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Distribution of *Trichinella spiralis* Larvae in Tissues of Swine[1]

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Abstract. Studies on the distribution of *Trichinella spiralis* in selected muscles of experimentally infected swine have indicated that the diaphragm generally contained the highest concentration of *T. spiralis*, followed by tongue, masseter, gluteal and intercostol muscles. Numerous tissues and organs devoid of striated muscle were also invaded by trichina larvae. Infected tissues were obtained from the circulatory, digestive, reproductive, nervous, endocrine, and excretory systems.

Trichinella spiralis was once regarded as a parasite which invaded only striated muscles. However various workers have reported the occurrence of *T. spiralis* larvae in numerous organs and tissues devoid of striated muscle. Gould (1945) summarized these reports listing myocardium, the pericardial, pleural and peritoneal cavities, the cerebrospinal fluid, the mucosa and lymphatics of the small intestine, mesenteric and cervical lymph nodes, thoracic duct, lungs, liver, brain and retina. The circulating arterial and venous blood were included as well as the bone marrow, pus from a furuncle, smooth muscle of the small intestine, pancreas, kidney, placenta, milk of nursing women, an excised mammary gland, duodenal drainage and gall bladder bile.

Hill (1957) examined organs from 55 pigs experimentally infected with *Trichinella spiralis* larvae. Trichinae were isolated from various organs devoid of striated muscle. The occurrence of the parasite in the tissues, percentagewise, was as follows: stomach wall 18, testes 15, liver 11, brain 9, lung 9, small intestine wall 9, pancreas 8, aorta 8, urinary bladder contents 7, urinary bladder 5, and heart 2. Trichinae were also recovered from the one spinal cord examined. No trichinae were recovered from kidneys, gall bladder contents, spleen, ovaries, wall of large intestine, uterus or Fallopian tubes.

In the course of investigations on experimental trichiniasis in swine at the Veterinary Medical Research Institute various tissues and organs have been examined for *T. spiralis*. The tissues and organs examined included many devoid of striated muscle.

Materials And Methods

These studies consisted of the determination of trichina con-

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tent of selected striated muscles of experimentally infected swine, and second, the occurrence of *T. spiralis* in tissues and organs devoid of striated muscles. The swine used in these trials were obtained from the herd maintained for experimental purposes at the Veterinary Medical Research Institute, Iowa State University. The pigs, 56 to 84 days old at time of exposure, were infected by feeding ground meat of experimentally infected rats. The infective dosages for the muscle distribution studies varied from 500 to 990,000 *T. spiralis* larvae, whereas those used for the studies on trichinae in tissues devoid of striated muscle varied from 425,000 to 990,000. The swine were sacrificed at 56 to 156 days after infection and tissues collected according to the procedure of Hill (1957). The tissue samples were 45 grams or less, depending upon the size of tissues. The samples were ground with individual food choppers. Examination was made by the artificial digestion-Baermann technique.

Results

A comparison of the trichina content of selected striated muscles from six experimentally infected swine is shown in Table 1.

Table 1. *T. spiralis* in muscle tissue of swine (Larvae per gram of tissue)

Pig No.	30	82	1955	M3	M2	M1
Diaphragm	8,340	7,500	1,575	549	508	13
Tongue	7,810	3,100	845	670	520	10
Masseter		1,550		151	312	10.7
Gluteal	1,935	2,660		124	233	5.8
Intercostal	4,890	1,105		128	157	5.5
Psoas	5,220					
Larynx	3,690					

The intensity of the infections induced varied widely as indicated by the range of larval counts from the diaphragm samples examined. The diaphragm yielded the highest trichina count per gram of tissue for 4 of the 6 swine examined. The tongue had the highest trichina concentration in 2 swine and was second highest in the remainder. The average yield of trichinae from the tongue was 82 percent of that for the diaphragm, varying from 41 to 122 percent. The average yield from the masseter muscles was 48 percent of the number from the diaphragm; those from the gluteal and intercostal muscles were 34 percent. Single examination of psoas and larynx muscles revealed yields of 63 and 44 percent, respectively, of the corresponding diaphragm count.

T. spiralis larvae were isolated from a wide variety of tissues devoid of striated muscle (Table 2). Infected tissues were obtained from the digestive, circulatory, nervous, reproductive, endocrine, and excretory systems.

Table 2. Distribution of *T. spiralis* in tissues of swine

Tissue	No. pigs examined	Number positive	No. larvae per positive sample
Salivary gland	5	2	39;294
Esophagus	1	1	2
Stomach	7	2	4;1
Small intestine	7	0	
Cecum	7	0	
Colon	7	0	
Liver	9	1	1
Gall bladder	9	2	1;4
Gall bladder contents	1	0	
Lymph nodes			
Cervical	8	5	2;3;69;720;3
Mesenteric	7	1	3
Thoracic	1	1	1
Inguinal	2	1	4
Heart	9	1	12
Aorta	8	3	1;1;3
Spleen	9	0	
Brain	2	0	
Spinal cord	2	2	163;1
Prostate	4	3	12,000;4500;48
Testicle	4	0	
Ovary	5	1	1
Uterus	4	1	11
Penis	2	2	633;2
Thymus	6	5	259;362;271;6;6
Pancreas	9	2	7;1
Kidney	9	1	1
Urinary bladder	9	2	988;976
Trachea	2	0	
Lung	9	0	

Only limited involvement was found for the digestive tract proper. The only esophagus examined contained *T. spiralis*, as did 2 of 7 stomach walls. The small intestine, cecum, and colon were negative. A somewhat higher rate of involvement was noted for organs associated with the digestive tract, trichina larvae being recovered from the salivary gland, liver, pancreas, and gall bladder wall. The maximum larval recovery was 294 from a salivary gland. A single examination of gall badder contents yielded no trichinae.

The examination of tissues of the circulatory system revealed a rather high rate of involvement of the lymph nodes. Trichinae were isolated from cervical, mesenteric, thoracic, and inguinal lymph nodes. Trichinae were recovered from the cervical lymph nodes of 5 of the 8 pigs examined, whereas the mesenteric lymph nodes of 1 of 7 pigs contained trichinae. The single thoracic node sample was infected, as was one of 2 inguinal nodes. The number of larvae recovered from the lymph nodes was generally small, but the cervical nodes from one pig contained 720 larvae. The heart and aorta were other organs of the circulatory system from which larvae of *T. spiralis* were ob-

tained. No trichinae were recovered from the 9 spleens examined.

Larvae were found in both spinal cord samples examined. Both brain samples examined were negative.

Three of 4 prostate glands contained trichinae. One contained 12,000 larvae; another contained 4,500. No trichinae were isolated from testicles but trichinae were found in both penis samples examined. Trichinae were recovered from both the uterus and ovaries.

The thymus was one of the endocrine glands found to contain trichinae. Five of the 6 samples examined contained larvae with a maximum recovery of 362 larvae. The pancreas and ovaries, both of which have endocrine functions, were also infected as previously mentioned.

Both the kidney and urinary bladder harbored trichinae. The two infected urinary bladder samples contained 988 and 976 larvae. The lung and trachea were both negative for trichinae.

Discussion

The studies on the distribution of *T. spiralis* larvae in the muscles of swine indicate that the diaphragm would generally be the muscle of choice when examining tissues of swine for the presence of trichinae. Based on the concentration of parasites found, the ranking of other muscles examined in decending order would be tongue, masseter, gluteal and intercostal muscles, with the psoas and laryngeal muscles tending to rank between the masseter and gluteal muscles. The size of the infective dosage had little effect on the site of greatest trichinae concentration. The results of these studies are similar to those of Reissman (1908) who found the greatest concentration of trichinae in the crura portion of the diaphragm, followed by the costal portion of the diaphragm, tongue, and laryngeal muscles. Meat inspection procedures utilized in parts of Europe and South America to detect trichininasis in swine consists of microscopic examination of pork tissues. The crura and costal regions of the diaphragm, the tongue and laryngeal muscles are the tissues usually examined, but other striated muscles are occasionally used.

These studies have confirmed the work of Hill (1957) showing that although *T. spiralis* larvae have a predilection for striated muscle of swine, numerous tissues devoid of striated muscle may be invaded by this parasite. Some of these tissues and organs are considered edible and are marketed for human con-

sumption. This would necessitate the processing of all swine tissues and organs sufficiently to kill trichinae. The feeding of offal to swine has been recognized as a mode of transmission of *T. spiralis,* but the garbage feeding regulations requiring cooking of garbage and offal have reduced the incidence of trichiniasis attributed to this source.

The studies on the occurrence of *T. spiralis* in tissues lacking striated muscles utilized only swine which received relatively large infective dosages. Additional studies will be necessary to determine whether this erratic parasitism would occur in swine administered light or moderate infective dosages. Mauss and Otto (1942) were of the opinion that heavy infections increased the probability of damage to organs and tissues without any change in proportion of larvae invading such tisuses. They estimated that 10,000 times as many larvae are found in striated muscle as in other tissues.

Both spinal cord samples examined in these studies contained trichinae. Similarly the single examination of a spinal cord by Hill (1957) also yielded trichina larvae. These findings emphasize the possibility of nervous system involvement in swine. Both of the pigs with spinal cord involvement in these studies showed severe clinical manifestations of trichiniasis among which was the inability to rise without aid commencing 12 and 21 days after infection. Although this was primarily due to muscle invasion by the trichinae, it may have been partially the result of invasion of the spinal cord by the parasite. Examination of brain samples from both pigs were negative.

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