capable of achievement through the caging together of inoculated and uninoculated animals.

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THE LIFE HISTORY OF THE SWINE KIDNEY WORM

INTRODUCTION

STEPHANURIASIS, or kidney worm disease of swine, as determined in the course of the investigations which are briefly reported in this paper, is a more or less generalized parasitic infestation, of relatively long duration, the causative agent being a nematode known to zoologists as *Stephanurus dentatus*, commonly called the swine kidney worm. The parasites invade the abdominal viscera, notably the liver, pancreas and spleen; the thoracic viscera, notably the lungs; the circulatory system, especially the portal vein and its branches, the gastro-hepatic artery and the posterior vena cava; the thoracic and abdominal cavities, the lumbar muscles, the diaphragm, the outer coat of the stomach and intestine, the perirenal fat, the kidneys and other organs and tissues. Coincident with the sojourn of the parasites in the various parts of the body, profound pathological changes are produced in the parasitized organs, tissues and cavities of the host which may terminate fatally either in the early or later stages of the life cycle of the parasite, or else these pathological processes may produce a condition of severe emaciation which is accompanied by an anemia in most cases.

The writers' investigations, which have already been partly reported in abstract,[1] have cleared up the cause of a pathological condition of the liver of swine which is responsible for the condemnation of livers in abattoirs, these livers usually having been designated by meat inspectors as "parasitic livers" without adequate evidence, however, as to the parasitic origin of the lesions and as to the kind of parasite involved. The investigations reported in this paper have definitely established the fact that in most, if not all, cases so-called "parasitic livers" contain either active or healed lesions which have been produced by *Stephanurus dentatus*, and have thus cleared up a problem of considerable importance and interest from the view-point of meat inspection.

COURSE OF LIFE CYCLE

1. *Preparasitic stages.*—Under laboratory conditions, at a temperature of about 26° to 27° C. the preparasitic stages of the development of *S. dentatus* were completed in from five to six days. Eggs obtained from gravid females and cultured in water or on a charcoal and feces mixture hatched in from twenty-four to forty-eight hours, and the larvae reached the first lethargus about twenty-four hours after hatching. The second lethargus was reached about forty-eight hours later, and the infective stage, that of the third stage larva, was usually attained about twenty-four hours after the onset of the second lethargus. Low temperatures have been found to retard the development of the eggs and larvae, and at temperatures sufficiently low not only was development arrested but the vitality of the eggs and larvae was destroyed. Thus, at a temperature of about 10° C., the eggs were not only unable to develop, but their vitality was completely destroyed in ten days. At temperatures ranging from 1.5 to −3.8° C. the vitality of eggs was destroyed in about twenty-four hours.

It has been determined that the preinfective larvae are readily destroyed by low temperatures. After having been kept at a temperature of 10° C. for a week, a culture of such larvae was removed to room temperature. Microscopic examination disclosed the fact that the larvae were inactive and had not yet attained the infective stage. Within a short period after the culture was removed from the refrigerator the larvae underwent a granular degeneration. The infective larvae also were found to be deleteriously affected by low temperatures and their vitality was rapidly destroyed by freezing. At a temperature of −19° C. the vitality of the infective larvae was destroyed in nine hours, but after six hours' exposure to this temperature some of the larvae were still viable. When the larvae were air dried on a slide their vitality was destroyed in about thirty minutes, but shorter periods of exposure did not prove fatal to all larvae. A fifteen- to twenty-minute exposure to drying showed many dead larvae; others recovered from such exposure following the addition of a drop of water.

2. *Experiments on skin penetration.*—The infective larvae of *Stephanurus dentatus* were found to be incapable of penetrating the intact skin of pigs. In several experiments infestation did not result following the exposure of the skin of the abdomen and of the inguinal and axillary regions to rich cultures of infective larvae. Under experimental conditions the larvae were found to be incapable of penetrating the skin of a three-day-old mouse stretched tightly across a cork ring, which was floated in a beaker containing physiological salt solution at a temperature of 37.8° C. When larvae were placed on the scarified skin of pigs or when they were injected subcutaneously infection resulted, the course of development being similar to that which followed the administration of larvae by mouth.

[1] *Journal of Parasitology*, vol. 15, No. 2, 1928.

3. *Migrations of larvae in the body of their hosts.*—The path followed by the larvae in the body of pigs, as determined in these investigations, is from the intestine to the liver by way of the portal vein. Some larvae remain in the portal vein and its branches for long periods, whereas others make their way into the hepatic tissue, gradually reaching the capsule. They wander extensively beneath the capsule of the liver, their paths being marked in the form of linear lesions which are visible underneath the capsule. The agamic worms are capable of perforating the liver capsule, thus getting into the abdominal cavity where they wander freely over the surfaces of the viscera. The agamic worms are also capable of perforating the wall of the portal vein and on reaching the perivascular connective tissue they penetrate it and become encapsulated. The larvae also occur in the lungs, reaching this organ by wandering from the liver through the vena cava or through the lymphatic circulation. In experimental infestations larvae and thrombi were almost invariably found in the posterior vena cava of pigs. In experimental infestations of guinea-pigs, larvae were commonly found in the lymph nodes, and in one instance a larva was also found in the blood taken directly from the heart. The agamic worms enter the perirenal fat from the abdominal cavity, boring into it with the aid of the buccal capsule. They also bore into other tissues, notably the wall of the stomach and the duodenum, the spleen, pancreas, lumbar muscles, diaphragm and other organs and tissues with which they come in contact.

In experimental stephanuriasis in pigs, worms appear in the liver and lungs before they are found in the peritoneal cavity and in such organs as the spleen and pancreas. The agamic worms are found entering the perirenal fat relatively late in the course of experimental infestations.

The principal lesions associated with experimental kidney worm infestation of swine are as follows: In heavy experimental infestations pleurisy and peritonitis are present; the abdominal cavity may contain a sero-purulent fluid. The liver is roughened, covered with a fibrinous exudate, and usually adherent to the diaphragm. The spleen is commonly covered with a fibrinous exudate. A fibrinous exudate is also found on the lungs in heavy experimental infestations. The portal vein and its branches, the posterior vena cava and the gastrohepatic artery show numerous thrombi and cicatrices. The periportal connective tissue is greatly increased. The liver, lungs and perirenal fat show abscesses in which the worms are found intact or in which they have degenerated into a creamy mass.

Deaths following experimental infestations of pigs were found to be common, the period of survival of these animals, following the administration of larvae, being dependent to a considerable extent upon the number of larvae administered.

HOST RELATIONSHIP

Although *Stephanurus dentatus* is known to reach sexual maturity in hogs only, the worms are by no means uncommon in cattle. In some of the southern states these parasites are responsible for condemnations of cattle livers. *Stephanurus* has been reared experimentally in guinea-pigs, in which animals they have been found to attain a considerable growth and development.

RELATION OF KIDNEY WORMS TO PARASITIC LIVERS

The liver lesions resulting from experimental stephanuriasis are of special significance in view of their importance from the view-point of meat inspection. In light infestations lesions in organs other than the liver may be slight or absent; the liver, however, shows lesions invariably and the healed lesions stand out as striking abnormalities.

The livers of experimentally infested pigs examined after the agamic worms have left the liver show thickening and scarring of the liver capsule, and a marked increase in the amount of interlobular connective tissue which in some areas has completely replaced the parenchymatous tissue. The surface of the livers also shows slightly elevated grayish mottled areas and occasionally small reddish areas which on section are found to contain blood.

Histological examination of tissue removed from such livers shows a pronounced increase in the interlobular connective tissue and pressure atrophy of the liver lobules which, in some areas, are almost entirely replaced by fibrous connective tissue. There is also a pronounced cellular infiltration, the majority of the cells being eosinophiles.

Livers condemned as "parasitic livers" at various abattoirs and sent to the Bureau of Animal Industry for examination have been compared with livers from cases with lesions experimentally produced by infecting swine with the larvae of *Stephanurus* and in all cases histological examination of such livers has shown the two conditions to be identical.

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