data on 6,204 sows and 39,855 pigs were accumulated. Each year records were kept. The results of this survey were reported by Raffensperger and Connelly (1927).

The successful management procedures in the McLean County System have been basic in many subsequent parasite control recommendations, Ransom (1927), Burch (1930), Schwartz (1936, 1952), Kingscote (1952), Spindler (1953), Kelly, Olsen, and Howe (1958), Anon. (1963).

CHAPTER III.

MATERIALS AND METHODS

1. Source of pigs

To determine the prevalence of the helminth parasites and coccidia of swine, 324 fecal samples were obtained from pigs 6 weeks to 6 months old in five counties in the northeastern quarter of Kansas, Figure 1. These were 1.) Riley County, 2.) Geary County, 3.) Wabaunsee County, 4.) Pottawatomie County and 5.) Doniphan County. Most of the samples came from Riley and Geary Counties. The age, location, breed, whether "Specific-Pathogen-Free," and type of habitat, i.e., concrete or pasture, of each herd was recorded. Also, the use and kind of anthelmintic was noted. The samples were collected from March to September, 1973. Approximately 10 percent of the pigs on each farm were sampled.

2. Methods of collection

Fecal samples were collected as fresh as possible from the ground. The collections were placed in paper cups, labeled immediately and brought back to laboratory for study. As far as possible, the material was examined in a fresh state. When this was not possible, the material was stored in a refrigerator at 4°C until studied.

3. Laboratory examination

Upon receipt at the laboratory, five gram samples were weighed from each cup. The fecal material was then diluted to 50 ml with tap water and placed in fecal jars. A magnesium sulfate salt flotation method was

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Figure 1

Location of the Five Kansas Counties Sampled in the Swine Parasite Survey

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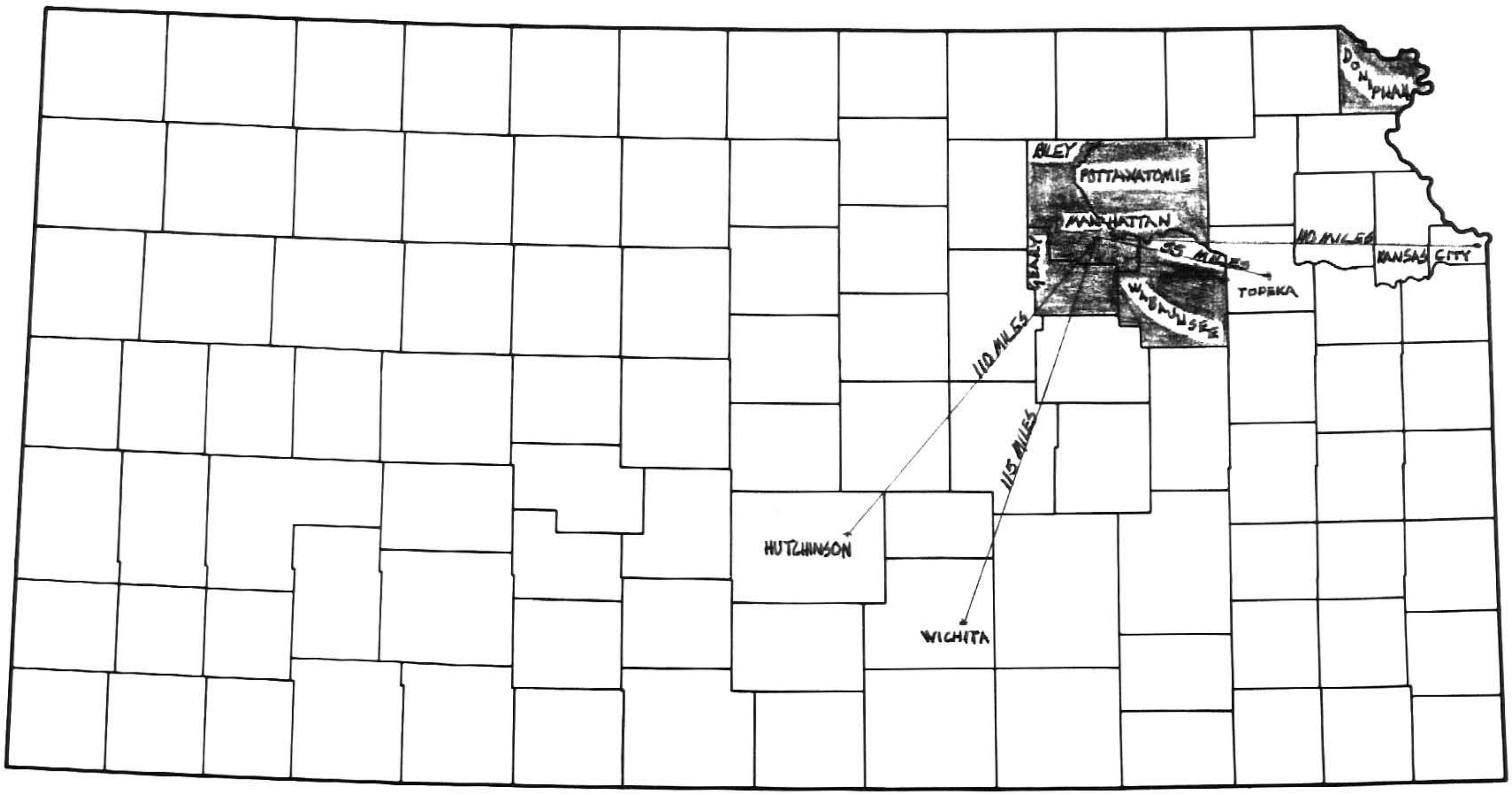
STATE OF KANSAS



used, Bello (1961). One ml of each homogenized sample was removed from each fecal jar and placed in a centrifuge tube. The tube was then filled to the top with magnesium sulfate solution. At this point an 18 mm cover-slip was placed on the top of the ground lip of the centrifuge tube and centrifuged for two minutes at 1000 RPM. Identification was made for each sample under categories of Ascaris, Trichuris, Metastrongylus and coccidia. The morphological characteristics of the helminth eggs with the exception of the strongyles, permitted separation of the genera. Strongyles may have included eggs of Hyostrongylus and Oesophagostomum, which appear similar.

Records were made of management practices and of the use and kind of anthelmintics at the time the samples were taken.

Fecal samples containing coccidial oocysts were placed in Petri dishes with 2.5 percent potassium dichromate and allowed to sporulate at room temperature. Sporulated oocysts were examined for morphologic characteristics and measurements were made. The oocysts were classified according to shape of oocysts, color, length, width, length-width ratio, surface characteristics, wall surface and thickness, presence of a micropyle, polar granule and residium. The sporocysts were measured for length, width, length-width ratio and checked for the presence of a residium and a stieda body.

All measurements were performed using ocular micrometer units and converting the final figures to microns.

Morphological details were examined using a 100X acromat oil immersion objective on an American Optical Co. Microstar microscope. An American Optical Co. Filar Micrometer Eye-piece was used for the measurements.

Vetterling (1965) was used as a guide for identifying the coccidia and the International Code of Zoological Nomenclature adopted by the XV International Congress of Zoology was followed, Stoll et al. (1961).

CHAPTER IV.

RESULTS

Two sets of data were gained from the survey: (1) Identification of nematode eggs and coccidial oocysts and (2) Percentages of nematode eggs and coccidial oocysts for 324 fecal samples from 33 swine-herds.

A record of parasites from each herd by species was recorded by herds and by individual pigs, (Tables 1 and 2). Pigs younger than 6 weeks old were not included in this survey.

The extent of parasitism among the 33 herds varied considerably, as did the number of infected pigs found in each herd.

In the 33 herds of swine tested, only 3 herds were not passing nematode eggs or coccidial oocysts. Of the 324 fecal samples examined during the survey, nematode eggs were detected in 88 percent of the swine and coccidial oocysts in 24.7 percent.

Ascaris proved to be the most prevalent nematode discovered during the survey, giving an infection rate of 41 percent for the 324 fecal samples.

Approximately 25 percent of the pigs were infected with *Trichuris*, 8 percent with strongyles, and 3 percent with *Metastrongylus*.

There were 17 percent with *Ascaris* only, 5 percent with *Trichuris* only, 4 percent with strongyles only, and 63 percent with two or more species of parasites. There were no pigs with *Metastrongylus* only.

Table 1. Percentages of Parasites by Species

Ascaris	41
Trichuris	25
Metastrongylus	3
strongyles	8
coccidia	25

Records for fecals from each herd (Table 2) showed 3 herds without nematode eggs or coccidial cocysts. Two herds had *Ascaris* only, 1 herd had strongyles only, 1 herd had *Trichuris* only, 25 herds had 2 or more types, and none had *Metastrongylus* only.

Table 2. Number of Each Species of Parasite Per Herd

Herds without parasites	3
Ascaris only	2
Trichuris only	1
strongyles only	1
coccidia only	1
Herds with two or more types	25

Data on the records of fecal samples for each farm are contained in Table 3.

Table 3. Record of Fecal Exams from Each Farm

Farm	Sample*	Ascaris**	Trichuris**	Metastrongylus**	Strongyles**	Coccidia**
1	10/230	1/10	0/10	0/10	1/10	2/10
2	10/120	10/10	8/10	0/10	0/10	1/10
3	10/40	5/10	1/10	0/10	0/10	1/10
4	10/100	0/10	0/10	0/10	4/10	0/10
5	10/50	8/10	1/10	0/10	0/10	0/10
6	10/100	1/10	1/10	3/10	0/10	8/10
7	10/24	1/10	5/10	0/10	0/10	10/10
8	10/100	9/10	10/10	0/10	1/10	8/10
9	10/170	3/10	0/10	0/10	0/10	8/10
10	10/120	9/10	2/10	0/10	0/10	0/10
11	10/200	9/10	2/10	0/10	0/10	5/10
12	10/60	9/10	0/10	2/10	0/10	9/10
13	10/130	0/10	2/10	0/10	0/10	7/10
14	10/300	8/10	2/10	1/10	2/10	3/10
15	10/240	0/10	0/10	0/10	0/10	0/10
16	10/100	2/10	0/10	0/10	1/10	1/10
17	10/200	0/10	0/10	0/10	0/10	0/10
18	10/150	4/10	0/10	0/10	0/10	0/10
19	10/360	2/10	0/10	0/10	0/10	0/10
20	10/100	10/10	6/10	0/10	0/10	0/10
21	10/160	10/10	7/10	0/10	0/10	0/10

Table 3. (continued)

Farm	Sample*	Ascaris**	Trichuris**	Metastrongylus**	Strongyles**	Coccidia**
22	10/100	0/10	4/10	0/10	0/10	0/10
23	4/?	2/4	4/4	1/4	0/4	0/4
24	10/50	1/10	3/10	2/10	3/10	1/10
25	10/150	4/10	2/10	0/10	0/10	1/10
26	10/75	7/10	3/10	2/10	0/10	1/10
27	10/40	0/10	0/10	0/10	0/10	0/10
28	10/90	4/10	3/10	1/10	1/10	2/10
29	10/300	0/10	0/10	0/10	0/10	10/10
30	10/10	0/10	0/10	0/10	4/10	2/10
31	10/40	0/10	6/10	0/10	4/10	0/10
32	10/30	9/10	6/10	0/10	4/10	1/10
33	10/74	8/10	3/10	0/10	4/10	0/10

*Numerator = number of swine from which fecal samples were collected; denominator = total number of swine.

**Numerator = number samples in which parasites were found; denominator = total of samples.

Of the 33 herds tested, 2 herds were being raised on concrete, 4 herds on wooden slats and the remaining 27 herds on pasture. Only 2 of the herds were being raised as "Specific-Pathogen-Free Swine." The owners of 19 of the herds claimed to have used some type of anthelmintic recently.

The prevalence of coccidia from 10 positive fecal samples is arranged according to the species of coccidia, Table 3. The species found were *Eimeria debliecki*, 20 percent; *E. scabra*, 60 percent; *E. suis*, 50 percent; *E. perminuta*, 10 percent; *E. debliecki*, 50 percent; *E. porci*, 20 percent; *E. cerdonis*, 30 percent; and *Isospora suis*, 10 percent.

Table 4. Species of Coccidia in 10 Samples

Sample	*E. debliecki*	*E. suis*	*E. scabra*	*E. perminuta*	*E. neo-debliecki*	*E. porci*	*E. cerdonis*	*I. suis*
1	+	+	+		+		+	
2		+	+		+			
3						+		
4		+	+					
5	+				+		+	
6		+	+	+				
7								+
8	+					+		
9			+		+		+	
10		+	+		+			

Time did not permit the identification of coccidia from every sample of every herd.

The management practices of the herds were compared with the McLean County System of Swine Sanitation, Raffensperger and Connelly (1927). Proper preparation of farrowing facilities was generally practiced. Only one herdsman made an attempt to clean the gilts or sows before farrowing. Most confined the females with their litters to avoid contamination of lots and pastures, but none of them hauled the litters to clean pastures. None of the herds were kept on permanent pastures, but most had access to old hog lots.

No attempt was made to remove the manure or pigs from an area after deworming and in no case was an anthelmintic used more than once.

CHAPTER V.

DISCUSSION

In spite of the injuriousness of parasites, swine raisers often take little note of them and apparently fail to recognize their importance. This indifference may stem in part from the fact that in the past there has been available relatively little quantitative information as to the extent which parasites can inhibit the growth of pigs. In addition, it is a fact, well recognized by parasitologists, that in sublethal infections the effects of parasites may not become apparent for some time, and in many cases, may not be recognized at all since, generally, all or nearly all of the animals in a herd are likely to be parasitized at one time, and the element of contrast is, therefore, lacking. Consequently, since parasitic diseases unlike bacterial and virus diseases, are usually of an insidious nature, the pigs being neither sick nor well, parasitism may be overlooked as a cause of unthriftiness. It is only when the concentration of infective stages in the environment becomes so great that fatal infections occur that parasitism becomes apparent to the casual observer.

Almost invariably pigs are exposed to repeated contacts with the infective stages of at least some of the parasites that infect swine. On most farms, the hog lots, farrowing houses, barns and pastures, through long continued use by swine afflicted with varying degrees of parasitism, have become seeded with the infective or transmitting stages of parasites. The extent to which contamination can occur is illustrated by the fact that literally thousands of parasite eggs and larvae have been recovered from as little as an ounce of soil collected from a permanent hog lot. Eggs of ascarids, lungworms and thorn-headed worms are capable of surviving on soil for long periods of time, Spindler et al. (1940), Lindquist (1959). As a result of this longevity, a cumulative action occurs when the soil is repeatedly contaminated with the droppings of animals harboring these parasites, and the longer the contamination continues, the greater is the concentration of the eggs that will ultimately result, within certain limits, at least.

It is practically inevitable, therefore, that pigs farrowed and raised on premises in constant use for swine will swallow each day numerous eggs of ascarids and whipworms, larvae of nodular worms, kidney worms and red stomach worms, and the larval stages of lungworms, spirurid stomach worms, and thorn-head worms. These larval stages are contained in the bodies of various arthropod and annelid intermediate hosts, of which pigs are fond. That parasites may be acquired by pigs early in life is shown by the fact that experimental litters farrowed and kept in filthy hog lots acquired infections of various parasites as soon as two days after birth, Spindler (1937). Prenatal infections in swine have been demonstrated by Enigk (1952), Stewart and Kent (1963) and Batte et al. (1966).

Every parasite that becomes established in the body of a young pig takes its toll on the health and vitality of its host.

In spite of the insidious and little recognized nature of parasites, losses by them may constitute the difference between profitable and unprofitable swine production. When it is necessary, because of parasites, to extend the feeding period of a herd of pigs as much as five weeks to bring the animals to a satisfactory market weight, or when losses of as much as 50 pounds in some animals is sustained because of parasites, the situation becomes serious. Such losses are a high price to pay for harboring pests which can be controlled, at least partially.

In spite of the development of higher standards of pig raising, only 3 of the herds in the survey sample were without any parasites.

The percentage of swine infected with Ascaris was placed at 41 percent in 1920 by Ransom and Foster; Spindler (1934), 74 percent; Andrews and Connelly (1945), 68 percent; Goldsby and Todd (1957), 49.5 percent. The current survey disclosed that 41 percent of Kansas swine examined were infected with Ascaris.

Porter (1939) in a survey of southern swine revealed a 25 percent infection with Strongyloides. Goldsby and Todd (1957) found approximately 14 percent of Wisconsin swine infected and Ames et al. (1973) in a Missouri survey found 9.1 percent. The present survey in Kansas revealed no Strongyloides in the area sampled.

Powers et al. (1959) in a study of Wisconsin farms found the prevalence of Trichuris in young swine to be 75.5 percent. The survey in Kansas revealed a prevalence of 25 percent.

Since the eggs of Hyostrongylus cannot be differentiated from those of the more prolific Oesophagostomum spp., the survey in Kansas lists only strongyles. Spindler (1933) disclosed that 98 percent of southern swine were infected with nodular worms. The Wisconsin survey, Goldsby and Todd (1957) revealed a 77 percent infection. Porter (1939) reported that 41 percent of southern swine were infected with Hyostrongylus and Goldsby and Todd (1957) reported 45.9 percent. The current survey reveals only an 8 percent prevalence of strongyles.

The prevalence of lungworms has been reported as 69 percent in southern swine, Spindler (1934, 1956); 31 percent in Michigan swine, Morgan and Hawkins (1949); 66 percent in Wisconsin, Goldsby and Todd (1957); 51.9 percent in Oregon swine, Sullivan and Shaw (1953) and 17.6 percent in Wisconsin, Powers et al. (1959). The present survey in Kansas showed a 3 percent prevalence.

The prevalence of swine coccidia has ranged from 2 to 100 percent, Vetterling (1965). The present survey shows a 25 percent prevalence. The prevalence of swine coccidia by species was not attempted. Identification of species from 10 animals was recorded. Since the number of swine used for identification was small, this does not preclude the presence of other species. The species identified were Eimeria debliecki, E. suis, E. scabra, E. perminuta, E. neodebliecki, E. porci, E. cerdonis and Isospora suis.

The pigs raised on slatted floors had little or no coccidiosis. Assuming that all coccidial life cycles are direct, and that these infections are self limiting and no reinfection occurs, this system of management appears to be beneficial to their control.

It should be pointed out that worm counts conducted by Goldsby and Todd (Ibid.) were a much more accurate method of determining parasitism than those used in this survey. Metastrongylus, for example, could be more accurately determined by lung examination than by looking for eggs in feces, because of the normal habitat of this parasite.

Management Practices

The recommendations of the McLean County system for swine disease prevention were followed closely only by one of the herdsmen in this survey. These recommendations require considerable labor on the part of the herd owner and labor was generally reserved for other farm work. There was general apathy toward this kind of work even when time and labor were available. Even with the SPF herds, greater emphasis was placed on the mechanical cleaning of the farrowing quarters than was placed on sow preparation. These observations may have been the result of the false sense of security which the swinesmen felt in owning "disease-free" swine.

None of the herdsmen subscribed to the importance of using sanitary practices, as they used old hog lots which probably were the sources of the parasitism found in these herds. The infectivity of these previously contaminated pastures was never considered by the owners.

Some type of anthelmintic was used in 19 of the herds. Deworming the breeding stock while it was held on hog lots and feeding floors was not regarded as an improper procedure. The treatments were administered without consideration of reinfection by contamination of the premises.

More emphasis should be placed on the need for repeated use of anthelmintics in a parasite control program. There were no herds in which deworming was repeated as recommended, Soulsby (1969). The tendency was to associate deworming with vaccinations and spraying for external parasites. These procedures were performed shortly before or after weaning. No special attempt was made to prevent reinfection by removing manure. Future success in parasite control recommendations must depend on better use of both sanitary measures and anthelmintics, as was pointed out by Todd (1955, 1957, 1960).

A comparison of the Kansas study with some of the previous studies is summarized in Table 5.

Table 5. Prevalence of Parasites Determined by Some Investigators

Locality	Author	Method of Collection	Ascaris	Trichuris	Strongyloides	Strongyles	Spirurids	Metastrongylus	Coccidia
Ill.	Ransom and Foster 1920	Viscera	41%						
Ga. and Fla.	Spindler 1933	Viscera				O. longicaudum 98% O. dentatum 81%			
	______ 1934	Viscera						69%	
	______ 1956	Viscera						69%	
Ga.	Porter 1939	Viscera (stomach)				H. rubidus 41%	Physocephalus and Ascarops 89.2%		
Ga.	Andrews and Connelly 1945	Viscera	68%						
Ill.	Allen and Jones 1949	Fecal smear	35%						
Mich.	Morgan and Hawkins 1949	Viscera (lungs)						31%	

Table 5. (continued)

Locality	Author	Method of Collection	*Ascaris*	*Trichuris*	*Strongyloides*	Strongyles	Spirurids	*Meta strongylus*	Coccidia
Ore.	Sullivan and Shaw 1953	Viscera (lungs)						51.9%	
Wis.	Goldsby and Todd 1957	Viscera	65.4%	13.9%	14%	*Oesoph.* 77%	36%	66%	
Wis.	Powers et al. 1949	Viscera	75.5%					17.6%	27.4%
Mo.	Ames et al 1973	Fecal flot.			9.1%				
Kan.	Byrd 1973	Fecal flot.	41%	25%		8%		3%	25%*

*Coccidia identified as *Eimeria deblieki*, *E. suis*, *E. scabra*, *E. perminuta*, *E. neodeblieki*, *E. porci*, *E. cerdonis*, and *Isospora suis*

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LITERATURE CITED

Allen, R. W. and Jones, L. D. 1949. The incidence of ascarids (Ascaris lumbricoides) in midwestern swine. Proc. Helminth. Soc. Wash. 16, 108-112.

Ames, E. R., Wescott, R. B. and Chang, J. 1973. Strongyloides ransomi infection in baby pigs in Missouri. J.A.V.M.A. 163, 161-162.

Andrews, J. S. and Connelly, J. W. 1945. Worm parasites in swine raised under a moderate degree of sanitation. Proc. Helminth. Soc. Wash. 12, 1.

_______ and Spindler, L. A. 1952. Eimeria spinosa recovered from swine raised in Maryland and Georgia. Proc. Helminth. Soc. Wash. 19, 1.

Anonymous. 1926. Swine sanitation. Vet. Med. 21, (abstract), 501.

Anonymous. 1963. Tooling up for swine production. Univ. of Wisc. Ext. Serv. Pub. P. 3.

Anonymous. 1970. Pork production on a business basis. Kansas State Univ. Ext. Serv. Pub. P. 3.

Batte, E. G., Moncol, D. J., and Barber, C. W. 1966. Prenatal infection with swine kidney worm (Stephanurus dentatus) and associated lesions, J.A.V.M.A. 149, 758-764.

Bello, T. R. 1961. Comparison of the flotation of Metastrongylus and Ascaris eggs in 3 different levitation solutions. Am. J. Vet. Res. 22, 597-600.

Buller, O. H., Koudele, J. W., Richards, J. A. and Orazem, F. 1971. Kansas State Univ. Ext. Serv. Pub. P. 46.

Burch, J. W. 1930. The Missouri plan for growing thrifty pigs. Mo. Univ. Agric. Coll. Circular 259.

Enigk, K. 1952. Zur biologie von Strongyloides ztschr. Tropenmed. U. Parasitol., 3, 358-368.

Foster, W. D. 1912. The roundworms of domestic swine, with special reference to two species parasitic in the stomach. Bull. 158, U.S. Department of Agriculture.

Gibson, J. E. 1931. Swine sanitation plan results in more pigs per sow. The Yearbook Agric. 1931. U.S. Dept. Agr., Washington, D. C. 503-505.

Goldsby, A. E., and Todd, A. C. 1957. Helminth infections in Wisconsin swine. North Am. Vet. 38, 101-104.

Hagen, W. A. and Bruner, D. W. 1961. The infectious diseases of domestic animals with special reference to etiology, diagnosis, and biologic therapy. Comstock Pub. Assoc., Ithaca, N.Y., 640 pp.

Hall, R. E. 1964. Management systems and their relationship to swine parasitism in Wisconsin. Thesis, Univ. Wisconsin.

Kelly, G. W., Olsen, L. S., and Howe, E. C. 1958. Control of the large roundworms in swine. Univ. of Nebr. Ext. Circ. (E.C. 1902).

Kingscote, A. A. 1952. Internal parasites of swine. Ontario Dept. Agric. Circ. 161.

Leland, S. E. Jr., and Cox, D. D. 1963. Control of _Strongyloides_ in swine. Ann. Report Florida Exp. Sta., 188-189.

Levine, N. D. 1961. Protozoan parasites of domestic animals and man. Burgess Publ. Co., Minneapolis, Minn. 412 pp.

Lindquist, W. D. 1959. Diseases of swine. Chapter 28. Nematodes, acanthocephalids, trematodes, and cestodes. Iowa State University Press, Ames. 419-444.

Morgan, B. B. and Hawkins, P. 1949. Veterinary helminthology. Burgess Publishing Co., Minneapolis, Minn. 400 pp.

Novicky, R. 1945. Swine coccidiosis in Venezuela. J.A.V.M.A. 107, 400-403.

Porter, D. A. 1939. Effectiveness of the swine sanitation system in controlling swine stomach worms in the south. Proc. Helminth. Soc. Wash. 6, 21.

Porter, D. A. 1940. Experimental infections of swine with the red stomach worm, _Hyostrongylus rubidus_. Proc. Helminthol. Soc. Wash. 7, 20-27.

Powers, K. G., Todd, A. C., and Goldsby, A. I. 1959. Swine whipworms in Wisconsin. Vet. Med. 54, 396-397.

Raffensperger, H. B. and Connelly, J. W. 1927. The swine sanitation system as developed by the bureau of animal industry in McLean Co., Ill. U.S. Dept. Agric. Tech. Bul. 44, 20 pp.

Ransom, B. G. 1918. Worms in pigs. U.S. Dêpt. Agric., Weekly Newsletter 5, 5.

_______ and Foster, W. D. 1920. Observations on the life history of _Ascaris lumbricoides_. U.S. Dept. Agric. Bul. 817, 47 pp.

______. 1927. The prevention of roundworms in pigs. U.S. Dept. Agric. Leaflet 6, 8 pp.

Robbins, E. T. 1926. Cheaper and more profitable pork through swine sanitation. A review of the McLean Co. system of swine sanitation on Illinois farms. 1925. Ill. Agric. Exp. Sta. Circ. 306, 16 pp.

Schwartz, B. 1936. Controlling lungworms of swine. U.S. Dept. Agric. Leaflet 118.

______. 1952. Internal parasites of swine. U.S. Dept. Agric. Bul. 1787.

Soulsby, E. J. L. 1969. Helminths, arthropods and protozoa of domesticated animals (Monnig). Williams and Wilkins, Baltimore, Md. 824 pp.

Spindler, L. A. 1933. Field studies of the larvae of nodular worms of swine with suggestions for control. North Am. Vet. 14, 37-44.

______. 1934. The incidence of worm parasites in swine in the southern United States. Proc. Helminth. Soc. Wash. 1, 40-42.

______. 1937. Infestation of suckling pigs with helminth parasites under conditions of constant exposure to infection. Proc. Helminth. Soc. Wash. 4, 62-63.

______. 1940. Effect of tropical sunlight on eggs of Ascaris suis, the large intestinal roundworm of swine. J. Parasitol. 26, 323-331.

______. 1942. Keeping livestock healthy. The Yearbook Agric. (1942). U.S. Dept. Agric., Washington, D. C.

______, Hill, C. H., and Zimmerman, H. E. 1943. The pathogenicity of S. ransomi, the intestinal threadworm of pigs. North Am. Vet. 24, 475-486.

______. 1944. Further observations on the pathogenicity of S. ransomi to swine. Proc. Helminth. Soc. Wash. 11, 12-13.

______. 1947. The effect of experimental infections with ascarids on the growth of pigs. Proc. Helminth. Soc. Wash. 16, 108-112.

______. 1951. Effects of parasites on growth of pigs. Vet. Med. 46, 421-427.

______. 1953. Prevention of roundworms in pigs. U.S. Dept. Agric. Leaflet 5, 8 pp.

______. 1956. The large intestinal roundworm. U.S. Dept. Agric., The Yearbook Agric. (1956). Separate 2718, 350-352.

Stewart, T. B. and Kent, K. M. 1963. Beetles serving as intermediate hosts of swine nematodes in southern Georgia. J. Parasitol. 49 (1), 158-159.

Stewart, T. B., Smith, W. N. and Jones, D. T. 1963. Prenatal infection of pigs with the intestinal threadworm, Strongyloides ransomi. J. Parasitol. 49 suppl., 45.

Sullivan, J. F. and Shaw, J. N. 1953. Incidence and effect of lungworms in Oregon swine. Oregon Agric. Sta. Tech. Bul. 28, 3-11.

Stoll, N. R., Dolfus, R. P., Forest, J., Riley, N. D., Sabrosky, C. W., Wright, C. W., and Melville, R. V. 1961. International code of zoological nomenclature adopted by the XV international congress of zoology. International Trust for Zoological Nomenclature. London. 176 pp.

Todd, A. C. 1955. Parasite control programs in preventive medicine. Proc. A.V.M.A. 92nd Annual Meet. (1955), 131-133.

______. 1957. The swine parasite problem, the helminths. Proc. U.S. Livestock San. Assoc. 61st Annual Meet. (1957), 284-286.

______. 1960. Control of internal parasites of swine. Vet. Med. 67, 71.

Vetterling, J. M. 1965. (Protozoa: Eimeriidae) of swine. Diss., Univ. Illinois.

______. 1966. Prevalence of coccidia in swine from six localities in the U.S. Cornell Vet. 56. (2) 155-166.

Wood, I. B., Berger, H., and Pankavich. 1963. (a) Weight gains and feed efficiency of swine experimentally infected with Ascaris suum. J. Parasitol. 49, 45.

______. 1963. (b) Effect of Ascaris suum adults on pigs. J. Parasitol. 49, 45.

A SURVEY OF HELMINTHS AND COCCIDIA OF SWINE
IN NORTHEASTERN KANSAS

by

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A survey was conducted in five counties in the northeast quarter of Kansas to determine the prevalence of helminth parasites and coccidia in swine. 324 fecal samples were obtained from 33 swine-herds. The samples were collected from pigs 6 weeks to 6 months old. Records of parasites, sanitation practices, anthelmintics and habitat were kept. The extent of parasitism among the 33 herds varied considerably as did the number of infected pigs found in each herd. *Ascaris* was the most prevalent nematode in the survey with an infection rate of 41 percent. 25 percent of the pigs were infected with *Trichuris*, 8 percent with strongyles, 3 percent with *Metastrongylus*, and 25 percent with coccidia. In spite of the development of higher standards of pig raising, only 3 of the herds in the area surveyed were without any parasites. The survey points out the fact that for a more profitable pig raising operation, such guides as the McLean County Swine Sanitation System must be adhered to.