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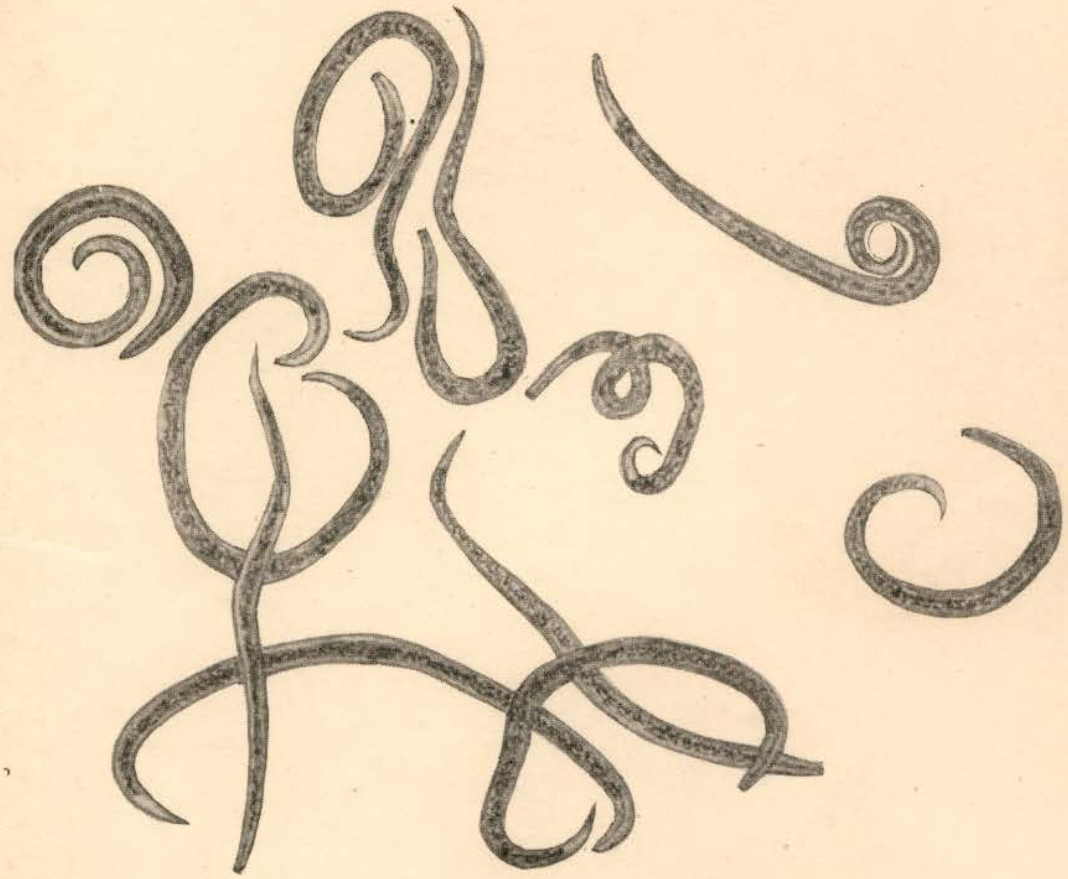

Ascaris larvae as seen in the lungs of an artificially infected pig. Enlarged 55 times.

THE UNIVERSITY OF NEBRASKA
COLLEGE OF AGRICULTURE
EXPERIMENT STATION
LINCOLN

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The Common Intestinal Roundworm of Swine

(Ascaris lumbricoides)

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The large intestinal roundworm of pigs is a very common parasite, and is probably present in every hog raising district of Nebraska. Until the last few years the true nature of this parasite was unknown. Little did we realize the actual harm done by this worm; but through the scientific investigations of Stewart, Ransom, and others we now know that this parasite causes heavier losses to the breeder and feeder of swine than any other now common in Nebraska.

Before the work by Stewart (1916-1918), it was considered an established fact that this worm had a direct life history, that is, that the eggs were passed in the feces of the host (pig or man), and after they developed to the infectious stage (with a small worm within the shell) were swallowed by a suitable host (pig or man), and upon reaching the intestine emerged from the shell and there developed to maturity.

Stewart's work, however, showed that the life history is not so simple as was generally supposed. He made the discovery that if rats and mice are fed eggs that have developed to the infectious stage the eggs will hatch out in the intestine and the larvae will migrate out of the alimentary tract and travel to the liver and lungs by the blood stream, undergoing considerable development in the meantime.

He further observed that the larvae do not remain in the lungs but migrate up the trachea and can be found in the mouth, and upon this observation suggested that the saliva containing the larvae might probably contaminate food eaten by human beings or pigs and in this way act as an intermediate host. It was later observed by Stewart that the larvae pass up the trachea and down the esophagus into the intes-

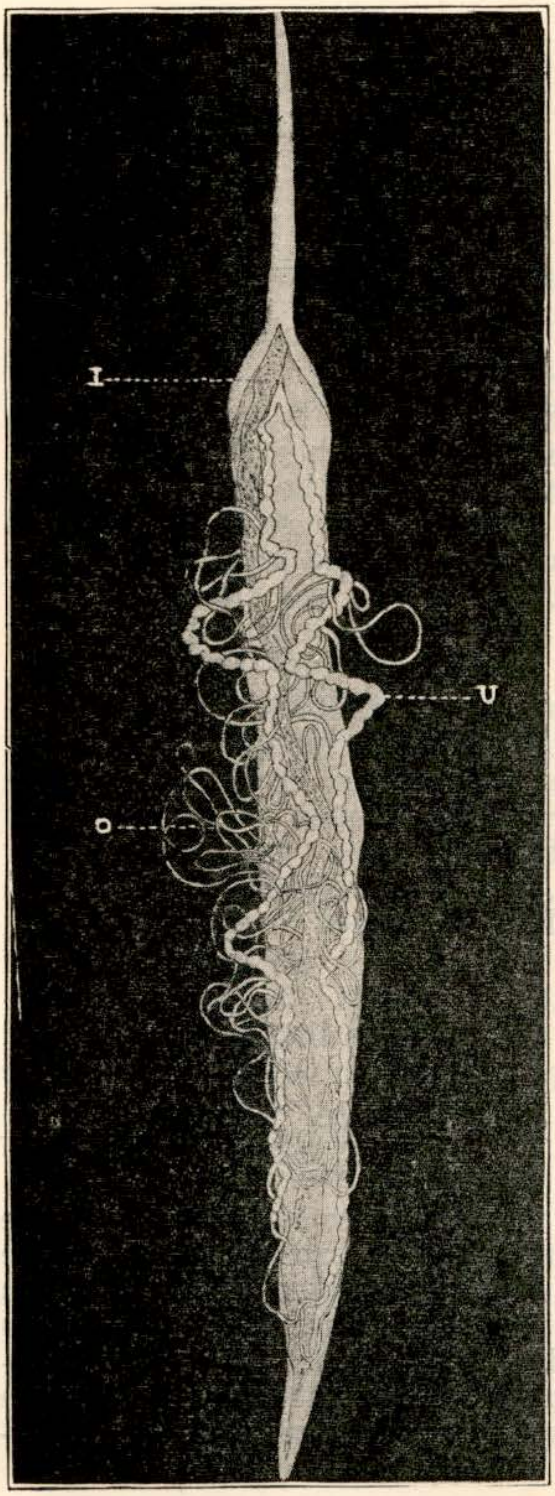

Fig. 1.—Female Ascaris dissected. Half natural size. I, intestine; U, uterus; O, ovary.

tine, ultimately passing out of the intestine in the droppings without undergoing any material changes in size or structure.

Similar experiments conducted by Stewart on pigs failed to reveal definite proof that these animals become infested by swallowing Ascaris eggs. He therefore offered the theory that rats and mice act as intermediate hosts in the life cycle by contaminating food eaten by human beings and pigs with the droppings containing larvæ that have passed thru the lungs and back into the intestine.

The more recent work of Ransom and his associates does not confirm Stewart's theory that rats and mice act as intermediate hosts in the life cycle of this parasite. They have presented evidence that this parasite undergoes its complete life cycle within a suitable host, such as the pig and presumably man. Their investigations also show that the Ascaris larvæ migrate through the lungs in guinea pigs, rabbits, sheep, and goats as well as rats and mice.

DESCRIPTION OF THE ADULT WORM

The coloring in the fresh condition is reddish-yellow or grayish-yellow; the body is elongated and spindle-

shaped. The male measures from 6 to 12.5 inches in length and about ⅛ of an inch thick; the posterior end is conical, bent hooklike. The internal organs consist of (1) the male genital organs (the much-folded, threadlike structure, the testicle; and the white, elongated, cone-shaped body, the seminal vesicle) and (2) the intestine, which, due to its contents, is of a yellowish-brown color and extends almost the entire length of the body. The female measures from 5 to 19 inches in length, and about ⅕ of an inch thick; the posterior end is conical and straight.

The internal organs of the female consist of the reproductive organs (the much-folded, threadlike structure, the ovaries; and the uterus or egg sac, a white structure which divides into two branches that extend throughout the greater part of the posterior two-thirds of the body) and an intestine which is similar to that of the male.

It has been estimated that one full-grown female worm in the intestine of a hog may produce as many as 80,000,000 eggs.

DESCRIPTION OF THE EGG OR OVUM

The egg is small, oval in shape, with a very thick, transparent shell and an external albuminous coating which is very irregular in outline. The eggs are 50 to 75 microns long and 40 to 58 microns wide.

Abnormal or unfertilized eggs also occur. They are distinguished by their elongated ovoid form (80 x 45 microns). The shell is very thin and smooth as compared with the fertilized ones, and their contents consist of a granular mass filling the entire shell.

Eggs deposited by the female in the intestine of the host are in an early stage of segmentation. Segmentation progresses during the passage of eggs through the intestine to a certain point, and if the eggs are not promptly eliminated from the intestine of the host segmentation ceases and development of the embryo does not continue. Because of the inhibitory effect of the body temperature, it is necessary that the eggs pass out of the intestine of the host to develop to their infectious stage. Development of eggs outside the animal body is chiefly influenced by temperature, moisture, and oxygen supply. At low temperature, development is very slow, and if low enough it discontinues entirely, so the time required for full formation of the embryo may be from a few days to months or even years.

A. Martin (1913) found the optimum temperature for development of the Ascaris eggs to be about 33° C. Ransom found that a considerable number of Ascaris eggs kept at this temperature would contain fully developed embryos at the end of ten days, and that practically all complete their development within a month. The author has found that a considerable number of eggs incubated at room temperature (21° C.) contained fully developed embryos at the end of fourteen days and that nearly all were completed within two months.

In the absence of moisture, development is inhibited and extreme dryness may destroy the eggs entirely. The moisture required is very little. Ross in 1916 found that Ascaris eggs placed on glass slides and left exposed to the sun in India for six weeks contained actively motile embryos at the end of that time. It is certain that under most climatic conditions there is sufficient moisture in the soil or wherever the eggs are dropped when eliminated from the host to enable them to develop at least intermittently and perhaps continually.

The eggs will resist freezing and may retain their viability after being in the soil (Nebraska) over winter.

Ascaris eggs are extremely resistant to chemicals and are not killed by the ordinary disinfectants. The author found that they will live in 2 per cent formaldehyde (5 parts of 40 per cent formaldehyde gas in water as obtained in commerce and 95 parts of water) for 22 months and probably longer. The eggs are also quite resistant to the ordinary chemicals. Yoshido found eggs to live in 1 per cent corrosive sublimate, 1.5 per cent nitric acid, 10 per cent iron sulfate (copperas),

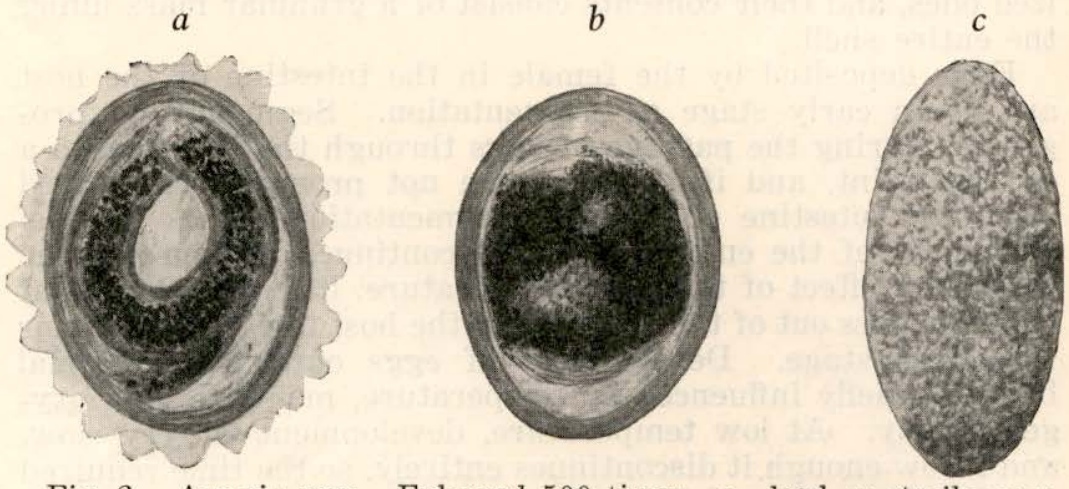

Fig. 2.—Ascaris eggs. Enlarged 500 times. a, dead or sterile egg; b, egg taken freshly from the uterus; c, ripe, infective egg with embryo ready to invade the pig.

0.5 per cent potassium permanganate, 10 per cent formalin, and 10 per cent hydrochloric (muriatic) acid for a considerable time.

AVENUE OF INFECTION

The common entrance of infection under natural conditions is undoubtedly by the swallowing of eggs containing fully developed embryos. The possibility of natural infection in other ways can not be excluded entirely. Ransom has shown that when Ascaris eggs containing fully developed embryos are injected under the skin they will hatch within a few days and that the larvæ will later appear in the lungs, reaching the same stage of development that they would in a similar time if the eggs were swallowed.

HATCHING OF ASCARIS EGGS

When the Ascaris eggs containing fully developed embryos are swallowed, they pass through the stomach unhatched (although hatching in the stomach may sometimes occur) and pass on to the small intestine, where they begin to hatch within a few hours after the eggs are swallowed. The eggshell is not digested by the digestive juices, but the embryo is released by a split in the shell, through which it emerges by its own efforts.

The eggs may hatch not only in animals where they can develop to maturity, but in almost any mammal that swallows eggs which have reached the infective stage.

Ransom and Foster have found that a few eggs will hatch by ordinary laboratory methods in almost any medium, including acid as well as neutral or alkaline media, not only at body temperature but at lower temperatures. The large majority, however, do not hatch outside of the animal body, although the embryos contained within the egg may remain alive and active.

LARVAL STAGE OF THE ROUNDWORM (Ascaris)

MIGRATION OF LARVAE IN BODY OF HOST

The newly hatched larvæ of the Ascaris measure about 0.2 to 0.3 mm. in length. In the liver they may reach a length of 0.6 mm. Larvæ in the lungs may grow to a length of 1.0 to 2.4 mm.

The larvæ, after hatching in the small intestine, burrow into the intestinal wall, from there being carried to the liver by the portal circulation, where they are distributed through the organ by small blood vessels. They may pass through the liver very rapidly or may be delayed for a time. From the liver

they are carried by the hepatic veins into the vena cava and from there into the right heart. The larvæ are carried from the right heart to the lungs by the pulmonary arteries, where they remain for a time. In the lungs they enter the air sacs, and after further development and growth, reaching a length of 1.0 to 2.4 mm., they pass on into the small intestine by way of the bronchi, trachea, larynx, pharynx, esophagus, and stomach. Here they become fully developed in their proper host (man or pig). Some larvæ evidently do not remain in the lungs more than a short time, but return to the heart by the pulmonary veins and are carried to all parts of the body in the general circulation.

Ransom and Cram have found larvæ in the liver, right heart, and lungs as early as seventeen hours after feeding.

A few larvæ may also be carried to the right heart from the walls of the small intestine by the lymphatic circulation without passing through the liver or by penetrating through the intestinal wall into the abdominal cavity and from there throught the diaphragm into the thoracic cavity and gaining entrance to the lungs. However, the two routes last mentioned are not regarded as common paths of migration.

DESCRIPTION OF LARVAL STAGE

The newly hatched larvæ are microscopic in size, usually between 0.2 and 0.3 mm. in length. The diameter of the body is nearly uniform throughout; the head and tail are conical. The anterior portion of the body is very clear and free from color. The intestinal cells contain many small yellowish-brown granules.

Under normal conditions it may be supposed that larvæ undergo at least two molts, the first molt at the time of hatching or shortly afterwards, the latter molt apparently before the larvæ reach the stage at which they migrate from the lungs to the intestine.

The larvæ in the lungs may reach a length of five to ten times the length of the newly hatched ones and can be seen by the naked eye if first isolated from lung tissue by the microscope. The body is almost uniform in diameter throughout; it is attenuated slightly at the anterior end and gradually from about the beginning of the posterior third of the body backward to the region of the anus, the tail being conical.

In the living larva the esophagus is distinctly visible, located in the anterior part of the body. The intestine is a yellowish-brown granular structure arising at the posterior

end of the esophagus and continuing backward to the anus, a short distance from the tip of the tail.

LESIONS CAUSED BY MIGRATING LARVAE

The principal organ affected is the lung. Ransom and Foster have observed alterations in the liver.

The lesions in the lungs vary greatly in their intensity, depending upon the severity of the invasion. In mild cases there are small, bright-red hemorrhagic spots in which the larvæ can usually be demonstrated without difficulty. As a rule the lungs are more or less edematous. In more severe cases there are present many hemorrhagic patches varying from pin points to those of considerable size, giving the lungs a mottled appearance. The bronchi and trachea often contain a frothy substance, which is sometimes stained with blood. In the extreme cases the entire lungs may be involved, are greatly swollen, edematous, extremely hemorrhagic, dark reddish-brown to a reddish-black in color, and firm like liver tissue. In these cases one frequently finds a blood-stained, frothy discharge from the nasal openings and the larvæ can be demonstrated with ease from almost any part of the lungs.

SYMPTOMS

The symptoms vary greatly, depending upon the number of larvæ migrating at one time. In cases where only a very small number of larvæ migrate at one time, there may be no visible symptoms.

The most common symptoms caused by the migration of Ascaris larvæ are a characteristic, jerky breathing commonly known as "thumps," rapid breathing, coughing, loss of appetite, emaciation, and usually a rise in temperature. This may reach 106° F., but does not commonly remain at a high level for any great length of time — as is commonly seen in hog cholera and the pneumonias, due to other causes — and usually disappears entirely within four or five days. There is generally an unthrifty appearance and interference with growth.

The losses by death are comparatively small, but pigs that survive a severe invasion of the lungs by Ascaris larvæ may not entirely recover and may fail to grow and develop at a normal rate and in this way cause heavy losses. In addition to this, the pigs involved acquire an increased susceptibility to intercurrent infections.

RELATION OF AGE TO WORM INFESTATION

Hogs may become infested at any age, but the time from birth up to two weeks old is the most dangerous period. They are very susceptible up to four months old. After they are four months old the danger of infestation is relatively small.

The condition found in pigs may also apply to man; that is, children are more commonly infected with Ascaris than adults.

METHOD OF CONTROL

The method of control is without question that of sanitation.

The first essential is to see that the pigs are farrowed under proper conditions. They should be farrowed in a pen that is so constructed as to have the floors built of an impervious material (not dirt floors), which will enable one to thoroughly clean out all litter and filth by scraping the floors and sides. After the litter has all been removed by scraping, the pens should be well scrubbed with strong, boiling, lye solution (lye solution can be prepared in an iron kettle, in the pens or close by). The hot water will destroy the eggs, and the lye will dissolve and help remove the dirt. In case the pens are not artificially heated, the cleaning should be done in the fall before freezing, as it is practically impossible to properly clean pens in cold weather.

Farrowing pens should not be occupied by other pigs between time of cleaning and time of placing sow in pen to farrow. The sows are placed in the clean pens a few days before farrowing, but not until they are well cleaned by washing with soap and water to remove all mud and dirt that is usually present on their skins. The udder particularly should be washed. If these precautions are taken, there is very little danger of the pigs getting eggs into their mouths from the udder of the sow while nursing. The dirt of an uncleaned udder may contain many eggs, so that the young pigs may get hundreds, thousands, or more of infective eggs with the first few mouthfuls of milk.

After farrowing, the sows and pigs should not be permitted to run on infected or contaminated soil (permanent hog lots). At the end of ten days or two weeks the sow and her litter are moved to pasture. The sow can be moved in an ordinary crate, on a farm sled, which may be backed up to the door of the pen and hauled away by a team of horses. The pigs may be carried in a small box on top of the crate. The

sow may be removed from pasture after the weaning of the pigs, but the litter should remain until they are at least four months old.

The pasture should be one which has not been used continuously for hogs, but a field that has been under cultivation during the normal rotation of crops and sown at the proper time with some forage crop. The pasture should be free of running streams. The drinking water should be clean and supplied in drinking fountains, and the feed given in self-feeders.

The colony houses should be so constructed that they may be moved from one pasture to another.

This system can be applied to spring or fall litters, although litters farrowed very early in the spring may have to be kept in the farrowing pens for more than two weeks, and late fall pigs may have to be taken off pasture before the pigs are four months old and put in winter quarters which are more or less contaminated with infectious eggs.

Yards that are constantly used by hogs should be so arranged that the hogs may be changed every year or two to fresh ground. The old yard should be plowed under and a crop sown which will permit a firm surface to be reestablished before using again for hogs. Hog yards should be located where proper drainage can be secured; but where natural drainage is impossible, tiling may be resorted to. The yards should be free from common mud wallows, as these are also a very prolific source of infection with worm eggs and other disease-producing factors.

TREATMENT

The practice of treating hogs with various remedies for the removal of Ascaris from the intestines is a very common procedure.

The remedies most used or recommended are turpentine, santonin and calomel, and oil of chenopodium.

When hogs are to be treated for worms it is always well to withhold food from them for twenty-four hours before administering the drug.

Turpentine is best given in milk. The required amount of the drug should be first shaken up with a small amount of warm milk, after which the mixture can be added to the milk offered to the hogs. The dose of turpentine is from one-half to one dram for every hundred pounds of live weight. This treatment should be repeated daily for three or four days in succession.

Santonin and calomel, being in powder form, are less suitable to be given in liquid mixtures. For every hundred pounds of live hog give eight grains of santonin and five grains of calomel. These drugs are best prepared by local druggists, dispensed in capsule form in doses suitable for fifty-pound pigs (four grains of santonin and two and a half grains of calomel).

In administering oil of chenopodium, Hall recommends administering two ounces of castor oil and following immediately by one dram of oil of chenopodium for swine weighing one hundred pounds. This dose of oil of chenopodium is probably sufficient for larger animals, though the dose of castor oil may be increased to three or four ounces for larger animals. For smaller ones the dose can be reduced in proportion to body weight, but the castor oil should not be less than one ounce for any animal.

In concluding, the writer desires to say that treatment for Ascaris is of little use, as it increases the degree of yard contamination by eggs, in this way increasing the danger of Ascaris pneumonia through large numbers of migrating larvæ, which do the greatest amount of harm, and during the period when treatment is absolutely useless.

If the Ascaris problem on our hog farms is to be solved, it is very evident that, instead of giving medicines to swine, sanitation as outlined above must be resorted to.

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