CYSTICERCUS OVIS, THE CAUSE OF TAPEWORM CYSTS IN MUTTON

By B. H. Ransom,
Chief, Zoological Division, Bureau of Animal Industry

INTRODUCTION

It has been known for nearly half a century that cysticerci occur in mutton, but they have generally been looked upon as zoological curiosities rather than parasites of real economic importance; in fact, it seems that this opinion has been so commonly accepted as an established truth that a systematic examination of sheep for such cysticerci, or measles, like that given cattle and hogs, has been considered unnecessary by meat-inspection authorities. So far as this country is concerned, however, the belief that sheep measles are rare has been lately discovered to be quite erroneous. Instead of being rare, sheep measles have been found to be of much the same order of frequency as beef measles and far more common than pork measles, which are almost unknown in the United States. Where the presence of measles has been carefully looked for, the percentage of affected sheep has run 2 per cent and over, and during the calendar year 1912 approximately 20,000 sheep carcasses were retained under Federal inspection at various abattoirs on account of measles, most of them during the last few months of the year.

In the light of these figures it is quite evident that the mutton cysticercus is far from being the unimportant parasite it is commonly assumed to be, and it is furthermore quite certain that as inspectors become generally more familiar with this parasite and with the proper methods of inspecting for its presence the percentage and gross number of cases found will materially increase.

As yet sufficient data are not at hand to indicate the extent of direct injury to sheep by the measles parasite, so that the chief practical importance of sheep measles recognized at the present time is in their relation to meat inspection and public health. Like beef and pork cysticerci, the mutton cysticercus is of special interest in meat inspection because it affects the musculature, that part of the animal which is at once the most valuable for food purposes and the most difficult to inspect thoroughly.

The beef and pork cysticerci are well known to be the intermediate stages of two species of tapeworms occurring in man. The question naturally arises, Is the mutton cysticercus likewise the intermediate stage of a human tapeworm? The leading foreign meat-inspection authorities have held that the mutton cysticercus is simply Cysticercus cellulosae, the pork cysticercus, in an unusual host, and have laid down identical
regulations governing the disposal of affected hog and sheep carcasses. The American meat-inspection regulations, which are similar to, though necessarily somewhat more stringent than, the German regulations because of the lack of a Freibank system in this country, require the condemnation of carcasses heavily infested with *C. cellulosae* and permit slightly infested carcasses to be rendered into edible fat. As a condemned carcass is entirely destroyed for food purposes and as the value of a sheep carcass rendered into edible tallow is scarcely greater than that of one which has been condemned and made into fertilizer or other inedible products, a carcass infested with *C. cellulosae* in any degree whatsoever would be practically excluded from use as food under American regulations. Accordingly, if the mutton cysticercus were actually *C. cellulosae*, the 20,000 sheep carcasses in which muscle cysticerci were found last year would have been eliminated from the meat supply of the United States. Relatively this loss would not have been very great, and in actual money value it would not have exceeded $100,000. In the future, however, much greater losses would occur, because the more efficient methods of inspection which would be developed by experience would naturally lead to the detection of more nearly all the cases of sheep measles than the earlier, less efficient methods. The number of sheep affected with measles is probably considerably in excess of 1 per cent of the entire number slaughtered, and accordingly the loss on this account would be very large if anywhere near all the cases were found on inspection and if they were disposed of under the assumption that the parasite involved is *C. cellulosae*.

Shortly following the discovery of the first cases found last year, the writer undertook an investigation of the question of sheep measles, with the result that it was quickly proved that the parasite involved is certainly not *Cysticercus cellulosae*, though closely resembling it in some respects, and in due course of time it was definitely established that the mutton cysticercus is the larval stage of a dog tapeworm.

The question of sheep measles is therefore much less serious than it would be if the parasite were one transmissible to man, particularly if it were the rather dangerous *Cysticercus cellulosae*. So far as meat inspection is concerned, however, sheep measles, though less important as a public-health question, are almost as important as though the parasite involved were transmissible to human beings, because meat containing parasites of sufficient size to be noticeable is more or less objectionable as food for esthetic reasons if on no other account.

**HISTORICAL SUMMARY**

Considering critically the various statements which have appeared relative to muscle cysticerci in sheep prior to the recent investigations by the present writer, it may be noted in the first place that excepting one of Morot's (1899a)1 cases (No. 3), which was quite evidently one of

---

1 Bibliographic references in parentheses refer to the "Bibliography," pp. 54-57.
generalized coenurosis, there is no definite conclusive evidence that more
than one species of parasite is concerned in sheep measles; hence the
presumption is that the muscle cysticerci reported from sheep all belong
to a single species. Taking into account the fact that it has now been
proved by experiment that muscle cysticerci in sheep develop into tape-
worms distinct from either *Taenia solium* or *T. hydatigena*, it is quite
clear that none of the observers reporting muscle cysticerci in sheep has
given sufficient evidence to show that the parasites in any instance were
*Cysticercus cellulosae*, as they were held to be by some, or *C. tenuicollis*, as
they were held to be by others, and not in all cases, *C. ovis*. Commonly
the only evidence to support the observer's identification is a statement
that the parasite showed the characters of *C. cellulosae* (Olt, Armbrüster, Colberg, Rick-
mann, Herter) or *C. tenuicollis* (Chatin, Glage). In a few
cases measurements of the hooks have been recorded, but
these apply equally as well or better to *C. ovis* than to *C. cellulosae* or *C. tenuicollis*.
Bongert's report is of special
interest in this connection, as
he gives a photomicrograph of
the hooks (fig. 1), comparison
of which with the hooks of
*C. cellulosae* shows that the
hooks agree imperfectly, thus
demonstrating the incorrectness of Bongert's positive opinion that the
parasite was *C. cellulosae*. The opinion formerly held by the present
writer (1908b) that certain partially grown muscle cysticerci with hooks
not yet fully developed which had been found in a sheep were *C. cellu-
losae* on account of the presence of certain characters also found in *C.
cellulosae* is likewise seen now to be quite erroneous.

Railliet and Morot noticed that the hooks of a cysticercus resembling
*Cysticercus cellulosae* from a sheep heart, though agreeing fairly well in
size with *C. cellulosae* hooks, as shown by the measurements which they
give, corresponded closely in form to those of *C. tenuicollis*. They
accordingly so identified the cysticercus, at the same time, however,
calling attention to the fact that the hooks are fewer in number than is
usual in *C. tenuicollis* and that they are smaller, differences possibly to
be attributed, according to their view, to the location of the parasite in
the muscles instead of in the serous membranes. It is quite probable—
in fact, not to be doubted—that the parasite in this case was *C. ovis*.
Not only have observers failed to give sufficient evidence that the mutton cysticerci in any case exactly agreed in morphology with *Cysticercus cellulosae* or *C. tenuicollis*, but they have also failed to produce experimental proof to support their identifications. *C. cellulosae* has never been produced experimentally in sheep by feeding *Taenia solium* eggs (Leuckart, Küchenmeister, Perroncito); nor, vice versa, has *T. solium* been produced in man as a result of ingesting mutton cysticerci (Chatin, Ransom1).

There is also no good evidence that *Taenia hydatigena* has ever been obtained as a result of feeding the mutton cysticercus to dogs. It is true that Chatin states that such is the case, but the evidence that the tapeworms were identical with those belonging to *Cysticercus tenuicollis* consists simply in Chatin's affirmation that they were the same, and there is no objective evidence at all to support this view. It also should be noted that no one has shown that segments of *T. hydatigena*, when fed to sheep, will produce muscle cysticerci. Leuckart, Küchenmeister, and others have found only *C. tenuicollis* as a result of such experiments.

Cobbold's opinion that *Cysticercus ovis* is the larva of a human tapeworm, the so-called *Taenia tenella*, has never had any supporting evidence and, of course, is now entirely discredited. Cobbold, however, it is interesting to note, was quite correct in another opinion which he at one time held—namely, that it is probable that the adult of *C. ovis* occurs in one of the carnivora.

Most of the records of muscle cysticerci in sheep are based upon isolated cases in which the parasites have usually been more or less degenerate. Thus, Cobbold noted the presence of degenerated cysticerci in mutton on several occasions and described *Cysticercus ovis* on the basis of a single specimen (fig. 2) which had lost the caudal bladder before it came into his hands. Maddox described *C. ovipariens* (figs. 3 and 4) on the basis of one degenerated cysticercus. The number of cases seen by Möbius, reported by Küchenmeister, is not stated. Chatin apparently saw muscle cysticerci on several occasions, and some of these evidently were alive and undegenerated. Morot refers specifically to five cases and refers to an indefinite number of others, in all of which the parasites were degenerated and were recognized as cysticerci only from the character of the cysts. Railliet and Morot reported one case of a single, apparently undegenerated cysticercus in the heart of a sheep, and refer

![Fig. 2.—Cysticercus ovis: Head and neck, X 30. (After Cobbold, 1894, p. 30, fig. 2.)](image)

1 For an account of the present writer's experiments, see pp. 21-26.
Oct. 10, 1913

Cysticercus Ovis

19
to a similar case of cysticercus in the heart of a kid. The case reported by Olt and Bongert showed numerous cysticerci, some of which apparently were alive. In another case seen by Olt the parasites were all degenerate. Armbrüster found calcified cysticerci in 2 or 3 sheep out of a shipment of 16 head. One case of muscle cysticerci was found by Colberg in which numerous degenerated parasites were present.

In a case of cysticerci in a sheep heart reported by Railliet the parasites were very young, without hooks. Glage is the only author thus far who has given a detailed statistical record of the frequency of muscle cysticerci in sheep. His records, however, are based entirely upon the presence of degenerated cysticerci, and it is not improbable that he overlooked many cases of live cysticerci. He found 32 cases (1.45 per cent) among 2,198 carcasses in which the head muscles and hearts were examined and 16 cases (0.8 per cent) among 1,984 carcasses in which only the hearts were examined. Rickmann fails to state the number of cases observed. The cysticerci in the one case reported by the present writer in 1908 were undegenerate but only partly grown. Herter mentions one case and says that only nine cases of sheep measles were recorded in the meat-inspection reports of Prussia for the year 1909. Making a very liberal allowance for the number of indefinitely reported cases, the total number of individual cases of sheep measles reported in the literature prior to the recent investigations in this country is considerably less than 100, and in only a very few of these were the cysticerci at all numerous or present in a living, fully developed, undegenerated condition. It is accordingly not surprising that the identity of these parasites should have remained so long undiscovered, particularly in view of the fact that they have received but little attention from experienced parasitologists, who, moreover, have had very unsatisfactory material for study.
Cobbold, for example, apparently studied only one specimen (imperfect), and Railliet seems to have had only one fully developed undegenerated specimen for critical examination.

Up to the present time sheep measles have been reported from the following countries: England, Germany, France, Algeria, German Southwest Africa, New Zealand, and the United States.

In completing this brief critical summary of the literature, only a few words need be given concerning the morphology of the parasites. As already noted, morphological details have been omitted from most of the accounts given of the recorded cases. The measurements of the hooks given by Railliet and Morot correspond to *Cysticercus ovis*, as do Bongert’s measurements and photomicrograph. Maddox was the first to observe the mammillated surface of the caudal bladder, which, however, has not been recognized as a distinctive difference between *C. ovis* and *C. tenuicollis*, except by the present writer (1908d), and apparently has escaped attention from other observers.

**LIFE-HISTORY INVESTIGATIONS**

Under date of February 29, 1912, Dr. S. E. Bennett, inspector in charge at Chicago, Ill., reported to the Bureau of Animal Industry that a number of sheep carcasses had been found to be infested with measles, and under date of March 1 Dr. O. B. Hess, inspector in charge at Seattle, Wash., also reported the finding of measles in several sheep carcasses. Specimens were forwarded to Washington from both stations for laboratory examination. The cysts in the specimens were all degenerate, but fragments of the caudal bladder of cysticerci were found, and in view of the presence of cuticular papillae, which are likewise present on the caudal bladder of *Cysticercus cellulosae*, and in accordance with the opinion of German meat-inspection authorities as to the identity of mutton cysticerci, the diagnosis of *C. cellulosae* was made. Shortly following the first reports, information was received that out of 4,537 sheep slaughtered at Seattle, Wash., 79 carcasses were retained on account of measles, and that during a month at Chicago 224 carcasses were retained.

With this information at hand it was immediately apparent that the diagnosis of *Cysticercus cellulosae* could not be correct, for the reason that *C. cellulosae* and its tapeworm stage, *Taenia solium*, are exceedingly rare in the United States. Probably not more than a dozen cases of pork measles are found annually at any of the large stations, where the number of hogs slaughtered amounts to hundreds of thousands. It was unbelievable that a parasite so rare in its usual host should be so common in sheep. A few days spent in studying numerous specimens obtained at the abattoirs in Chicago developed the fact that the sheep-measle parasite was certainly not *C. cellulosae*, though in certain characters they were very similar. In some details of structure the muscle cysticerci
resembled *C. tenuicollis*, but in other respects the two forms did not agree. Accordingly an experiment was undertaken to determine whether the parasites would develop in dogs and whether the tapeworms, if any developed, would prove to be *T. hydatigena* (the tapeworm corresponding to *C. tenuicollis*; also known as *T. marginata*, the marginate tapeworm of the dog), as affirmed by Chatin (1886a), who stated that he had obtained *T. marginata* by feeding mutton cysticerci to dogs, or whether they would prove to be some other species. Seven dogs were under observation in 1912. Five of these were fed cysticerci from sheep muscle, while two, as controls, were fed *C. tenuicollis* from the omentum or mesenteries of sheep. With three exceptions, as noted below in the records of the experiment, the dogs were given a dose of castor oil and the feces examined for the presence of parasite eggs before the cysticerci were fed. During the experiment the dogs were nourished on dog biscuits, corn-meal mush, and some cooked meat but no mutton and were confined in separate kennels.

Dog No. 1.—A grayish brown young female. Fed muscle cysticerci from sheep. Feces were not examined before feeding cysts.

- March 25. Fed 1 cyst from heart muscle of sheep.
- March 27. Fed 1 cyst from heart muscle of sheep—probably dead.
- March 29. Fed 3 cysts from heart muscle of sheep.
- March 30. Fed 3 cysts from heart muscle of sheep—1 probably dead.
- April 1. Fed 1 cyst from diaphragm of sheep—probably dead.
- April 2. Fed 1 cyst from body muscle of sheep.
- April 3. Fed 2 cysts from heart muscle of sheep.
- April 24. Fed 1 cyst from heart muscle of sheep.
- April 29. Fed 2 cysts from heart muscle of sheep.
- May 2. Fed 1 cyst from heart muscle of sheep.
- May 22. Fed 1 cyst from heart muscle of sheep.
- May 24. Fed 2 cysts from heart muscle of sheep.

- Total... 23 cysts.

- June 22. Eggs of *Toxascaris* and a tapeworm segment found.
- June 27. Tapeworm segments found in feces.
- July 24. Chloroformed. About 25 individuals of *Toxascaris* in upper half of jejunum. Seven tapeworms, all with gravid segments, in ileum. Heads attached near upper end of ileum, about 65 cm. from ileocecal valve. Length of tapeworms, 45 to 55 cm.

Dog No. 2.—A white-and-tan young female. Fed *Cysticercus tenuicollis* from peritoneum of sheep. Feces were not examined before feeding cysts.

- April 5. Fed 3 cysts.
- April 11. Fed 1 cyst.
- April 18. Fed 7 cysts.

|-------------------|---------------------|------------------|

- June 22. Eggs of tapeworm and *Toxascaris* eggs found.
- July 11. Two tapeworm segments found in feces.
- July 26. Chloroformed. Numerous individuals of *Toxascaris* in jejunum and duodenum. Nine tapeworms with gravid segments; one of the tapeworms was about 110 cm. long. The tapeworms were attached about 8 cm. below the pylorus, 80 cm.
from the ileocecal valve, and the posterior ends of the worms extended to within 40 cm. of the ileocecal valve.

Dog No. 3.—A young black-and-white female. Fed muscle cysticerci from sheep. March 29. Received one-half ounce of castor oil at 5 p.m. March 30. Feces were examined with negative results.

April 5. Fed 1 cyst from myocardium.
April 6. Fed 3 cysts from myocardium.
April 10. Fed 3 cysts from myocardium.
April 11. Fed 6 cysts from myocardium.
April 13. Fed 1 cyst from myocardium.
April 29. Fed 1 cyst from myocardium.
May 2. Fed 1 cyst from myocardium.
May 21. Fed 1 cyst from myocardium.
May 23. Fed 1 cyst from myocardium.
May 24. Fed 3 cysts from myocardium.

Total... 21 cysts.

June 11. Feces examined but no eggs found.

No segments or eggs have been found (prior to July 22).

July 22. Chloroformed. Four tapeworms attached 25 to 35 cm. from the ileocecal valve, one of them with gravid segments, about 45 cm. long when extended, other three not over 2 to 5 cm. long. Three very short tapeworms in cecum. In large intestine a string of about 10 gravid segments. Total number of tapeworms, seven.

Three individuals of Toxascaris in jejunum.

Dog No. 4.—A young red male. Fed muscle cysticerci from sheep. March 29. Received one-half ounce of castor oil at 5 p.m. March 30. Feces were examined and Toxascaris eggs found.

April 18. Fed 1 cyst from myocardium of sheep.
April 19. Fed 1 cyst from cheek muscle of sheep.
April 23. Fed 16 cysts—3 from myocardium and 13 from muscles of sheep.

Hooks were well developed.

April 24. Fed 1 cyst from myocardium of sheep.
May 2. Fed 1 cyst from myocardium of sheep.
May 15. Fed 1 cyst from myocardium of sheep.
May 21. Fed 1 cyst from myocardium of sheep.
May 24. Fed 2 cysts from muscles of sheep.

Total... 24 cysts.

June 11. Eggs of Toxascaris, but no tapeworm eggs found.

June 27. Three broken tapeworm segments found in feces.

July 24. Chloroformed. Two individuals of Toxascaris in upper part of jejunum. Sixteen or seventeen tapeworms extending down into lower part of colon. None attached more than 4 cm. above ileocecal valve. One attached in cecum. None with gravid segments. Length, 20 to 50 cm.

Dog No. 5.—A medium-sized brindled male. Fed muscle cysticerci from sheep. March 29. Received one-half ounce of castor oil at 5 p.m. March 30. Feces were examined with negative results.

April 23. Fed 20 cysts from muscles of sheep. Hooks were well developed.
April 24. Fed 1 cyst from myocardium.
May 2. Fed 1 cyst from myocardium.
May 15. Fed 1 cyst from myocardium.
May 21. Fed 1 cyst from myocardium.
May 24. Fed 2 cysts from muscles of sheep.

Total... 26 cysts.
June 11. Tapeworm eggs and eggs of *Toxascaris* were found in feces.

June 19. Two or three segments found in feces.


Dog No. 6.—A medium-sized white male. Fed muscle cysticerci from sheep.

March 29. Received one-half ounce of castor oil at 5 p.m. March 30. Feces were examined and *Toxascaris* eggs found.

April 23. Fed 20 cysts from muscles of sheep. Hooks well developed.

April 24. Fed 1 cyst from myocardium.

May 2. Fed 1 cyst from myocardium.

May 15. Fed 1 cyst from myocardium.

May 21. Fed 1 cyst from myocardium.

May 24. Fed 2 cysts from muscles of sheep.

Total... 26 cysts.

June 11. Tapeworm eggs and eggs of *Toxascaris* were found in feces.

June 19. Two tapeworm segments were found in feces.

July 26. Chloroformed. Eight or nine tapeworms with gravid segments, one of them measuring 1 meter in length. Heads attached 135 cm. above the ileocecal valve, and posterior ends of the worms extending to a distance of 55 cm. from the ileocecal valve. Numerous individuals of *Toxascaris* in jejunum and in duodenum.

Dog No. 7.—A medium-sized black-and-white spotted female. Fed *Cysticercus tenuicollis* from peritoneum of sheep. Feces were not examined before feeding cysts.

April 9. Fed 4 *Cysticercus tenuicollis*

April 18. Fed 7 *Cysticercus tenuicollis*.

May 28. Fed 7 *Cysticercus tenuicollis*.

Total... 18.

June 22. Feces show a few young tapeworm segments.

July 11. Found several portions of tapeworms; each portion contained from 2 to 20 segments.

July 26. Chloroformed. Three or four individuals of *Toxascaris* in duodenum and jejunum. Ten tapeworms with short strobila not over 10 mm. long in duodenum.

In continuation of the experiment with the dogs another experiment was undertaken for the purpose of recovering the cystic stages of the tapeworms. Ten lambs were purchased from a lot of thirty-nine, the remainder of which were slaughtered at one of the packing houses in Chicago and found to be free on post-mortem examination from both muscle cysticerci and *Cysticercus tenuicollis*. One of the ten died shortly after purchase and consequently was not used in the experiment. The sheep were kept during the experiment in floored and covered pens in one of the sheep barns at the Union Stock Yards, Chicago, and were fed dry hay and occasionally oats and received water piped from the water mains. The identity of the various lambs was maintained by numbered ear tags.

Lamb No. 1.—July 24. One half of a gravid segment from a tapeworm out of dog No. 1 (a dog which had been fed muscle cysts) was cut in pieces and given in a drench with water.

August 7. Dr. Day reported that lambs Nos. 1, 2, 3, and 5 were more or less sick but would probably recover.
August 21. Is very thin and has a diarrhea, but is feeding well.

October 15 (eighty-three days after feeding). Chloroformed. In poor flesh, very little fat. Cysticerci were found in the panniculus carnosus. Forty-two degenerate cysts were counted in the diaphragm; ten degenerate cysts in the wall of the esophagus. Several cysts in anterior lobes of lungs, 2 to 3 mm. in diameter; contents caseous. One contained a small dead cysticercus, 1 mm. in diameter; rudiment of head present. Numerous small degenerate cysts in heart. Numerous cysticerci in muscles of mastication; some living, others degenerate. A few nodules in the wall of the rumen, and one in the wall of the fourth stomach, 2 to 4 mm. in diameter, hard, shotlike, with thick wall and cheesy contents. No cysticerci were found in these cysts. Nodules present on wall of cecum, probably *Oesophagostomum*. No cysticerci found in these nodules. Many degenerate cysts among those present in the musculature in various parts of the body. The sizes of 13 live cysts measured in situ were as follows, in millimeters: 9 by 3.5, 8 by 3, 7 by 4, 7 by 3, 6 by 5, 5 by 2, 5 by 3, 5 by 3, 8 by 3.5, 7 by 3, and 8 by 3.5. A cyst 5 or 6 mm. in diameter with thick leathery capsule contained a live cysticercus which was active under the microscope. This cysticercus was not fully developed, only the blade of the hooks being formed. Other cysticerci showed fully developed hooks, and cysticerci from degenerate cysts showed in some cases hooks not yet fully formed.

Lamb No. 2.—July 26. A gravid segment from a tapeworm out of dog No. 6 (a dog which had been fed muscle cysts) was given in a drench with water.

August 7. Dr. Day reported that lambs Nos. 1, 2, 3, and 5 were more or less sick but would probably recover.

August 17 (twenty-two days after feeding). This animal died, but its death was not reported until two days later, when decomposition was so far advanced that Dr. Day did not attempt a post-mortem examination. 1

Lamb No. 3.—July 26. A gravid segment from a tapeworm out of dog No. 6 (a dog which had been fed muscle cysts) was given in a drench with water.

August 7. Dr. Day reported that lambs Nos. 1, 2, 3, and 5 were more or less sick but would probably recover.

August 18 (twenty-three days after feeding). This animal died. Decomposition was far advanced the following day when a post-mortem examination was made, but some of the masseter muscle and some of the muscle of a hind leg were obtained. Dr. Day reports that cysts in the masseter muscle were quite well formed and contained a tiny white spot just visible to the eye. Microscopic examination by Dr. Day showed that the head was not well formed, but papillae were evident on the caudal bladder.

Lamb No. 4.—July 24. A gravid segment (cut in pieces) from dog No. 1 (a dog which had been fed muscle cysticerci) was given in a drench with water.

August 7. In very bad condition; probably will die.

August 11 (eighteen days after feeding). Dead.

August 12. An incomplete post-mortem examination was made by Dr. Day. Advanced decomposition. A number of cysts were obtained from the masseter muscles.

Lamb No. 5.—July 24 a gravid segment from a tapeworm out of dog No. 3 (a dog which had been fed muscle cysticerci) and on July 26 two gravid segments from a tapeworm out of dog No. 6 (a dog which had been fed muscle cysticerci) were given in a drench with water, a total of three segments.

August 7. Dr. Day reported that lambs Nos. 1, 2, 3, and 5 were more or less sick but would probably recover.

1 In prior publications (Ransom, 1913, p. 78; 1913, p. 31) it was erroneously stated that all of the lambs which had been fed eggs of the muscle cyst tapeworm showed tapeworm cysts in the muscles. The condition in lamb No. 2, of course, was not determined, as no autopsy was made on this animal. The statement (Ransom, 1913, p. 31) that the lambs died in 14 to 22 days after feeding is also inaccurate. It should be 13 to 23 days.
August 12 (ten days after feeding). Dead. Post-mortem examination by Dr. Day the following morning showed a large number of cystic parasites in the masseter muscles, heart, tongue, and diaphragm. There were also numerous cystic parasites in the skeletal muscles and a few hemorrhagic spots.

Lamb No. 6.—July 24, four segments from tapeworms out of dogs Nos. 1 and 3 (dogs which had been fed muscle cysticerci), two segments from each dog, and July 26 six segments from tapeworms out of dog No. 6 (a dog which had been fed muscle cysticerci) were given in a drench with water, a total of ten segments.

August 5. Appears ill and out of condition.

August 6 (thirteen days after feeding). Dead. Post-mortem by Dr. Day showed that the parasites had already migrated to the muscles, and were found as very minute cysts, more numerous in the heart and masseter muscles than elsewhere. There were about 25 c. c. of fluid in the pericardium. The heart was very thickly studded with minute cysts. There were about 350 c. c. of fluid in the peritoneal cavity. A careful examination of the fluid was made, but no parasites were found. The liver appeared normal.

Lamb No. 7.—July 26. A gravid segment from a tapeworm out of dog No. 2 (a dog which had been fed *Cysticercus tenuicollis* from the peritoneum of sheep) was given in a drench with water.

August 21. Reported by Dr. Day as doing well.

October 18 (eighty-four days after feeding). Chloroformed. Animal in poor flesh. Twelve to fifteen cysts on omentum and mesenteries, two of which are alive, the others degenerate. One degenerate cyst under peritoneum in pelvic cavity. Degenerate cysts vary in size up to a maximum of 20 mm. in diameter. Contain dead cysticerci, a small amount of colorless serous fluid and flocculent débris or a greenish, caseous material. The live cysticerci measure 8 by 15 mm., and show the usual macroscopic characters of *Cysticercus tenuicollis*. A few degenerate cysticerci of small size on the surface of the liver. No cysticerci in the muscles, lungs, or other organs, except as noted above. *Oesophagostomum* nodules on the intestine.

Lamb No. 8.—July 26. Ten gravid segments from a tapeworm out of dog No. 2 (a dog which had been fed *Cysticercus tenuicollis* from the peritoneum of sheep) given in a drench with water.

August 21. Reported by Dr. Day as doing well.

October 17 (eighty-three days after feeding). Chloroformed. Animal in poor flesh. A considerable number of small degenerate cysticerci on surface and in depths of liver. About 25 degenerate cysts on omentum and mesenteries. One live cysticercus on omentum about 12 mm. in diameter shows the usual macroscopic characters of *Cysticercus tenuicollis*. One degenerate cyst on tendinous portion of diaphragm (abdominal surface). Small nodules in lungs, one of which contained a young dead cysticercus showing under the microscope transverse ridges on the cuticle of the caudal bladder. Synthetocaulus nodules also present on the lungs. Several pockets in the lungs with fibrous walls containing greenish pus. The contents of these pockets were examined, but no cysticerci were found. Heart and muscles were free from parasites. A cyst from the omentum, 8 mm. in diameter, with thick fibrous wall contains a dead cysticercus with evaginated head and bladder about 3 mm. in diameter. Two cysts from the omentum or mesentery, 5 and 6 mm. in diameter, respectively, contain each a dead cysticercus and a small amount of colorless serous fluid and flocculent débris. The other degenerate cysts are similar, except the contents in some are greenish, caseous. Their size varies from 2.5 to 10 mm., and all have thickened walls ⅛ to ⅜ mm. thick. The degenerate cyst from the tendinous portion of the diaphragm is flattened, 8 mm. in diameter. Its wall is thin, and it contains a dead *Cysticercus tenuicollis* and a small amount of serous fluid and white flocculent matter.
Lamb No. 9.—A check animal, not fed with tapeworm segments.

The following experiments relating to the possibility of the development of sheep-measle tapeworms in man have been carried out, the writer being the subject.

On March 6, 1913, a cysticercus about 5 mm. in diameter, and March 14 another cysticercus of similar size, both from sheep hearts, were swallowed. Both cysticerci were alive and in good condition, exhibiting lively contractions of the caudal bladder when viewed under the microscope. On March 28 eight fully developed cysticerci were isolated from a sheep carcass heavily infested with Cysticercus ovis and swallowed. These cysticerci were apparently in good condition and were undoubtedly alive, as they showed active movements under the microscope. No signs of tapeworm infestation have appeared in the case of the writer.

SUMMARY OF LIFE-HISTORY EXPERIMENTS

Five dogs were each fed from 21 to 26 muscle cysticerci from sheep on various dates between March 25 and May 24. Subsequent to June 11, tapeworm eggs or segments were demonstrated in the feces, or tape-worms were found post-mortem in the case of all five dogs. No tape-worms were found in one of the dogs (No. 5) post-mortem, but a month earlier this dog had shown tapeworm eggs and segments in the feces. In the case of two of the dogs (Nos. 5 and 6) it was evident that the tape-worms had reached egg-producing maturity within seven weeks, as the earliest feeding of cysticerci was on April 23, eggs being demonstrated in the feces on June 11. The number of tapeworms recovered varied from 7 to 16.

Two dogs were fed Cysticercus tenuicollis, 18 and 21 cysticerci, respectively, between April 5 and May 28. The first tapeworm eggs were found in the feces on June 22. On post-mortem examination 9 tapeworms were found in one dog and 10 in the other.

Six lambs (Nos. 1 to 6) were fed with gravid segments of tapeworms from the dogs which had been fed Cysticercus ovis, two (Nos. 7 and 8) with gravid segments of tapeworms from one of the dogs which had been fed C. tenuicollis, and one (No. 9) was retained under the same conditions as the others but without receiving any cysticerci. Lambs Nos. 1 to 6 received ½ to 10 segments, and lambs Nos. 7 and 8, 1 and 10 segments, respectively. Of the former all but the one receiving half a segment died in 13 to 23 days after feeding, the one receiving 10 segments being the first to die, followed by one receiving 1 segment (death in 18 days), then by one receiving 3 segments (death in 19 days), then by two more receiving 1 segment each (death in 22 and 23 days, respectively), leaving the lamb which received half a segment to survive until killed—83 days after feeding. Both of the lambs fed with segments of Taenia hydatigena (adults
of *C. tenuicollis*) survived until killed at the close of the experiment. All but one of the lambs (No. 2), which died 22 days after feeding, were examined post-mortem.

Omitting this lamb from consideration, all of the lambs which received segments from the tapeworms produced by feeding muscle cysticerci showed cysticerci in their muscles when examined. Those found in the lamb which died 13 days after feeding were very small; those in the lamb which died 23 days after feeding were somewhat farther along in development, the beginnings of the head being already evident. Eighty-three days after feeding, the muscle cysticerci were found to have reached full development; some which had fully developed were already more or less degenerated, and some were found which had begun to degenerate before they reached their full development. In addition there were present live cysticerci which had not yet fully developed.

The lambs which had been fed segments of *Taenia hydatigena* showed a few *Cysticercus tenuicollis*, most of which were degenerate. In both animals there were small degenerate cysticerci on the liver. There were no visible lesions of the liver in the lambs fed segments of *T. ovis*. No *C. tenuicollis* was found in any of the lambs fed segments of *T. ovis*, and no *C. ovis* in the lambs fed segments of *T. hydatigena*. The check lamb showed neither *C. tenuicollis* nor *C. ovis*, and neither of these parasites was found at the post-mortem inspection of the remainder of the lot from which the experiment sheep had been selected.

Since these experiments show that muscle cysticerci in sheep resembling *Cysticercus cellulosae* and corresponding to the form described by Cobbold as *C. ovis* develop into tapeworms when swallowed by dogs, it has been definitely proved that these cysticerci are not *C. cellulosae*. The adult of *C. cellulosae* (*Taenia solium*) does not occur in dogs; moreover, the tapeworms which were produced in the dogs are quite different from *T. solium*. Furthermore, the experiments prove that the muscle cysticercus and its adult stage are specifically distinct from *C. tenuicollis* and *T. hydatigena*. It appears that the ingestion of one or more gravid segments of *T. ovis* is likely to prove fatal to sheep.

Attempts to produce tapeworms in man by feeding mutton cysticerci failed. On three occasions live mutton cysticerci were swallowed by the writer, a total of 10 cysticerci being ingested. No evidence of tapeworm infestation has since appeared. This experiment tends to prove that *Cysticercus ovis* is not transmissible to man.

**SYNOPSIS OF LIFE HISTORY**

The adult of *Cysticercus ovis* is a tapeworm (*Taenia ovis*) which occurs in the intestine of dogs. Since the parasites which live on dogs as a rule also thrive on wolves, and, since coyotes and other wolves frequently
devour sheep, it is quite likely that *T. ovis* also occurs in coyotes and other wolves as well as in dogs. In view of the fact, however, that dogs come in much closer relations with sheep it seems quite evident that dogs are chiefly responsible for the transmission of the parasite to sheep. It is possible though rather unlikely that the tapeworm occurs in other carnivores than dogs and wolves. There is little likelihood that the parasite is transmissible to man, and for all practical purposes its nontransmissibility to man may be considered an established fact. No such tapeworm has been reported from man, and, moreover, there are no authentic cases of the occurrence in man of any dog tapeworm belonging to the genus *Taenia*. Furthermore, Chatin has noted that the swallowing of muscle cysticerci from sheep failed to result in infestation in his case. The present writer, as already noted, has likewise on three occasions swallowed live and active muscle cysticerci from sheep without resulting infestation (p. 26).

Following the ingestion of the eggs of the tapeworm by sheep, the parasites reach the muscles in less than 13 days; they either do not pass through the liver or, unlike *Cysticercus tenuicollis*, leave no trace of their passage through this organ. In less than three months (83 days) the cysticerci reach their full development. As early as seven weeks after the ingestion of the cysticercus by a dog, its development to the mature egg-producing tapeworm may be complete. The development therefore appears to be somewhat more rapid than in the case of *Taenia hydatigena*, which was found by Leuckart (1856a) to require from 10 to 12 weeks. No doubt, however, the period required for development is subject to great variation, and though seven weeks is perhaps near the minimum for *T. ovis*, the period very likely may be greatly prolonged, as has been noted by Hall (1911, p. 510) in the case of the gid tapeworm.

ZOOGICAL DESCRIPTION OF THE SHEEP-MEASLE PARASITE

**Taenia ovis** (Cobbold, 1869) Ransom, n. comb., 1913.

1869: *Cysticercus ovis* Cobbold, 1869a, p. 30, fig. 2 (in *Ovis aries*; England).
1873: *Cysticercus ovipariens* Maddox, 1873a, p. 245-253, pl. 18, figs. 1-15, 27-28, pl. 19, fig. 1 (in *Ovis aries*; England).
1878: *Cysticercus cellulosa* of Küchenmeister, 1878, in Küchenmeister and Zürn, 1878-1881a, p. 104 (apparent misdetermination of *C. ovis*; in *Ovis aries*; Germany).
1885: *Cysticercus tenuicollis* of Chatin in Railliet, 1885a, p. 234 (apparent misdetermination of *C. ovis*; in *Ovis aries*; France).
1886: *Cysticercus oviparus* Leuckart 1886d, p. 498 (for *C. ovipariens*).
1913: *Taenia ovis* (Cobbold) Ransom, 1913.

**SPECIFIC DIAGNOSIS OF TAENIA.**

**Larval stage.**—An oval cysticercus (Pl. II, fig. 1) 3.5 by 2 mm. to 9 by 4 mm. in diameter. Head and neck invaginated from the wall of the caudal bladder not at one end but about midway between the ends. Membrane of bladder very thin; with small mammillate projections; not corrugated transversely (fig. 5 and fig. 6, a). Neck transversely corrugated, coiled spirally when invaginated, 1 to 5 mm. long when evaginated. Head 500 to 800 μ in width; suckers oval, 240 to 320 μ in diameter; rostellar-
Cysticercus Ovis

lum prominent, 275 to 375μ in diameter. Hooks (fig. 6) 24 to 36 in number, commonly 28 to 32, arranged in a double crown of alternating large and small hooks. Hooks rather slender (more slender and more lightly built than those of Cysticercus cellulosae); dorsal root of large hooks longer than the blade; in both large and small hooks a more or less well-marked outward curving of the dorsal border of the hook in the transitional region between the blade and dorsal root; ventral root of small hooks transversely enlarged, not bifid but sometimes presenting a faint median groove. Large hooks 156 to 188μ long, average 173μ; blade (from point of blade to tip of ventral root measuring in a straight line) 68 to 84μ, average 78μ (based on measurements of 24 hooks, fully developed or nearly so, from 10 cysticerci taken from various sheep and 13 hooks from the heads of 4 adult worms). Small hooks 96 to 128μ long, average 113μ; blade (from point of blade to tip of ventral root measuring in a straight line) 48 to 60μ, average 57μ (based on measurements of 26 hooks, fully developed or nearly so, from 11 cysticerci taken from various sheep and 10 hooks from the heads of 4 adult worms).1

Calcareous corpuscles numerous in the neck, less numerous in the head, and very rare in the caudal bladder.

Adult stage (Pl. II, fig. 3; text figs. 7, 8, 9, and 10).—Length of living worms with gravid segments, 45 to 110 cm. Length (preserved material), 14 to 53 cm.; maximum width, 4 to 8.5 mm.; terminal segments, 2.5 to 15 mm. long by 4 to 6 mm. broad, usually longer than broad (measurements of 17 specimens with gravid segments). Strobila tends to twist in the form of a spiral. Head 0.8 to 1.25 mm. in breadth; neck, 0.65 to 0.9 mm. wide (measurements of 26 preserved specimens). Rostellum 375 to 430μ in diameter (8 specimens). Suckers 270 to 320μ in diameter (4 specimens). Number, arrangement, shape, and size of hooks as in larva. Segments with convex lateral borders, in consequence of which the edge of the strobila commonly presents a scalloped outline whose regularity is broken by the protuberant genital papillae. The genital papillae are irregularly alternate and are situated posterior of the middle of the segment; in gravid segments they may attain a diameter of over 1 mm. and a height of three-fourths of a mm. Genital sinus large, varying in depth and width up to a maximum of about 400μ. Cirrus pouch 450 to 550μ long; inner end near the outer side of the ventral longitudinal excretory vessel. The testicles are distributed in an area which extends anteriorly to the anterior limits of the segment and laterally to the longitudinal excretory vessels. This area is bounded posteriorly by a curved line which in sexually mature segments intersects the median line at a distance from the anterior border of the segment varying from a little more than a third to a little less than half the length of the segment and intersects the longitudinal excretory vessels a short distance in front of the posterior border of the segment, thus leaving an approximately semicircular space entirely free from testicles, most of which is occupied by the ovary. Behind the latter is the so-called yolk gland. The ovary is bilobed, the

1 Measurements of 26 hooks.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Large hooks:</td>
<td>μ.</td>
<td></td>
<td>μ.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Entire</td>
<td>156 to 188</td>
<td>160 to 184</td>
<td>173</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blade</td>
<td>76 to 80</td>
<td>68 to 84</td>
<td>75</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>79</td>
<td>75</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Small hooks:</td>
<td>μ.</td>
<td></td>
<td>μ.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Entire</td>
<td>96 to 120</td>
<td>104 to 128</td>
<td>112</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blade</td>
<td>52 to 60</td>
<td>48 to 60</td>
<td>57</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>57</td>
<td>57</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
FIG. 6.—Hooks of *Taenia ovis*, *T. hydatigena*, *T. solium*, *T. balaniceps*, and *T. krabbei*. Large and small hooks designated by the same letters are from the same heads. The hooks shown in *v* and *v* are from the type material of *T. krabbei* (B. A. I. No. 19352). Enlarged. (Original.)
antiporal lobe being slightly larger than the other. Laterally the ovary extends to
the testicular field, but anteriorly is separated from it by a space which is greatest in

the median line. Posteriorly the testicular field extends beyond the posterior limits
of the ovary but slightly, if at all, and falls short of a transverse line drawn through
the posterior border of the yolk gland.
Gravid uterus (figs. 9 and 10) with 20
to 25 lateral branches from the median
stem. Eggs (embryophores) oval, 30 by
24 to 34 by 28μ in diameter.
HOSTS.—Larval stage: Sheep (Ovis
aries); goat (Capra hircus). Adult stage:
Dog (Canis familiaris).
LOCATION.—Larval stage: Muscles
(heart, voluntary muscles, esophagus),
more rarely lungs, wall of stomach (?),
and kidneys (?). Adult stage: Lumen
of small intestine.
LOCALITIES.—England, France, Germany, Algeria, German Southwest Africa, New
Zealand, and United States.
TYPE SPECIMENS.—Probably not in existence.
REMARKS ON MORPHOLOGY AND COMPARISON WITH OTHER SPECIES
The larval stage of the sheep-measle tapeworm somewhat resembles
Cysticercus cellulosae in its general morphology. The spirally disposed
neck and head and the mammillate surface of the caudal bladder suggest
the pork cysticercus. The smaller average size and more delicate struc-
ture of the cysticercus and the shape and number of the hooks, however,
differentiate it quite clearly from C. cellulosae. The hooks are somewhat
slighter in build, have smaller blades, and are different in outline; the
number commonly exceeds the usual number found in C. cellulosae,
though the limits of variation in number are such in the two forms (24
to 32 in C. cellulosae, according to various authors, and 24 to 36 in C.

1 This record is based on a specimen in the collection of the Bureau of Animal Industry collected in April,
1912, from the heart of a goat about 2 years old, origin unknown, slaughtered at one of the abattoirs in
Kansas City, Mo.
that a definite diagnosis can not be made in individual cases on the basis of the number of hooks if this number happens to be 32 or less.

Apart from the fact that its normal location is in muscle and not on serous membranes, *Cysticercus ovis* may be distinguished from *C. tenuicollis* by its smaller size, the different relationship of the head and neck to the caudal bladder, the presence of mammillate projections on the surface of the caudal bladder instead of transverse corrugations, and the different size of the hooks. In *C. tenuicollis* the head and neck are invaginated from one end of the caudal bladder instead of from the side, as in *C. ovis* (Pl. II, figs. 1 and 5). The mammillate projections on the surface of the caudal bladder of *C. ovis* (figs. 5 and 11) are very much in
contrast to the transverse rugae on the caudal bladder of *C. tenuicollis* (fig. 12).

As the number of hooks of *Cysticercus tenuicollis* has been found by various observers to vary from 26 to 44, an accurate distinction between this form and *C. ovis* which would be applicable in all cases can not be drawn on the basis of the number of hooks, though, as a rule, the number of hooks found in *C. ov{is} is less than the number commonly present in *C. tenuicollis*. There is also an overlapping in the size of the hooks, the recorded limits for the large hooks being 170 to 220µ in *C. tenuicollis* (larva and adult) and 156 to 188µ in *C. ov{is} (larva and adult), and for the small hooks 110 to 160µ in *C. tenuicollis* (larva and adult) and 96 to 128µ in *C. ov{is} (larva and adult).

The hooks of *Cysticercus tenuicollis*, however, average considerably larger than those of *C. ov{is}, both in total length and in length of blade (fig. 6). In 25 large hooks from four adult and two larval individuals of *Taenia hydatigena* (*C. tenuicollis*) ranging in length from 180 to 212µ, averaging 197µ, the blade varied from 72 to 108µ in length and averaged 93µ; and 20 small hooks from the same specimens ranging in length from 116 to 136µ, average 129µ, had blades ranging in length from 60 to 76µ, average 68µ. The average length of 37 large hooks of *T. ov{is} (adult and larva) having a range of 156 to 188µ was 173µ, with the blade ranging from 68 to 84µ,
The average length of 36 small hooks of *T. ovis* (adult and larva) having a range of 96 to 128\(\mu\) was 113\(\mu\), with the blade ranging from 48 to 60\(\mu\), average 57\(\mu\). In form the hooks of *T. hydatigena* and *T. ovis* are very similar. The small hooks may be distinguished from each other by the fact that the ventral root, though transversely enlarged in both species, is rather deeply bifid in *T. hydatigena* (fig. 6, r), a condition which is absent in *T. ovis* or at most only faintly indicated.

Of the more common tapeworms of the dog the one with which *Taenia ovis* seems most likely to be confused is *T. hydatigena (T. marginata)*, the adult of *Cysticercus tenuicollis*. Apart from the differences exhibited by the hooks as noted above, the segments of the strobila show certain characters by which the two species may be differentiated. (Pl. II, figs. 3, 4, 5; and text fig. 6.) The strobila of *T. hydatigena* is thicker (dorso-ventrally) relatively to its other dimensions than that of *T. ovis* and the latter has a tendency to twist spirally. The segments of *T. hydatigena* have a rather regular quadrilateral form, and the edge of the strobila is comparatively straight, whereas in *T. ovis* the segments have convex lateral borders, the convexity usually being well marked, and the edge of the strobila presents a scalloped outline. The posterior margin of the segment projects more prominently in the former than in the latter species. In *T. ovis* the genital pore is in a large prominent genital papilla, and there is a large and deep genital sinus; in *T. hydatigena* the genital papilla is small and the genital sinus shallow and inconspicuous. The testicles in *T. ovis* do not extend posterior of a line drawn through the anterior border of the yolk gland parallel with the posterior border of the segment; in *T. hydatigena* they extend beyond the posterior limits of the ovary and yolk gland practically to the posterior border of the segment (figs. 7 and 8). With respect to the branching of the uterus, *T. ovis* and *T. hydatigena* are quite different, the uterus of the former having 20 to 25 lateral branches from each side of the median stem, whereas the uterus of the latter has but 5 to 8 such branches (figs. 9 and 10).

Other well-known tapeworms of the dog, such as *Taenia pisiformis* (*T. serrata*), *Multiceps multiceps* (*T. coenurus*), *Multiceps serialis* (*T. serialis*), *Echinococcus granulosus* (*T. echinococcus*), and *Dipylidium caninum*, are less likely than *T. hydatigena* to be confused with *T. ovis*. In addition to distinct morphological differences, the small size of *E. granulosus* and *D. caninum* precludes any chance of mistaking them for *T. ovis*. *T. pisiformis* may be distinguished by the large size of its hooks (the large hooks being 225\(\mu\) or more in length) and the small number of lateral branches of the uterus (8 to 10). *M. serialis* may be distinguished from *T. ovis* by the fact that the hooks are considerably smaller, the recorded limits of length of the large hooks being 135\(\mu\) and 157\(\mu\), that the ventral roots of the small hooks are distinctly bifid, and that the genital papillae are small and inconspicuous. *M. multiceps* has large hooks about the same in length as those of *T. ovis* but with blades longer
than half the total length of the hook; and as the genital sinus and genital papilla are very small, the two species may be readily distinguished from each other.

Of the less common or less known tapeworms of the dog the species of *Dibothriocephalus* and *Mesocestoides* are immediately to be distinguished from *Taenia ovis* by the absence of cephalic hooks and rostellum and by the location of the genital pores in the ventral median line of the segment. Likewise, the absence of hooks and rostellum distinguishes *Ophidiotaenia punica* (*Proteocephalus punicus*) from *T. ovis*.

The remaining species of tapeworms known to occur in the dog are *Taenia balaniceps*, *T. brauni*, *T. brachysoma*, and *T. krabbei*, all of which, with the exception of the last, may be readily distinguished from *T. ovis* upon the basis of their published descriptions.

*Taenia balaniceps* Hall (1910, pp. 139–151, figs. 1–8) differs from *T. ovis* in various particulars, among which may be mentioned the following: The worm is smaller, the length of the longest specimen being only 24 cm.; the head is smaller, not exceeding 752\(\mu\) in breadth, and the segments in corresponding stages of development are smaller. The hooks are smaller, 93 to 98\(\mu\) being given as the limits of length of the small hooks and 145\(\mu\) as the length of the large hooks (fig. 2.) The testicles extend practically to the posterior border of the segment, as in *T. hydatigena*. The lateral branches of the uterus, instead of being slender and more or less separated by intervening spaces as in *T. ovis*, are comparatively thick and are pressed close together.

*Taenia brauni* Setti, 1897 (Setti, 1897b, pp. 210–214, pl. 8, figs. 9–14), differs from *T. ovis* in that it is much smaller, its total length being from 15 to 18 cm., and the size of the posterior segments 5 or 6 mm. long by 3.5 mm. wide. *T. brauni* was described as lacking a true rostellum but as possessing a double crown of 30 hooks, the large hooks measuring 130 to 140\(\mu\), though in some cases only 95 to 100\(\mu\) in length, and the small hooks usually 85 to 90\(\mu\), occasionally 70 to 75\(\mu\), in length. *T. ovis*, however, has a well-developed rostellum and hooks considerably larger than the dimensions given for *T. brauni* and is thus clearly a different species from the latter, though the two forms agree in possessing prominent genital papillae and perhaps are similar in regard to the branches of the uterus, as Setti states that the lateral branches are numerous, slender, and perpendicular to the medium stem.

*Taenia brachysoma* Setti, 1899 (Setti, 1899c, pp. 11–20, pl. 1, figs. 1–9), is also a much smaller species than *T. ovis*, specimens with gravid segments being not over 10 cm. long and not over 3 mm. in maximum width. The number of hooks is 30 to 32. The large hooks measure 135 to 145\(\mu\) and the small hooks 95 to 105\(\mu\) in length, the former thus being considerably smaller than in *T. ovis*, and the latter averaging smaller. The ventral roots of the small hooks are described as having a median groove, thus presenting a condition intermediate between simple and

---

1 This species, as pointed out by Hall (1910, p. 140), is probably not a true parasite of the dog.
bifid, at the same time twisted so that the lateral axis tends to lie in the plane of the blade and dorsal root.\footnote{Setti does not make it clear whether this twisted condition is invariably present. The small hooks of \textit{Taenia hydatigena} commonly present a similar appearance after subjection to the pressure of a cover glass.}

The genital papillae are small and inconspicuous in \textit{T. brachysoma} and the genital sinus measures not over 170\(\mu\) in maximum depth. The lateral branches of the uterus number only 10 to 12 on each side of the median stem.

\textit{Taenia krabbei} Moniez (1879c, pp. 161–163; 1880a, pp. 44–50, 56, pl. 1, figs. 12–14, pl. 2, figs. 4–7) produced in a dog by feeding cysticerci from the muscles of reindeer is described as much longer, wider, and thicker than \textit{T. coenurus} and \textit{T. serrata} and has much wider segments proportional to their length, but its head is more delicate. It is also much larger than \textit{T. marginata}, the head is larger, and the segments are wider in proportion to their length. The genital pores are located in large papillae, often attaining a diameter of 1 millimeter, equal to the length of the contracted segment. The cysticercus according to Moniez is much smaller than the cysticercus of \textit{T. solium}. The number of hooks varies from 26 to 34. The caudal vesicle, compared to the size of the head and neck, is very slightly developed and does not contain much fluid. The orifice of invagination of the cysticercus may be either at one pole or at one side. The invaginated head and neck commonly curve spirally as in \textit{Cysticercus cellulosae}, but to a less degree. The size of the hooks is not given by Moniez.

If the stated magnification of a drawing by Moniez is correct, the length of the large and small hooks would be about 215\(\mu\) and 160\(\mu\), respectively, but inasmuch as the large hooks of \textit{C. tenuicollis}, shown in another drawing, measure, according to the magnification given, about 350\(\mu\) in length, whereas the maximum recorded length is less than 250\(\mu\), it is not unlikely that there has been some error also in stating the magnification of the drawing of the hooks of \textit{T. krabbei}, so that sizes calculated from the magnifications of Moniez’s drawings can not be considered at all accurate. Cysticerci in the Bureau of Animal Industry Helminthological Collection found in reindeer in Alaska by Dr. D. S. Neuman and corresponding to \textit{T. krabbei}, so far as may be determined from Moniez’s description and figures, except as to the size of the hooks, have hooks (fig. 6) of the following dimensions: Large hooks 150 to 170\(\mu\) in length, average 162\(\mu\), with blades 75 to 80\(\mu\) long, average 77\(\mu\); small hooks 85 to 120\(\mu\) in length, average 107\(\mu\), with blades 52 to 60\(\mu\) long, average 57\(\mu\) (measurements based on 34 large and 34 small hooks from 8 cysticerci). The average size of the hooks is thus less than the average of the hooks in \textit{C. ovis}, but they show no remarkable difference in form from those of the latter. Corresponding closely to Moniez’s findings, the number counted on eight heads varied from 26 to 32. The invaginated head and neck of the cysticercus form a much larger structure than in \textit{C. ovis} both actually and relatively to the size of the caudal bladder. On account of
their shriveled condition the size of the cysticerci could not be accurately determined; apparently, however, they are somewhat smaller than *C. cellulosae*, rather slender and considerably elongated. The cysticercus of *T. krabbei* is readily distinguished from *C. ovis* by its elongated form, by the fact that the orifice of invagination of the head and neck is commonly at one end of the cysticercus instead of at the side, and by the larger size of the body formed by the invaginated head and neck both actual and relatively to the size of the caudal bladder. On account of certain evident similarities, such as the prominent genital papillae, and on account of the lack of an accurate detailed description of *T. krabbei*, no clear distinctions can be drawn between *T. krabbei* and *T. ovis*, though, no doubt, distinct differences could be found upon comparing specimens of the two species.

Since the foregoing paragraph was written some of Moniez's cotypes have been received from Prof. R. Blanchard, one specimen of the adult (B. A. I. No. 17351) and two specimens of the cysticercus (B. A. I. No. 17352). The cysticerci, considerably shrunken, measure about 2 by 3 mm. The surface of the caudal bladder is mammillated (as is also the case in the Alaskan cysticercus), and the cysticercus in this character thus resembles *Cysticercus ovis*. The number of hooks was not determined, as most of them in the one specimen dissected were lost in mounting. Two of the large hooks measured 148 μ long and had blades 70 μ long. A small hook measured 105 μ long and had a blade 60 μ long (fig. 6, v, v'). It has thus been determined that the sizes heretofore assigned to the hooks of *Taenia krabbei*, based on Moniez's drawings, are erroneous and the apparent discrepancy between *T. krabbei* and the Alaskan cysticercus, noted in the preceding paragraph, has been removed. The ventral root of the small hooks is transversely enlarged, but is not distinctly bifid. A tendency toward the bifid condition, however, has been observed in some instances in the Alaskan specimens. The data thus far available do not indicate a specific difference between Moniez's species and the Alaskan form, and the weight of evidence is still in favor of the correctness of the presumption that the Alaskan cysticercus and *T. krabbei* are identical. The adult specimen (B. A. I. No. 17351) corresponds closely to the drawing given by Moniez (1880a). The segments are remarkable for their great breadth, as compared with their length, and the large genital papillae, about a millimeter in diameter, are quite conspicuous. As the strobila may be abnormally contracted in length, too much weight should not, perhaps, be placed upon the extreme shortness of the segments relative to their width as a feature by which *T. krabbei* may be distinguished from *T. ovis*. It seems probable, however, that there is a more or less marked difference in this respect between the two forms. The two posterior segments in the specimen of *T. krabbei*, which are gravid, are nearly as long as broad, measuring about 4 mm. in length by 4.5 mm. in breadth. They are considerably smaller than the gravid segments of *T. ovis*. A distinct difference
between *T. ovis* and *T. krabbei* is apparent in the gravid uterus. Instead of the 20 to 30 lateral branches seen in *T. ovis* there are in *T. krabbei* only about 10 lateral branches from each side of the median stem. It is quite clear from the brief study which has been made of the type material of *T. krabbei* that it is specifically distinct from *T. ovis*, although the similarity between the two species is very close in many respects.

**MACROSCOPIC APPEARANCE OF CYSTICERCUS OVIS**

The cyst of the fully developed undegenerated cysticercus as seen embedded in the muscles of its host is oval and varies in size from 4 by 2.5 mm. to 9 by 4 mm. or slightly larger (Pl. III, A and B). It is whitish in color and varies in transparency according to the thickness of its fibrous capsule, which may be very thin and rather transparent or comparatively thick and rather opaque. In transparent cysts the head and neck of the cysticercus are apparent as a small, bright, white spot showing through the wall of the cyst. Removed from its cyst the cysticercus (Pl. II, fig. 1) appears as a small oval vesicle very transparent and delicate, filled with a clear fluid, and varying in size when fully developed from 3.5 by 2 mm. to 9 by 4 mm. On one side may be seen the opaque white head and neck invaginated into the vesicle or quite commonly partially evaginated and then projecting above the surface of the vesicle. *Cysticercus ovis* is more delicate in appearance and averages in size smaller than *C. cellulosae*. It is considerably smaller than a fully developed *C. tenuicollis*.

Degenerate cysts (fig. 13, b, and Pls. III, fig. E, and IV, fig. 2) vary in size, shape, thickness of capsule, and consistency and color of contents. The sizes of 50 degenerate cysts taken at random varied from 3.5 to 15 mm. in diameter; 7 by 4 mm. was a common size. Different authors have observed cysts varying in size from that of a millet seed to that of a bean. The shape is commonly oval or spheroidal, but may exhibit various irregularities.

The fibrous capsule of the degenerate cyst may be quite thin or relatively very thick. For example, the capsule of a cyst from the masseter muscle, measuring 7 by 4 mm., was about one-third of a millimeter thick; another cyst, 5 by 2.5 mm. in diameter, from the same muscle had a capsule about three-fourths of a millimeter thick; a cyst 10 by 7 mm. from the heart had a capsule 3 mm. thick; and the capsule of another cyst, 8 by 6 mm. in diameter, also from the heart, measured one-third of a millimeter in thickness. The cavity of the cyst is commonly irregular in shape and contains besides the cysticercus a mass of caseous, caseo-calcareous, or calcareous material, or sometimes an albuminous coagulum or a soft purulent substance. The color of the contents may be white, yellowish,
greenish, orange, or brown, and several of these colors may be observed in the contents of a single cyst. In some cases the cysticercus more or less shriveled and commonly with evaginated head may be readily distinguished upon close scrutiny, but generally is to be found only with difficulty in degenerate cysts. The dead cysticercus found in degenerate cysts usually has a bright-white color which makes it more readily apparent when the contents of the cyst happen to be mostly of a contrasting color. In some of the larger degenerate cysts it is noteworthy that the cysticerci found have been no larger than those found in much smaller cysts. For example, the cysticerci found in two degenerate cysts, 10 by 9 and 10 by 7 mm. in diameter, respectively, measured in their shriveled condition 2 mm. in diameter in one case and 2½ mm. in diameter in the other and thus were somewhat smaller than the shriveled cysticercus from a cyst 5 by 4 mm. in diameter, which measured 3 by 2 mm.

DISTRIBUTION IN BODY

The cysts of *Cysticercus ovis* as found in sheep carcasses are usually comparatively few in number and are commonly limited to the heart or diaphragm, though in many such cases if the muscular parts of the carcass are cut into slices additional cysts are brought to view. Not uncommonly cysts may be found in the muscles of mastication and in the tongue. Sometimes they appear superficially on the muscles beneath the skin, sometimes in the panniculus carnosus itself. The abdominal musculature is not uncommonly affected. Degenerate cysts may be found in the lungs, and in this location they can not be distinguished macroscopically from the small degenerate cysts of *C. tenuicollis*. The parasites have been found in a degenerate condition in the wall of the esophagus. Degenerate cysts found in the wall of the rumen and fourth stomach in a lamb which had been fed segments of tapeworm (pp. 23 and 24) were probably *C. ovis*. Morot has found degenerate cysts in the kidney which may have been *C. ovis*. Degenerate cysticerci in the liver are probably not *C. ovis*, but are more likely *C. tenuicollis*, which frequently occurs in this location. In the writer's experiments none of several lambs fed segments of the tapeworm stage of *C. ovis* showed any invasion of the liver, whereas the liver was affected in each of two lambs fed segments of *Taenia hydatigena*.

*Cysticercus ovis* is therefore essentially a parasite of the intermuscular connective tissue and occurs but rarely in other locations. Except the heart and diaphragm, the parasite appears to have no distinct preference for any particular location in the carcass, and the parts named may appear to be preferred by the parasite simply because these parts are the most readily examined in post-mortem inspection, so that carcasses which have these parts affected are likely to be picked out by inspection, whereas other carcasses which may harbor cysts somewhere in the depths of the musculature are passed by because they show no cysts in accessible parts. The muscles of the head, particularly the muscles of mastication, are
frequently the seat of infestation, and these muscles may be considered as perhaps a preferred location, though this is uncertain. That the tongue is a common location has been established by Dr. W. J. Stewart of the Bureau of Animal Industry, who has found that about one-half of 1 per cent of the tongues of all sheep slaughtered at his station are infested.

LOCATION IN SHEEP CARCASSES EXAMINED IN UNITED STATES

In the cases given in Table I the carcasses were examined by slicing the musculature. The number of cysts found in various locations is given. The number found in the head in some instances includes cysts found in the tongue. The columns designated "Superficial" and "Deep" refer, respectively, to cysts elsewhere than in the heart, diaphragm, and head which were either found on a superficial examination of the dressed carcass (Superficial) or were embedded in muscle so that they were found only on dissection (Deep). Cases Nos. 1 to 6 were examined by Dr. I. C. Mattatall at National Stock Yards, Ill.; Nos. 7 to 12 and 13 to 16 by the writer at Seattle, Wash., and Portland, Oreg., respectively; Nos. 17 and 18 by Dr. R. E. Holm at Wallace, Idaho; No. 19 by Dr. E. C. Joss at Tacoma, Wash.; Nos. 20 to 25 by Dr. E. C. Joss at Seattle, Wash.; Nos. 26 to 32 by Dr. E. C. Joss at Portland, Oreg.; Nos. 33 to 35 by the writer at Chicago, Ill.; Nos. 36 to 38 by Dr. I. C. Mattatall at National Stock Yards, Ill.; and No. 39 is lamb No. 1 in the experiments already reported in this article (pp. 23 and 24).

TABLE I.—Location of Cysticercus ovis in sheep carcasses examined after dissection.

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Location of cysts</th>
<th>Location of cysts</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Heart</td>
<td>Diaphragm</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>14</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>8</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>9</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>10</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>11</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>12</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>13</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>14</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>15</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>16</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>17</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>18</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>19</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>20</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>21</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>22</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

1 X indicates numerous cysts.
2 This carcass also had degenerate Cysticercus ovis in the lungs and wall of esophagus and degenerate cysts in the wall of the rumen and fourth stomach which were probably C. ovis.
A carcass examined by Dr. O. B. Hess at Seattle, Wash., not recorded above, showed 1 cyst in the heart, 3 in the masseter muscles, 15 in the forequarters, 22 in the "rack," 13 in the saddle, and 7 in one hind leg. The number in the diaphragm or visible superficially was not stated.

Besides the carcasses referred to above there were examined in Chicago in April, 1912, by Dr. W. C. Siegmund and the writer, 59 carcasses which had been retained in the course of routine inspection on account of the presence of cyst in the heart. The examination consisted in examining carefully the diaphragm and the surface of other exposed muscles, examining the internal and external muscles of mastication and tongue after slicing them, and finally examining the cut surfaces after the carcass had been cut into three to five market cuts.

Four carcasses for which the number of cysts in the heart was not recorded showed no additional cysts. Fifty carcasses had one cyst in the heart. Ten of these had additional cysts, three having one cyst each in the diaphragm, two having one and two cysts, respectively, in the muscles of mastication, two having one superficial cyst each in the abdominal musculature and on the hind leg just below the patella, respectively, three having one cyst each on the cut surface of a hind quarter, "rack," and forequarter, respectively, and one having a cyst in the wall of the esophagus. Three carcasses which had two cysts in the heart showed no additional cysts. Two carcasses which had three cysts in the heart showed no additional cysts.

DEGENERATION OF CYSTICERCUS OVIS

The cysticerci observed in the course of the routine post-mortem inspection of sheep are usually more or less degenerated, and are either in a condition of caseation or calcification (Pls. III, fig. E, and IV, fig. 1). This does not necessarily indicate that live cysticerci are relatively rare. It may be accounted for in part by the fact that degenerate cysticerci are much more conspicuous than the live parasites and, hence, less likely to be overlooked. On the other hand, the validity of this explanation is somewhat offset by the possibility that the cysticerci remain alive only for a short period compared with the length of time they persist in the degenerated condition, in which event one would expect to find degenerated cysticerci more often than living ones. How soon degeneration may begin or how rapidly it may proceed is uncertain, but it is quite clear that in different instances the process varies considerably in these respects and in its character as well. Degeneration as noted elsewhere may occur before the cysticerci have reached their full development. It is probably often influenced by the presence of bacteria introduced by the parasite itself or carried to the cyst by the blood stream, and bacterial action may perhaps have a great deal to do with the large size commonly attained by the degenerate cysts of Cysticercus ovis.
The results of the experiments described in another part of this paper prove that degeneration may begin in less than three months after infection, but no data are at hand to show how soon the process may be completed; nor, on the other hand, is it known how long the cysticercus may remain in the tissues of its host before it dies and degenerates.

The various degenerative processes occurring in *Cysticercus ovis* have not been worked out in detail and, hence, will not be considered at length. They are quite similar, at least in some of their variations, to the processes of degeneration which affect *C. bovis* and *C. cellulosae*. A very common occurrence in the case of *C. ovis*, as already alluded to, which seems to be quite unusual in the case of the other two species, is the tendency of degenerate cysts to reach a size which is very large in comparison with the cysticercus itself. In some instances it appears that the increase in size of the cyst may go on indefinitely, fresh calcareous material being continually deposited in the cyst, associated with a breaking down of the inner layers of the capsule and a new growth peripherally.

Like the beef cysticercus, *Cysticercus ovis* tends to degenerate comparatively early when located in the heart. For example, the cysts in the heart of a lamb killed 83 days after infestation (p. 24), so far as observed, were all degenerate. Some of the cysticerci in other locations, including the muscles of mastication, were degenerate, but the great majority were alive. Except in the case of the heart, no definite relation has been observed between the location of the cysticerci and the liability to early degeneration.

The association of live and degenerate cysticerci in the same carcass is a matter of interest, though of less practical importance than in the case of beef and pork measles. In beef measles the association of live and degenerate cysticerci in the same carcass is fairly common. It is often stated in regard to *Cysticercus cellulosae* that if any of the parasites in an infested carcass are degenerated it is likely that all of those present will also be in the same condition. This is by no means invariably true. In a case of pork measles seen by the writer in October, 1912, at an abattoir in Chicago, most of the cysticerci were undegenerated, but degenerate cysticerci were quite common, particularly in the diaphragm and superficial muscles. In the case of *C. ovis*, so far as the writer's experience goes, if the cysticerci found in the heart, diaphragm, muscles of mastication, and other parts of the carcass readily accessible for examination are degenerated, the cysticerci in other parts of the body are likewise, as a rule, in a similar condition. Nevertheless, if *C. ovis* were transmissible to man, it would be unsafe, when only degenerated cysts are found on inspection, to pass a carcass for food upon the assumption that any that might be present in uninspected portions of the musculature would also be degenerated. Live and degenerated cysticerci occasionally, at least, occur together in the same carcass. As noted
above, a considerable number of degenerated cysticerci were found in a sheep 83 days after infection, though most of the parasites were still alive and undegenerated. One other case is recalled in which degenerated and living cysticerci were associated. In this case the cysticerci in the heart, diaphragm, and muscles of mastication were degenerated and partially calcified, as were several found in various portions of the body musculature, but deep in the muscles of one hind leg there was a live cysticercus showing no signs of degeneration whatever.

This accords with what would naturally be expected. One would expect live and degenerate cysticerci in the same carcass as the result, first, of variations in the longevity of cysticerci, as in the case of the experimental sheep mentioned above, or, second, as the result of infestations occurring at different times. It seems that the latter must surely occur often. In view of the close association which commonly exists between sheep and dogs, the sheep in a flock attended by an infested dog are exposed to the chance of repeated infestation, and, hence, sheep must frequently harbor simultaneously cysticerci which have come from eggs ingested on various occasions.

**DIAGNOSIS OF SHEEP MEASLES**

So far as known, the presence of *Cysticercus ovis* can not ordinarily be determined in the living animal, and its diagnosis therefore depends upon a post-mortem examination. It is not always possible to determine definitely whether cysticerci found in sheep or goats are or are not *C. ovis* without resorting to the use of the microscope, but usually microscopic examination is not necessary.

The location of *Cysticercus ovis* in muscle tissue differentiates it clearly from *C. tenuicollis*, which, so far as has yet been proved, is found only in relation with serous membranes. Cases occur, however, in which this rule can not be applied with certainty, as, for example, when the diaphragm or abdominal muscles are involved it is sometimes practically impossible to state on the basis of location alone whether the parasite in question is *C. ovis* or *C. tenuicollis*—that is, the parasite may appear to be in direct relation both with the musculature and the serous membrane which covers the musculature. Here the size of the cysticercus may help to determine its identity; if over 10 mm. (two-fifths of an inch) in diameter, it is *C. tenuicollis*; if less than this size, it is probably *C. ovis*, but may be a young *C. tenuicollis*.

The relation of the head to the caudal bladder—midway between the two ends in *Cysticercus ovis* (Pl. II, fig. 1) and at one end (Pl. II, fig. 5) in *C. tenuicollis*—will indicate the species if the parasite happens to be of a well-marked oval form. Even in very young cysticerci in which the head is yet rudimentary, the relative position of the head is the same as in the fully formed cysticercus. Cysticerci affecting the liver of sheep or
goats may be assumed to be *C. tenuicollis*. *C. ovis* has not as yet been found in the liver. Even in carcasses exhibiting heavy infestation of the musculature, the liver has not been involved. Small-sized cysticerci in the lungs, however, may be *C. ovis*, as degenerate cysticerci of this species have been found in this location in a case of heavy infestation of the carcass.

More difficulty is likely to be experienced in the identification of degenerate cysticerci than of the live parasites, and even more than in the case of the live cysticerci the location must be chiefly depended upon in distinguishing macroscopically between *Cysticercus ovis* and *C. tenuicollis*.

The cysticercal nature of degenerate cysts can often be confirmed by squeezing out the cysticercus, or fragments of it. It should be remembered that the degenerate cyst may be of a much larger size than the contained cysticercus, so that the fact that a cyst is larger than the maximum size of *Cysticercus ovis* does not necessarily exclude this species from consideration. Degenerate cysts of *C. tenuicollis* on the diaphragm or abdominal muscles commonly become more firmly calcified than those of *C. ovis* and show a white, wrinkled surface not seen in the case of the latter.

Excluding from consideration cases of invasion of the musculature by the gid bladder worm, whose true nature will be revealed by examination of the brain and the discovery of characteristic lesions in that location there are two known conditions which may be mistaken for the degenerate cysts of *Cysticercus ovis*: Namely, large *Sarcocystis* nodules and encysted foreign bodies, such as barbs from certain plants which work through the tissues and finally come to rest somewhere in the muscles and become encysted.

In the case of *Sarcocystis* nodules shown in the accompanying illustration (Pl. III, figs. C and D) there were a considerable number of nodules in the diaphragm and heart, 5 mm. and upward in diameter. The walls of these cysts were firm and thick, their contents of a purulent nature. No cysticerci or remains of cysticerci could be discovered. Instead, in each cyst there were found one or more small, transparent vesicles not visible except microscopically. These vesicles, with delicate membranous walls of homogeneous structure without nuclei, contained a finely granular substance and numerous calciform spores about 15 μ long, which demonstrated conclusively that the cysts were *Sarcocystis* cysts. Usually *Sarcocystis* cysts in sheep are so small as to be evident only microscopically, and cysts large enough to be seen with the naked eye are, so far as known, very rare. Knowledge of the characteristics of the unusual forms of *Sarcocystis* cysts such as that described above is too limited to enable one to state definitely the points by which they may be differentiated macroscopically from degenerate *Cysticercus ovis* cysts. In
the case of the latter, however, it is frequently possible by opening the
cyst and squeezing out its contents to demonstrate the presence of a
cysticercus or the visible and recognizable fragments of one. *Sarcocystis*
cysts simulating degenerate C. ovis cysts are, so far as appears from our
present knowledge, of rare occurrence, and consequently cysts occurring
in the musculature of the size and general appearance of degenerate C.
obis are presumably C. ovis unless there is evidence to show that they are
not, such as, for example, the discovery of *Sarcocystis* spores and the
total absence of any cysticercus or remnant thereof.

Illustrating the possibility of confusing encysted plant barbules with
degenerate *Cysticercus ovis* cysts is a case recently observed in which
there was a small nodule about 5 by 4 mm. in diameter in the diaphragm
in the muscle tissue just beneath the serosa. This nodule consisted of a
thin capsule and contents of a somewhat caseous consistency and might
have been taken on casual observation for a small degenerate C. ovis
cyst. Careful examination, however, failed to reveal any morphological
evidence of a cysticercus, instead of which there were found in the midst
of the caseous material three or four tiny barbules from some plant, very
finely pointed and tapering and spirally coiled. These were scarcely
evident to the unaided eye amid the caseous material, but their nature
became quite apparent on microscopic examination.

**GEOGRAPHIC DISTRIBUTION**

Abroad, cases of sheep measles have been found in England, France,
Germany, Algeria, German Southwest Africa, and New Zealand.

In this country relatively few of the numerous cases found at abattoirs
have been traced to the point of origin of the infested sheep. Cases
traced to the point of origin have been from Montana (10 counties ¹),
Idaho (5 counties ²), Washington (4 counties ³), Oregon (11 counties ⁴),
California (3 counties ⁵), Colorado (1 county ⁶), and Nevada (middle and
western part).

The parasite is probably more or less generally distributed throughout
the western United States, and is likely present also in the East, though
as yet no cases have been definitely traced to eastern localities. It is
probable that it will be found to occur wherever sheep are attended by
dogs, particularly wherever dogs have frequent opportunities of devouring
dead sheep.

¹ Rosebud, Yellowstone, Meagher, Cascade, Choteau, Hill, Blaine, Lewis and Clark, Teton, and Beaver
head Counties.
² Fremont, Bonneville, Bingham, Washington, and Canyon Counties.
³ Adams, Walla Walla, Yakima, and Klickitat Counties.
⁴ Polk, Benton, Marion, Multnomah, Crook, Gilliam, Morrow, Umatilla, Union, Wallowa, and Baker
Counties.
⁵ Modoc, Tehama, and Butte Counties.
⁶ Conejos County.
PREVALENCE

Most of the published records of sheep measles refer to isolated cases found by accident, and accordingly indicate little as to the prevalence of the parasite. Glage (1905), however, in Germany, found degenerate cysticerci in the muscles of 32 out of 2,198 (1.45 per cent) sheep carcasses examined for these parasites by inspection of the head muscles and the heart, and in 16 out of 1,984 (0.8 per cent) in which the heart only was inspected.

Table II shows the total number of sheep slaughtered at 26 meat-inspection stations in the United States during 11 months beginning January, 1912, and the number of carcasses found affected with muscle cysticerci.

**Table II.—Carcasses of sheep found affected with muscle cysticerci during 11 months at 26 meat-inspection stations in United States.**

<table>
<thead>
<tr>
<th>Station</th>
<th>Total kill.</th>
<th>Affected.</th>
<th>Station</th>
<th>Total kill.</th>
<th>Affected.</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>898</td>
<td>1 0.01</td>
<td>O</td>
<td>31,237</td>
<td>17 0.05</td>
</tr>
<tr>
<td>B</td>
<td>262,361</td>
<td>1</td>
<td>P</td>
<td>6,920</td>
<td>1 0.01</td>
</tr>
<tr>
<td>C</td>
<td>4,335,153</td>
<td>4,678 0.11</td>
<td>Q</td>
<td>110,912</td>
<td>564 0.48</td>
</tr>
<tr>
<td>D</td>
<td>150,382</td>
<td>24</td>
<td>R</td>
<td>19,708</td>
<td>120 0.55</td>
</tr>
<tr>
<td>E</td>
<td>157,953</td>
<td>12 0.01</td>
<td>S</td>
<td>59,759</td>
<td>1</td>
</tr>
<tr>
<td>F</td>
<td>61,905</td>
<td>107 0.17</td>
<td>T</td>
<td>23,381</td>
<td>132 0.57</td>
</tr>
<tr>
<td>G</td>
<td>55,205</td>
<td>10 0.02</td>
<td>U</td>
<td>161,010</td>
<td>1,469 0.91</td>
</tr>
<tr>
<td>H</td>
<td>237,799</td>
<td>1</td>
<td>V</td>
<td>2,169</td>
<td>1 0.05</td>
</tr>
<tr>
<td>I</td>
<td>1,488,997</td>
<td>2,695 0.18</td>
<td>W</td>
<td>1,435,594</td>
<td>5,739 0.4</td>
</tr>
<tr>
<td>J</td>
<td>272,379</td>
<td>35 0.02</td>
<td>X</td>
<td>526,713</td>
<td>30 0.01</td>
</tr>
<tr>
<td>K</td>
<td>36,976</td>
<td>23 0.06</td>
<td>Y</td>
<td>166,581</td>
<td>19 0.01</td>
</tr>
<tr>
<td>L</td>
<td>706,584</td>
<td>1,010 0.15</td>
<td>Z</td>
<td>86,238</td>
<td>741 0.85</td>
</tr>
<tr>
<td>M</td>
<td>91,784</td>
<td>1</td>
<td>Total</td>
<td>11,601,898</td>
<td>17,446 0.15</td>
</tr>
</tbody>
</table>

The foregoing table does not indicate accurately the prevalence of sheep measles. In the first place, many cases would necessarily be missed under methods of inspection as nearly perfect as practically possible; in the second place, the methods of inspection for *Cysticercus ovis* have not been developed to the same degree of perfection at the various stations; and finally, at certain stations the methods of inspection for *C. ovis* have reached a high degree of efficiency only in recent months, while the figures given cover also earlier months during which the inspection was less perfect and during which it may even have happened that no cases were found at all. For example, it will be noted from Table II that, in the case of Station R, 0.55 per cent of the sheep slaughtered during January to November were found to be infested. As a matter of fact, however, the great majority of the cases of measles at the station were found toward the close of the period covered; that is, 105 cases, or 2.25 per cent of about 4,300 sheep slaughtered, were found during September, October, and November.
The actual percentage of sheep infested with measles, at least in those sections of this country where a close relationship exists between sheep and dogs, probably approximates 5 per cent much more nearly than it does the very small percentage derived from the figures given in Table II.

AGE OF INFESTED SHEEP

Information as to the age at which sheep are most likely to be found infested with measles is meager. A priori it would be expected that rather young animals would most commonly show infestation. As a rule, young animals are more liable to infestation with tissue parasites than old animals, possibly because their tissues offer less resistance to the migration of the parasites than those of older animals. This greater susceptibility is offset to some extent by the fact that the longer an animal lives the more opportunity he has for becoming infested, other things being equal.

Among a total of 189 infested sheep whose ages (approximate) were recorded by inspectors of the Bureau of Animal Industry at several stations, the distribution of cases according to age was as follows:

<table>
<thead>
<tr>
<th>Number of cases</th>
<th>Number of cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 months</td>
<td>20</td>
</tr>
<tr>
<td>8 months</td>
<td>57</td>
</tr>
<tr>
<td>10 months</td>
<td>3</td>
</tr>
<tr>
<td>1 year</td>
<td>4</td>
</tr>
<tr>
<td>1½ years</td>
<td>3</td>
</tr>
<tr>
<td>2 years</td>
<td>63</td>
</tr>
<tr>
<td>2 to 4 years</td>
<td>12</td>
</tr>
<tr>
<td>3 to 5 years</td>
<td>14</td>
</tr>
<tr>
<td>4 years</td>
<td>1</td>
</tr>
<tr>
<td>5 years</td>
<td>10</td>
</tr>
<tr>
<td>6 years</td>
<td>2</td>
</tr>
</tbody>
</table>

Owing to the lack of data as to the relative numbers of sheep of these various ages which are slaughtered, the figures in the above table do not prove anything. They seem to indicate, however, that *Cysticercus ovis* is more commonly met with in young than in old sheep. As one possible explanation of the apparent rarity of *C. ovis* in old sheep it is reasonable to suppose that as the animals grow older any parasites which they may have picked up in earlier life tend to disappear more or less completely as a result of degeneration and absorption by the surrounding tissues. Meanwhile with increasing age the susceptibility to infestation diminishes, and this, combined with the death and disappearance of the parasites acquired during youth, tends to result in freedom from infestation.

ECONOMIC IMPORTANCE

Sheep measles, instead of being as formerly considered a sort of zoological or pathological curiosity, is a matter of great importance to the sheep grower, the butcher, and the consumer of mutton. Although the tapeworm cysts are not transmissible to man, mutton infested with them is not a desirable article of food, and modern ideas in meat inspection require that mutton infested with these parasites to any considerable
extent shall either be condemned or rendered into tallow, according to the degree of infestation, although theoretically there is no objection from the hygienic standpoint to passing affected mutton for food after the parasites have been removed. Practically, however, it is impossible in many cases to remove the parasites, because such extensive dissection would be required that there would be but little left of the meat when the parasites had been removed. Consequently, therefore, a large number of sheep carcasses which are retained by inspectors on account of measles go either to the tallow tank or to the condemned tank, because the character of the infestation is such that it is impracticable to remove the parasites.

At first thought it might seem that the loss on account of these condemnations would fall on the butcher, as the sheep are already bought and paid for before they are passed upon by the meat inspector, but as a matter of fact the producer is made to bear at least a part of the loss. When a condition involving losses on account of condemnations exists among live stock and continues to prevail, the butchers naturally and invariably make ample allowances in the prices paid for the probable loss from condemnations based upon their experience as to losses in the past, so that the producer, although he may not realize it, is made to bear more or less of the burden, sharing it, perhaps, with the consumer, to whom it is likely the butcher will pass on a portion of his loss.

The Federal meat-inspection records, as already noted, indicate that tapeworm cysts in the muscles of sheep are common throughout the West, and furthermore, it is safe to say that the proportionate number of cases of sheep measles found on post-mortem inspection, already representing a high percentage, will continue to increase as meat inspectors become more expert in detecting the presence of the parasites. The natural consequence will be that sooner or later, if this is not already the case, the sheep raiser will suffer a reduction in the selling price of his product below that which he would receive were it not for the losses from condemnations experienced by the butcher.

This indirect loss is in all probability not the only loss experienced by the sheep raiser. It has already been noted that in the experiments five of the lambs died in from 13 to 23 days after infestation. These died approximately in the order of the size of the doses of tapeworm eggs given, those receiving the smallest doses surviving the longest. Three of them received only the eggs contained in a single tapeworm segment, the other two receiving 3 and 10 segments, respectively. The sixth sheep, which survived, received only one-half of a segment, yet the number of eggs was sufficient to make the animal sick for a time, corresponding probably to the period during which the embryonic worms were invading and establishing themselves in the muscles. Quite clearly, therefore, the sheep-measle parasite is deadly in its effects upon sheep, provided a sufficient number of tapeworm eggs are swallowed, and even
Oct. 10, 1913

*Cysticercus Ovis*

49

if not enough are swallowed to kill the animal, it may be made sick by the invasion of the parasites. Accordingly it is quite probable that many of the cases of death and sickness, which are more or less constantly occurring among sheep without apparent cause, are the result of infestation with the measle parasite.

It has been suggested by Dr. S. W. McClure that sheep measles may be responsible for the many stiff lambs found during spring and summer on the western sheep ranges.

SIGNIFICANCE IN MEAT INSPECTION

As *Cysticercus ovis* affects the very part of the carcass which is the most valuable as food—namely, the musculature—it is of great interest in meat inspection and of special importance on account of its prevalence.

Under a system of meat inspection which recognizes but one class of meats as fit for food, such as the system provided for by Federal law in this country, it is proper to pass for food sheep carcasses which show a slight infestation with *Cysticercus ovis* after the removal of the parasites and any lesions caused by them. Carcasses showing more than a slight infestation may be rendered into edible tallow, but if heavily infested should be condemned. As a rule, packers do not take advantage of the provision which permits moderately infested carcasses to be rendered into tallow, but prefer to treat such carcasses the same as condemned carcasses and to manufacture them into inedible products. Though it is possible that all the parasites may not be found and removed from slightly infested carcasses, since it is manifestly impracticable to inspect the depths of the musculature throughout the carcass, it has been determined by experience that there is little likelihood that more than one or two, if any, cysts will be present in the depths of the muscles if only a few are found in the heart, diaphragm, head muscles, tongue, and other superficial or readily accessible parts. Accordingly, if only a limited number of the parasites are found in these locations, there is no reasonable objection to passing such a carcass after their removal.

Even if carcasses are occasionally passed which contain a few cysts that have escaped observation because hidden in the musculature, no great harm is done, since the parasites are not transmissible to man and at most can only offend the esthetic sense of the consumer. Certainly the consequences of passing such carcasses do not balance the great waste which would result if all sheep carcasses infested in any degree whatsoever (amounting to 1, 2, 3, perhaps even 5, per cent of the total number slaughtered) were excluded from use as food. In the light of our present knowledge the German regulations are unnecessarily stringent in placing sheep measles in the same category as pork measles, the basis of these regulations, of course, being the unproved and apparently altogether false assumption that the parasite concerned is *Cysticercus*
cellulosae, and hence transmissible to man. Under American regulations concerning Cysticercus cellulosae, necessarily more stringent than the German regulations because of the absence of a Freibank in our system of handling meats, no sheep carcass affected with measles even in the slightest degree could be passed for food if the sheep parasite were Cysticercus cellulosae. The demonstration of the fact that the muscle cysticercus of sheep is not Cysticercus cellulosae and that it is not transmissible to man therefore means that many thousands of sheep carcasses which would otherwise go unnecessarily to the tallow or condemned tank are saved for food, and thus fortunately one of the factors involved in diminishing our already too slender meat supply has been eliminated. Even during the year 1912, when the prevalence of sheep measles was first recognized and before the inspection for Cysticercus ovis had been developed to an efficient stage, the money value of sheep carcasses retained on account of measles amounted to nearly $100,000.

The person who kills mutton for his own use need not be so critical nor so strict with reference to sheep measles as the official meat inspector. The latter, in the absence of legal provision for a Freibank where meat not dangerous to human health but of inferior grade can be sold, has to exclude a great deal of meat from the market which is fit for food under certain conditions, though it can not properly be passed on the same basis as meat unconditionally fit for food. Home-dressed sheep carcasses, therefore, even though infested in a higher degree than would be permitted in carcasses which may pass for food under the Federal meat-inspection regulations may better be utilized for food than wasted, although here the individual will largely be governed by his own feelings in the matter, by his squeamishness or lack of it. Such carcasses, however, should not be sold, at least not without declaration of their nature, as they are obviously of less value than carcasses which are free from infestation.

So far as its detrimental effect on account of the presence of Cysticercus ovis is concerned, measly mutton may be eaten with impunity unless the parasites are very numerous or have produced a watery condition or discoloration of the meat, in which case the carcass should be discarded even though the prospective consumer may have no objections to the meat from an esthetic standpoint. In order that further propagation of the parasites may be avoided, a measly sheep carcass discarded from use as human food should not be fed to dogs unless it is first cut into small pieces not exceeding 2 or 3 pounds each and thoroughly boiled.

SURVIVAL OF CYSTICERCUS OVIS AFTER DEATH OF HOST

The length of time Cysticercus ovis may survive after the death of its host has not been determined. It will, however, live at least six days. Cysticerci in portions of a carcass shipped from Chicago on March 25, 1913, presumably the day of slaughter, and received in Washington on
March 28, were still alive on March 31. After its arrival in Washington
the meat was kept in an ice box, at a temperature not lower than 40° F.

As to the period of survival when frozen it was found in one experiment
that the cysticerci in a sheep slaughtered on October 15, 1912, were
dead on November 7, 23 days after slaughter, the mutton meanwhile
having been kept in a frozen condition. Through an oversight no exami-
nation of the mutton was made at intervening dates, so that no information
was obtained as to how long the parasites actually retained their
vitality. The cysticerci were observed by Dr. L. E. Day, who took
charge of this experiment on November 7, to be slightly shriveled after
thawing. On November 7, about half a pound of the infested mutton
was fed to a dog and similar amounts on November 8, 9, 10, and 11. On
the last date another dog was also fed. Autopsy on the former dog on
December 2, 24 days after feeding, showed no parasites of any kind in
the alimentary tract. The other dog when examined post-mortem on
January 4, 53 days after feeding, showed a few Dipylidium caninum,
but no other parasites.

From this experiment it appears probable that a period of three weeks
is sufficient, as in the case of Cysticercus bovis, to insure the death of
cysticerci in mutton. Since, however, Cysticercus ovis is not transmissible
to man, the same necessity of holding slightly affected carcasses in cold
storage for a sufficient period of time to destroy the vitality of any
cysticerci which may have been overlooked does not exist. In this
respect it is accordingly not so important as in the case of Cysticercus
bovis to know how long the cysticerci may survive after the slaughter of
its host.

PROPHYLAXIS

In addition to the highly important preventive measure of destroying
the carcasses of all dead sheep by burning, the simplest, most feasible,
and most effective means of eradication is to keep the dogs of the ranch
or farm free from tapeworms by systematic medicinal treatment. As
the sheep-measle tapeworm in dogs begins to produce eggs about two
months after infection, judging from the results obtained in the experi-
ments, it is evident that dogs should be treated about every two months
in order to remove any tapeworms acquired since the preceding treat-
ment before they have developed sufficiently to produce eggs. In prac-
tice, however, such frequent treatment seems scarcely necessary, and it
is fairly certain that effective control of tapeworm infestation can be
maintained if dogs are submitted to treatment four times a year—that is,
every three months. The following method of treatment is employed
by Dr. E. T. Davison at the Federal Quarantine Station at Athenia,
N. J., and has proved very satisfactory in the case of imported sheep
dogs quarantined and treated on account of tapeworm infestation:

Allow the dog to have the usual feed and drink about 3 or 4 p. m. on the day
preceding treatment, but give nothing further in the form of food or drink, with
the exceptions noted, until after the medicine has acted. About 10 a. m., to a dog of ordinary size, give four 10-grain capsules filled with ethereal extract of male fern (Oleoresina aspidii, U. S. P.), administering at the same time about an ounce of water or milk, preferably the latter. By a 10-grain capsule is meant one which will hold 10 grains of quinine. Forty-five minutes later give a second dose, consisting of four capsules (10-grain) filled with freshly ground areca nut, and with this give as before about an ounce of water or milk. It is important that the areca nut be freshly ground. This treatment is usually followed by profuse defecation and the expulsion of the tapeworm, if any is present, in 30 minutes to an hour after giving the areca nut. No untoward aftereffects have been noted in any case among several hundred dogs treated with this remedy. The patient is usually ready for his evening meal.

In administering the medicine an assistant stands the dog up on his haunches and holds the dog's mouth open by firmly grasping the upper jaw in one hand, the lower jaw in the other. The capsules are dropped on the back portion of the tongue, and enough water or milk is thrown in the animal's mouth to make him swallow. After administering each of the two doses the dog's head should be tied up as high as he can hold it and not choke. If this detail is omitted, the patient will almost invariably throw up the dose. During the remainder of the day the dog should be kept in confinement and the fecal discharges gathered up and burned, buried, or otherwise disposed of in such a manner as to prevent the possibility of contaminating the feed or water of sheep or other live stock.

Incidentally it may be remarked that treating dogs for tapeworm will rid them not only of the sheep-measle tapeworm but also of other species of tapeworm whose intermediate stages are found in live stock, one of which, the gid parasite, fortunately as yet not widespread in the United States, affects the brain of sheep with almost invariably fatal results. Though in certain localities coyotes harboring tapeworms are undoubtedly responsible for some of the infestation of sheep with tapeworm cysts, yet it is the dogs accompanying the sheep more or less constantly day and night and depositing their feces laden with tapeworm eggs in the immediate neighborhood of the sheep which are the chief source of infestation, and if this source is removed by keeping the dogs free from worms, the sheep can be kept practically free from tapeworm cysts of all kinds. In addition, it is important that the carcasses of all dead sheep be destroyed by burning them in order to remove this source of infection of dogs and coyotes.

SUMMARY

Sheep measles, or tapeworm cysts in mutton, were first recorded in England in 1866 and the parasite named *Cysticercus ovis* in 1869 by Cobbold. *C. ovis* usually has been considered identical with *Cysticercus cellulose*, the pork-measle parasite, and also has been confused with *C. tenuicollis*. It has been considered an intermediate stage of a human tapeworm, *Taenia tenella* or *T. solium*, and also of a dog tapeworm, *T. hydatigena* or *T. marginata*.

*Cysticercus ovis* is the intermediate stage of a dog tapeworm, *Taenia ovis* (Cobbold) Ransom. It may attain its full development in sheep in less than three months after infection, and in the dog the tapeworm may
reach the egg-producing maturity in seven weeks after the ingestion of the cysticercus.

*Cysticercus ovis* is commonly limited to the heart or diaphragm, but not infrequently occurs in the muscles of mastication and tongue and sometimes in various locations in the musculature. It may occur in the lungs, the wall of the esophagus, or the wall of the stomach. Doubtful locations are the kidney and liver. It is essentially a parasite of the intermuscular connective tissue and is evidently rare in other locations.

The cysticerci seen by meat inspectors are usually degenerated. Those located in the heart tend to degenerate early. Degeneration may be well established in less than three months after infection. Either partially grown or fully developed cysticerci may degenerate and may be associated with living cysticerci in the same carcass as a result of variations in longevity of the parasites or of repeated infections.

There is no known method of diagnosing the presence of *Cysticercus ovis* in the living animal. The parasites are to be recognised in the sheep carcass by their location in the musculature, by their small size, and by the lateral position of the head of the cysticercus, *C. tenuicollis* being found in relation with serous membranes, being of larger size when fully developed than *C. ovis*, and having its head in an apical position with reference to the caudal bladder. In some cases microscopic examination may be required to differentiate between these two species. The possibility exists of confusing degenerate cysticercus cysts with *Sarcocystis* cysts and with encysted foreign bodies, such as plant barbules.

Sheep measles have been reported from England, France, Germany, Algeria, German Southwest Africa, and New Zealand and have been found in sheep from seven Western States of this country. It probably occurs wherever sheep are attended by dogs, but has not yet been found in sheep known to have originated in the eastern United States (p. 45).

Over 17,000 of the sheep slaughtered under Federal supervision during the year 1912, prior to December 1, were found to be affected with measles. With the development of more efficient methods of inspection for *Cysticercus ovis* the number of cases detected will be relatively much more numerous. The number of infested sheep in the Western States probably exceeds, on the average, 2 per cent of the total number. Young sheep, not over 2 years of age, apparently are more likely to show infestation than old sheep.

*Cysticercus ovis* is of economic importance, first, because of the losses resulting from the condemnation of carcasses found by the meat inspector to be more or less heavily infested, and, second, because of the direct losses which probably occur among sheep as a result of the invasion of the parasites. The extent of these losses can not be estimated at present.

*Cysticercus ovis* is of special interest in meat inspection because it affects the musculature and because it is so prevalent. Carcasses which
are only slightly infested may properly be passed for food after the removal of the parasites, but carcasses showing a heavy infestation should be condemned. Moderately infested carcasses may be rendered into edible tallow, but are usually treated the same as condemned carcasses and are manufactured into fertilizer and other inedible products. As *C. ovis* is not transmissible to man, meat-inspection regulations concerning it need not be so stringent in certain respects as those governing beef measles or pork measles.

The length of time *Cysticercus ovis* may survive after the death of its host has not been determined.

The most important preventive measures against the infestation of sheep with *Cysticercus ovis* consist, first, in destroying by fire the carcasses of dead sheep on the farm or range so that they may not be devoured by dogs or wolves, and, second, in keeping dogs free from tapeworms by systematic medicinal treatment. These measures will also protect sheep from infestation with tapeworm cysts of various other kinds, which they acquire from dogs.

**BIBLIOGRAPHY**

**ARMBRÜSTER.**

**BONGERT.**

**CHATIN, JOANNES.**
1885. See Railliet, Alcide, 1885 a, p. 234.

**COBBOU), THOMAS SPENCER.**
1869 a. Entozoa; being a supplement to the introduction to the study of helminthology. London, viii+124 p., 3 fig. 4°. [Wa.]
1873 c. The internal parasites of our domesticated animals; a manual of the Entozoa of the ox, sheep, dog, horse, pig, and cat. London, ix+144 p., 28 fig. 12°. [Wa, Wm.]
1873 h. Maddox on an entozoon from the sheep. *Lond. M. Rec.*, v. 1, Aug. 6, p. 487-488. [Wm.]
1875 a. Revised list of Entozoa, with notes and references. *Veterinarian, London* (566), v. 48, s. 4 (243), v. 21, Feb., p. 102-106, (567), s. 4 (243), Mar., p. 169-172. [Wa.]
1879 b. Parasites, a treatise on the Entozoa of man and animals, including some account of the Ectozoa. London, xi+508 p., 85 fig. 8°. [Wa.]


**Cysticercus Ovis**

**Colberg.**


**Gilruth, J. A.**


**Glage, Friedrich.**


**Hall, Maurice Crowther.**


**Herter.**


**Küchenmeister, Gottlob Friedrich [Heinrich].**


1878. See Küchenmeister and Zürn, 1878–81 a, p. 104.

**Küchenmeister, Gottlob Friedrich [Heinrich]; and Zürn, Friedrich Anton.**

[1878–81 a]. Die Parasiten des Menschen. Leipzig, Aufl. 2, x+iv+5–582 p., figs., 15 pl. 8°. [Wa.]

**Leuckart, Karl Georg Friedrich Rudolph.**


1886 d. The parasites of man, and the diseases which proceed from them. A textbook for students and practitioners. Natural history of parasites in general. Systematic account of the parasites infesting man. Protozoa-Cestoda. Transl. from the German, with the cooperation of the author, by William E. Hoyle. Edinburgh, xxvi p., x 1., 771 p., 404 fig. 8°. [Wa, Wm.]

**Maddox, R. L.**

1873 a. On an entozoon with ova, found encysted in the muscles of a sheep. [Read before Roy. Micr. Soc., May 7.] Month. Micr. J., London (54), v. 9, June 1, p. 245–253, pl. 18–19. [Wa, Wm, Wc.]
MONIEZ, R[omain-Louis].
1880 a. Essai monographique sur les cysticerques. Thèse. Lille, 190 p., 1 l., 3 pl. 4°. [Wm.]

MOROT, CHARLES.

OLT.

PERRONCITO, EDOARDO.
1900 d. Esiste una Tœnia tenella diversa dalla T. solium? [Read 13 luglio.] Gior. r. Accad. di med. di Torino, an. 63, s. 4., v. 6 (8), agosto, p. 814. [Wm, Wc.]

RAILLIET, ALCIDE.
1885 a. Éléments de zoologie médicale et agricole. Paris, [Fasc. 1], 800 p., 586 fig. 8°. [Published oct.] [Wa.]

RAILLIET, ALCIDE; AND MOROT, CHARLES.

RANSOM, BRAYTON HOWARD.

RICKMANN, W.
Cysticercus Ovis

Setti, Ernesto.

1897 a. Nuovi elmiinti dell’Eritrea.  Boll. mus. di zool. [etc.], Genova (57), 50 p., pl. 8–9, 41 fig.  [Wm.]


1899 b. Una nuova tenia nel cane (Taenia brachysoma n. sp.).  Boll. mus. di zool. [etc.], Genova (71), 10 p., pl. 1, 9 fig.  [Wm.]

DESCRIPTION OF PLATES

PLATE II. Fig. 1.—*Cysticercus ovis* from lamb which had been fed eggs of *Taenia ovis* (lamb No. 1, p. 23).

Fig. 2.—*Cysticercus celluloseae*. The cysticerci have been extracted from their cysts. Natural size. (From photographs.)

Fig. 3.—*Taenia ovis*. This tapeworm was developed by feeding *Cysticercus ovis* to a dog (dog No. 6, p. 23). One-half natural size. (From a photograph.)

Fig. 4.—*Taenia hydatigena* (*T. marginata*) from an imported sheep dog.

Fig. 5.—*T. hydatigena* (*T. marginata*) from a dog (dog No. 2, p. 21) which had been fed *Cysticercus tenuicollis*. In figure 5, diagonally above and below, are shown two small specimens of *C. tenuicollis* developed in a lamb (lamb No. 7, p. 25) by feeding segments of *T. hydatigena*. One-half natural size except the two cysticerci, which are shown natural size. (From photographs.)


Fig. A.—Section of hind leg showing two "deep" cysticerci. Fig. B.—Hind leg showing three "superficial" cysticerci. (Two-thirds natural size. Original.)

Figs. C and D.—Heart and portion of diaphragm of sheep showing *Sarcocystis* nodules likely to be mistaken for degenerate cysticerci. (Two-thirds natural size. Original.)

Fig. E.—Sheep heart showing numerous small degenerate cysticerci (*Cysticercus ovis*). (Two-thirds natural size. Original.)

IV. Fig. 1.—Carcass of sheep showing a degenerate cyst of *Cysticercus ovis* at the point indicated by the penknife. (From a photograph by Dr. T. White and Dr. A. English.)

Fig. 2.—Degenerate cysts of *Cysticercus ovis* in muscle of sheep; portion of carcass shown in Plate III, figs. A and B. About natural size. (From a photograph by Dr. T. White and Dr. A. English.)