A Critical Study of the Taenioid Cestodes of the Dog (*Canis familiaris*).

by

C. Ruth Shaw

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Approved by:

Mary E. Karr
Instructor in Charge.

May 25, 1928.

H.H. Lane
Head of Department.
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A Critical Study of the Taenioid Cestodes of the Dog (Canis familiaris).

INTRODUCTION

The purpose of this study is twofold: first, to determine what species of cestodes parasitize the dogs of this locality; and, secondly, to discuss critically the anatomical details of each species. It is of interest and great value to the parasitologists to know what specific forms occur in the various localities, and previous to this time no such a study has been made in this locality. The author here presents her own interpretations of details, some of which are not in exact accord with accounts of them in the literature.

The tapeworms of the dog have attracted considerable attention for many years. The large amount of work on the commoner forms led at an early date to several valuable discoveries which have proven to be of permanent scientific importance. From an economic standpoint the tapeworms of the dog are of great importance, as several species have an intermediate stage which develops in man and in domestic animals, often with serious or fatal consequences.
The number of tapeworms which infest the dog is surprising. In numerous instances, man has been found to be host to *Dipylidium caninum*, a species of dog tapeworm. The intermediate host of this cestode is the flea or louse which parasitized the dog externally, and the larval stage may be obtained by a dog or by man ingesting such an infected flea or louse. The result of this ingestion is the development of the adult tapeworm within this new host. The majority of human infections have been in children, who have evidently been too "friendly" with their pet dogs. Rudolphi Blanchard has reported within recent years cases of such human infections.

The thirty-five dogs used for this study had been subjected to previous experimentation for other purposes, but in no case had the digestive tract, the "home" of the adult tapeworms, been disturbed. Examination was made soon after the death of the animal. All this material was provided by the Department of Physiology of the University of Kansas. The author wishes to take this opportunity to thank Dr. O. O. Stoland, head of the Department of Physiology, the instructors of Medical Physiology, and the students themselves who made it possible for her to obtain this material. All material was received in excellent condition.

The author is indebted to Miss Mary E. Larson, assistant professor of zoology, of the University of Kansas, who
was ever ready to help with a suggestion or a kindly criticism. Her assistance was of great practical, as well as inspirational, value.

LITERATURE:

According to the literature the tapeworms of the dog were considered to be of some importance by scientists of the eighteenth century. Several species were described at that early time; *Taenia hydatigena* was described and named by Pallas in 1766, and *Taenia pisiformis* was named by Gmelin in 1790. All textbooks of Parasitology pay some attention to this subject but in each it is rather limited. Veterinarian books contain more material, and it is of greater value. The bulletins published by the Bureau of Animal Industry, of the United States Department of Agriculture, and by the National Museum are of unusual value in that they deal with the latest discoveries and experiments. Many of the bulletins by B. H. Ransom, and Maurice C. Hall, both of the Department of Animal Industry, are very valuable, and have direct application to the investigation in hand. Frequently, articles appear in the different journals of biology and parasitology.

Many of the contributions have been made by the German and the French. Some of the French literature has proved helpful, but no German works were used.
METHOD OF PROCEDURE.

The dogs were all killed by excessive etherization. Immediately after death the digestive tract was removed and dropped into a jar of normal saline solution— to await examination at the earliest possible time. Within two hours after the intestinal tract had been removed it was placed on a dissecting tray for examination. Beginning at the posterior end of the large intestine the whole tract was slit lengthwise, and all tape worms were picked out by the use of forceps and dropped into a dish of normal saline solution. If it was necessary to leave them in this solution three or four hours they seemed as normal in their activity at the end of this time as when first dropped into it. The majority of them were killed and fixed in mercuric chloride solution (corrosive sublimate), which was prepared according to the following formula (Jordan, 1924):

Mercuric chloride 7 grm.
Sodium chloride .75 grm.
Distilled water 95.0 c.c.

Since the mercuric chloride dissolves very slowly in cold water the saline solution was made up first, heated, and the mercuric chloride was then dissolved in the hot solution. Mercuric chloride is an excellent fixative for cytoplasm, but gives still better results when combined with a nuclear fixative such as acetic acid. Therefore, just prior to use 5 c.c. of acetic acid should be added.
The worms were left in this fixative for two to twelve hours—the time being determined by their size. Occasionally seventy per cent. alcohol was tried for killing as well as preservation, but after several days or weeks the worms were observed to be not as firm and white as those that had been killed in corrosive sublimate and then preserved in alcohol. Formalin was tried in the same way for killing and preservation, with the same results as with the alcohol. After having been left in the sublimate the required length of time the worms were taken out and put for twenty-four hours in fifty per cent. alcohol, to which a little iodine had been added, to remove the excess of the sublimate. They were then washed in clear fifty per cent. alcohol to remove all the iodine, and finally placed in seventy per cent. for preservation. This process of killing and fixing is very satisfactory as the worms may then be preserved in alcohol for months or years. Some of the worms were later taken from the seventy per cent. and used for making in toto mounts.

No work was done on classification until the collection was complete. Preliminary classification into genera only was made by a study of external features. Later microscopic examination was employed in order to make specific identification. The technic of making in toto mounts proved to be a problem in itself. The method found to be best was the one given by Cort (in Hegner, Cort, and Root, 1923) for making
in toto mounts of trematodes and cestodes. This method with the author's modifications is as follows:

1. Specimens preserved in 70 per cent. alcohol.
2. 50 per cent. alcohol—30 min. to 1 hr.
3. 35 per cent. alcohol—30 min. to 1 hr.
4. Wash in distilled water.
5. Stain in dilute Delafield Haematoxylin (diluted about 20 or 25 times with distilled water)—for 12 to 24 hrs. according to the thickness of the specimen.
6. Wash in distilled water.
7. 35 per cent. alcohol—30 min. to 1 hr.
8. 50 per cent. alcohol—30 min. to 1 hr.
9. Destain in acid alcohol (70 per cent. alcohol with 1 per cent. HCl) until properly differentiated—two hours or more.
10. Alkaline alcohol (70 per cent. alcohol plus a few drops of .1 per cent. aqueous solution of bicarbonate of soda)—10 to 15 min.
11. Flatten between two slides and use rubber bands on each end to hold slides together.
12. 95 per cent. alcohol—24 hrs.
13. Absolute alcohol—1 hr.
14. Xylol—3 hrs., or until specimen is entirely clear; or Oil of Wintergreen may be used for
clearing, and it seems to make the specimen more transparent since it dissolves many of the calcareous corpuscles.

15. Separate the slides and add balsam to slide on which worm is left.

16. Carefully drop on cover-slip.

This method was found to be exceptionally good for all worms of the genus *Dipylidium*. In these the excretory system, and the ducts connecting the testes with the vas deferens showed extraordinarily well. It was also quite satisfactory for *Taenia pisiformis*, but for *Taenia hydatigona* and *Multiceps serialis* it did not give such good results. As Hall notes for *M. serialis*, the thickness of the worms and the number of the calcareous corpuscles make them unfavorable subjects for making in toto mounts. No special method of mounting heads was necessary as very good results were obtained by flattening each with the rest of the worm. No loss of hooks was suffered.

All of the above procedure was necessary before accurate identification of species could be made. A great number of in toto mounts were made of each species; therefore, every decision that was arrived at concerning anatomical details was the result of careful study of numerous slides.
DISCUSSION.

The two lines of interest in this research were set forth in the introduction. The first purpose was to determine just what species of taenioiud cestodes occur in Kansas dogs. Several such studies have been made in different localities throughout the world, and it is important to note the differences in frequency and distribution of each species. After studying the different genera and the species of each genus, numerous questions as to details of anatomy arose. Further anatomical studies followed and this opportunity is taken to set forth new conceptions of some of these points.

In studying the parasitism of dogs it is important to note that in his study of "Disease in Captive Wild Mammals and Birds" Fox found 188 of 890 cases of parasitism to be that of cestodes. From this it may be concluded that tapeworms are very abundant and that their hosts are far from being limited. Almost all groups of vertebrates are attacked by them. The larvae often occur in invertebrates. Until the seventeenth century these larvae were regarded as abscesses or diseased growth, but by the close of the seventeenth century their real nature had been suggested.

Cestodes have long been forms of interest to scientists. Leuckart and others thought a jointed tapeworm to be a colony composed of two generations; first, the head and
neck derived from the larva, and second, the proglottids produced by segmentation of the neck. This view of an adult tapeworm as a colony was generally accepted from 1851-1880. During the next fifteen years the varied facts of the ontogeny of this group led some authors to adopt the monozoötic view, i.e., that a cestode is one individual. Today the monozoötic view is quite generally accepted.

The following account will be divided into two parts as suggested by the foregoing discussion.

I. The Taenioid Cestodes of the Dog.

The dogs used for this study were selected at random. Practically every dog examined appeared to be quite healthy; the presence of parasites seemingly had no effect. Some dogs that seemed healthy were found to harbor hundreds of tapeworms. In some cases the intestinal tract was completely obstructed but the dogs showed no signs of such disturbances. But Ward says that Taeniasis may produce symptoms of intestinal troubles and even at times nervous symptoms akin to those caused by rabies.

Of the thirty-five dogs examined here twenty-nine were infected with tapeworms. That is only six, or seventeen per cent., of the thirty-five were free from tapeworm infection. Eighty-three per cent. seems a high incidence of infection when it is realized that it was a random se-
lection of dogs. Before final identification was made as to species it was evident that three genera were represented in the collection. These genera and their frequency are considered in the following table.

<table>
<thead>
<tr>
<th>Genus</th>
<th>No. of dogs infected</th>
<th>Per cent. of all dogs examined</th>
<th>Per cent. of the 29 infected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Taenia</td>
<td>12</td>
<td>34</td>
<td>42</td>
</tr>
<tr>
<td>Multiceps</td>
<td>6</td>
<td>17</td>
<td>21</td>
</tr>
<tr>
<td>Dipyidium</td>
<td>23</td>
<td>66</td>
<td>79</td>
</tr>
</tbody>
</table>

Of these three genera there were six species—two species of genus Taenia, a single one of genus Multiceps, and three species of the genus Dipyidium. The following table lists these species, and gives the frequency of each.

<table>
<thead>
<tr>
<th>Species</th>
<th>No. of dogs infected</th>
<th>Per cent. of all dogs examined</th>
<th>Per cent. of the 29 infected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Taenia pisiformis (Bloch, 1780a) Gmelin, 1790a</td>
<td>11</td>
<td>31</td>
<td>38</td>
</tr>
<tr>
<td>Taenia hydatigena Pallas, 1766</td>
<td>5</td>
<td>14</td>
<td>17</td>
</tr>
<tr>
<td>Multiceps serialis (Gervais, 1847a) Stiles &amp; Stevenson, 1905a</td>
<td>6</td>
<td>17</td>
<td>21</td>
</tr>
<tr>
<td>Dipylidium caninum (Linnaeus, 1758a) Railliet, 1892v.</td>
<td>9</td>
<td>26</td>
<td>31</td>
</tr>
<tr>
<td>Dipylidium sexcoronatum von Ratz, 1900a</td>
<td>16</td>
<td>46</td>
<td>55</td>
</tr>
<tr>
<td>Dipylidium walkeri Sondani, 1923.</td>
<td>4</td>
<td>11</td>
<td>14</td>
</tr>
</tbody>
</table>
The life history of each species is important if one is to understand clearly the reason for the variation in frequency of the different species. The intermediate host, or that animal in which the larval stage of the adult develops, may determine the distribution and frequency of the cestode by its distribution. Thus, if a *Dipylidium caninum* lived in a dog of a locality where the dogs had no fleas or lice, and thus no intermediate hosts for this species of tapeworms in which the eggs of the adult might develop, it means that that particular worm would have no progeny.

The most common intermediate host of *Taenia pisiformis* is the rabbit, so it is readily understood why this species should be found so frequently in this locality since rabbits are so very numerous here. *Cysticercus pisiformis* develops in the mesentery and omentum of rabbits, and has been found in the mouse and beaver. Braun and Lühe report the occurrence of the cysts in the liver of hares. Ackert and Grant assert that the usual intermediate host is the cottontail, and occasionally the cysticercus which is about the size of a small pea is found also in hares and mice. They found by experiment that this dog tapeworm may develop in the young cat, *Felis domestica*. Ackert's experiments on cysticerci of *Taenia pisiformis* show that it will not develop in fowls and previous investigations prove that it fails to develop in man (it has been reported in man, but these reports have been found to be erroneous), or in swine. It was found that
evagination of C. pisiformis occurs in the duodenum of the domestic cat. Scott's experiments show that these cysts may be caused to evaginate in an artificial manner. The cysticerci must be treated with artificial gastric juice, and then immersed in artificial pancreatic juice. This is an easy method of obtaining material for preservation. Scott feels that this suggests a way in which it may be determined why many tapeworms have a specific definitive host. Such an explanation may be that the special host furnishes the right stimulus at the right time to call forth the proper reaction of the cysticercous.

An interesting specimen of Taenia pisiformis is the "three-sided" tapeworm found in a very heavily infested dog. Each proglottid, from the youngest to the most mature, is triangular in cross-section. Maurice C. Hall, of the U. S. Dept. of Agri., says it is "one of the trihedral tapeworms, and this form of abnormality has been reported a number of times for a number of species". This particular specimen, which is immature, measures nine inches in length.

The fact that a relationship exists between cysts and tapeworms was made known for the first time by Pulles in 1760-67 when he worked out the life history of Taenia hydatigena. T. hydatigena is called the large tapeworm of the dog. The bladder-worm, Cysticercus tenuicollis, of this species is found in the omentum of sheep. Most authorities
say that the larval stage lives in the peritoneal cavity of ruminants and the pig, and occasionally in the monkey and the squirrel. It was reported that *C. tenuicollis* was observed in a man in North America, but the case is not quite certain as the number of hooks was less than that of *C. tenuicollis* and coincided with that of *Cysticercus cellulosae*, the larval stage of *Taenia solium*, though the size appeared to be that of *C. tenuicollis*. This is according to Pantham, Stephens and Theobald. The oncosphere develops when ingested by the pig, goat, or sheep. It is freed from the egg shell in the stomach and not in the intestine of the host, and passes through the blood vessels to the liver, and later migrates to the omentum or abdominal cavity. In the liver distinct changes are observable which have led to the conclusion that there is a secondary migration out of the liver into the abdominal cavity where further development takes place. *C. tenuicollis* is a large cyst; sometimes called a "water ball"; it may be one and one-half inches in diameter. The development of the oncosphere of *T. pisiformis* is thought to be similar to that of *T. hydatigena*.

Underhill states that from the standpoint of medical interest the cysticerci of *Taenia hydatigena* rank third, following *Cysticercus bovis*, the cystic stage of *Taenia saginata*, and *Cysticercus cellulosae*, of *Taenia solium*, which rank first and second respectively. *C. tenuicollis* has its development
under serous membranes of the sheep principally, but it may occur in other ruminants and in the pig. Infestation is by water or food bearing ova which have been spread about by dogs harboring the adult worm. The migration of the parasites causes hemorrhagic trails. The head is fully developed about the fortieth day after infestation by the ovum, and the vesicle reaches its full growth at about the seventh month. The location and size of the cysts render them easy of elimination from parts which may be used as human food. These cysts produce the condition known as measles in sheep.

Ransom described another type of measles in sheep, in which the cysts occur in the muscles instead of in the serous membranes as Cysticercus tenuecollis do. This cysticercus is known as Cysticercus ovis, the larval stage of the common dog tapeworm, Taenia ovis, of the United States. The location of the cysts is usually diagnostic in the case of these two species. Another differentiating feature is found in the size of the cysts— if more than two-fifths of an inch in diameter it is C. tenuecollis, but if less than that it is C. ovis. It is readily perceived that measles of either type depreciates the value of the meat, especially that type which is found in the muscles.

Very few sheep are raised in this part of Kansas, a
fact that may explain why no *Taenia ovis* was found in these dogs. *Taenia hydatigena* was found in five of the thirty-five dogs examined, but this may be explained by the fact that other ruminants, than sheep, and pigs may harbor the intermediate stage of this species.

Hall and Wigdor, 1918, say that *Taenia pisiformis* is probably the commonest of dog tapeworms belonging to the genus *Taenia*. Ward found it present in forty-five per cent. of the dogs examined in Lincoln, Nebraska, but Hall found it in only six, or three per cent., of the two hundred dogs he examined at Detroit, Michigan. This difference in distribution Hall explains in the following words—"As long as dogs have access to wild hares and rabbits, which harbor the larval forms, this tapeworm will be common in dogs. It is commoner in dogs in the country and small cities than in large cities." Of *Taenia hydatigena* he says that it seems to be less common than it was twenty years ago. This, he thinks, is due to the increase in "application of adequate meat inspection to the abattoirs of the United States and the increased care in the disposal of slaughter house refuse will make this worm increasingly scarcer". This he predicated in 1918. It was found in only two of the two hundred dogs examined at Detroit. He thinks that as the farmers learn the impropriety and danger of the primitive method of disposing of the viscera of slaughtered animals *T. hydatigena* may
be one of the first dog tapeworms to become extinct.

When this study was begun it was a question whether or not to expect any Multiceps multiceps. Results show that no Multiceps of this species was found. This is really an important result for had they been found it would have raised the question whether or not the sheep of this locality are being exposed to infection by this parasite which in its larval form causes that distressing condition called gid, stumpy, stagers, or turn sick. Sheep are more commonly affected than cattle and other animals. It is a common disease in Europe, but has been of rare occurrence in the United States. The symptoms are the result of the activity of Coenurus cerebral-\*\*, the intermediate stage, in the central nervous system of the intermediate host. However, Multiceps serialis is often mistaken for M. multiceps.

Multiceps serialis is found in the dog, but all attempts to infect cats and ferrets with it have failed. Scott proved that the cysticerci of this species would not infect pigs. Ackert's experiments show that cysticerci of this species will not develop in fowls. Neither do they develop in man. The larval parasite is found in the rabbit—more commonly in the wild ones than in the domestic varieties. Scott reports that his cyst may grow to be as large as a goose egg, and that a single jack rabbit may have as many as half a dozen or more of these so-called "water-blisters" in
various stages of development. Sondhi thinks the wild hare of India serves as intermediate host for this species in India for there are no rabbits in that country. Its larva is a coenurus named Mmulticeps serialis (or Coenurus serialis). M. serialis is of comparatively little economic importance, but deserves attention because some investigators, particularly among the Italians, insist upon identifying it with Mmulticeps multiceps.

Of the two hundred dogs examined by Hall and Wigdor in Detroit forty-five per cent. had Dipylidium. Sondhi reports, after examining the dogs of Lahore, that sixty-five per cent. of the worms collected belonged to this genus. As shown in the above table twenty-three, or sixty-six per cent., of the dogs examined here had Dipylidium infection.

The intermediate hosts of Dipylidium caninum are the dog flea, Ctenocephalus canis, the human flea, Pulex irritans, and the louse, Trichodectes latus. These intermediate hosts have such a close relationship to the dog and its environment that it is easily understood why the per cent. of infection with this species is so high. The larval stage, Cryptocystis trichodectes, develops and lives in the body cavity of the flea or louse. The life histories of Dipylidium sexcoronatum and Dipylidium walkeri are not known. The frequency of D. sexcoronatum is sufficient to suggest the possibility of the fleas and lice serving as intermediate
hosts for this species as well as for Dipylidium caninum.

Contrary to all expectations, Dipylidium caninum was not the most frequent species of this genus. Dipylidium sexcoronatum, the most frequent of the species here, received little recognition until about 1917. In 1918 Hall and Wigdor recorded the impression that it was as common as Dipylidium caninum. G. Sondhi in writing of this genus after having made a study of the tapeworms of the dogs of Lahore says: "Contrary to expectations the type species Dipylidium caninum was not met with in the material from Lahore, it seems certain that the form recorded by Gaiger (1915) and other authors under this name as occurring in dogs of Northern India must belong to one of the other species of the genus. The species found to be the most abundant in the Lahore dogs failed to agree in many characters of importance with any known form and is here described as new". Sondhi described this new species and named it Dipylidium walkeri. It is of interest that in the author's collection of Dipylidium there are worms from four dogs which correspond very closely to his description of this new species. The evidence is quite strong that such is the case, hence they are recorded as Dipylidium walkeri. These specific differences will receive further consideration in the following discussion.

The following chart considers all adult tapeworms of the dogs studied, their larval stages, and their intermediate
hosts.

<table>
<thead>
<tr>
<th>Adult.</th>
<th>Type of larval stage.</th>
<th>Name of larval stage.</th>
<th>Intermediate host.</th>
<th>Location of larva in host.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>2. Taenia hydatigena.</strong></td>
<td>Cysticercus.</td>
<td>Cysticercus taenicollias.</td>
<td>Ruminants, esp. sheep, and pigs.</td>
<td>Peritoneum</td>
</tr>
<tr>
<td><strong>5. Dipylidium sexcoronatum.</strong></td>
<td>?</td>
<td>?</td>
<td>Fleas and lice (?).</td>
<td>?</td>
</tr>
</tbody>
</table>

In the above discussion mention has been made of a few of the diseases which are carried by dogs. These diseases may be more prevalent in other countries than they are in the United States but Ransom considers this problem of dogs as carriers of disease a serious one. Considerable progress has
been made in recent years toward the suppression of unrestricted dogs in the United States. Any great reduction in the prevalence of parasites of live stock which are transmitted by dogs is not likely to be observed until live stock owners appreciate more generally the importance of these animals as carriers of disease. The results of this study emphasize the importance of the urgent argument which Ransome makes for the elimination of the vagrant and the proper control of all other dogs.

II. Descriptions of Species with Discussion of Some of Anatomical Details.

In 1919 Hall published an exceedingly valuable paper on "The Adult Taenioid Cestodes of Dogs and Cats, and of Related Carnivores in North America". In this paper he includes keys for each superfamily, for each subfamily, and for each genus; as well as a complete life history and description of each species. His descriptions of the hooks of each species are lengthy; many of these detailed differences the writer of this paper found hard to discern in her own study. All of the following descriptions have been checked with this work, and some of the anatomical details are discussed at length in the light of what was seen on the author's in toto mounts. The illustrations which Hall used
were the result of a collation from the published works of many different investigators. Some of them are excellent while others are not so good. All figures accompanying this paper are the result of careful study and exact reproduction of details as found on the author's own slides.

It is often desirable to determine at least the genus to which a cestode specimen belongs. The following very simple key has been worked out with that aim in view; genera of all dog tapeworms (including the genus *Diphyllolothrium*) may be determined by its use.

1. Unarmed; genital pores not lateral ----- 2.

   Armed; genital pores lateral --------- 3.

2. Uterus forms an elongate sac
   in the median field of the
   gravid proglottid ----------- Genus *Mesocestoides*.
   Uterus forms a rosette in
   the gravid proglottid ------ Genus *Diphyllobothrium*.

3. Two genital pores to each
   segment ------------------ Genus *Dipylidium*.
   A single genital pore to each
   segment ------------------ 4.

4. Strobila less than one centimeter long ----------- Genus *Echinococcus*.
   Strobila at least several centimeters long --------- 5.
5. Vagina usually showing a reflex loop in the vicinity of the longitudinal excretory canals ———— Genus *Multiceps*.

Vagina straight or curved in the vicinity of the longitudinal excretory canals ———— Genus *Taenia*.

The author feels that the following classification is sufficient for the identification of any cestode, and hence inserts at this point the classification of the beef tapeworm, *Taenia saginata*, of man. This form will be followed throughout this paper.

Phylum *Platyhelminthes*.

Class Cestoda.

Superfamily *Taenioidea* Zwicko, 1841.

Family *Taeniidae* Ludwig, 1886a.

Subfamily *Taeniinae* Stiles, 1896b.

Genus *Taenia* Linnaeus, 1758a.

Species *saginata* Goeze, 1782.

Genus *Taenia* Linnaeus, 1758a.

Generic characteristics.

The hooks of the genus *Taenia* are quite large, and are arranged in a crown of two rows on a distinct rostellum.

There is no outstanding generic character descriptive of the
head—the shape depends greatly upon the amount of muscular contraction. The strobila is composed of from ten to hundreds of segments. The worms of this genus are large and thick in comparison with those of the genus Dipylidium and comparable to those of the genus Multiceps. The larvae are cysticerci in mammals; the adult lives in carnivorous mammals.

Type-species—Taenia solium Linnaeus, 1758a.

Taenia pisiformis (Bloch, 1780a) Gmelin, 1790a.

Synonyms—

Vermis vesicularis pisiformis Bloch, 1780a;
Hydatigera pisiformis (Bloch, 1780a) Goeze, 1782a;
Hydatigera utriculenta Goeze, 1782a;
Hydatigera cordata Batsch, 1786a;
Hydatigera utricularis Batsch, 1786a;
Vesicaria pisiformis (Bloch, 1780a) Schrank, 1788a;
Taenia serrata canis domestici et vulpis Rudolphi, 1793a;
Cysticercus pisiformis (Bloch, 1780a) Zeder, 1803a;
"Taenia serrata Goeze" of most authors;
Taenia novella Neumann, 1896f.

Specific characteristics.

The head (figure 1, Plate I) is approximately 1.3 mm. in diameter, and the rostellum is large and powerful. The large hooks, arranged as a double crown on the rostellum, u-
usually number 38, 40 or 42. The hooks of the more anterior row are larger than those of the second row. Viewed from the front the head is approximately square, with a sucker in each corner. The suckers are round to elliptical with a maximum diameter of about 310 microns. The neck is but slightly narrower than the head and is about 700 microns long.

Hall says that the strobila attains a length of 60 cm. to 2 meters, average specimens being 90-100 cm. long and consisting of about 400 segments. In this collection the average length is not more than 60 cm. The first segments are very short and much wider than long. 150 to 175 of these immature segments precede the mature ones. The mature segments are about equal in width and length, and are about 12 to 15 cm. behind the head. These mature segments measure a little over 4 mm. in width. Posterior to these mature proglottids the older ones are being transformed into ripe (or gravid) proglottids. The gravid segments attain the length of 1 cm., and the width of about 4 mm.; they make up half or more of the length of the strobila. The serrate appearance of the strobila is due to the fact that the posterior angles of all segments are quite prominent. The ladder arrangement of the excretory canals shows up very nicely. The genital pores are very irregularly alternate, usually two or four in succession on one side and rarely more than six in succession. The genital papilla is only moderately prominent and is loc-
ated near the middle of the lateral edge of the segment, though in a gravid proglottid it may be somewhat posterior.

The details of the male and female genitalia are shown in the drawing of the mature proglottid, figure 2, plate I.

**Male genitalia**—The testes, of which there are 400 to 500, are arranged in two strata in each segment. They are round and measure about 100 microns in diameter. They occupy nearly all the field between the longitudinal excretory canals not actually occupied by other genital structures. The field between the ovaries and the space between the vas deferens and the vagina are clear from testes. They press close up to the ovaries and may be seen posterior to the vitellarium. The fact that they are two layers thick dorso-ventrally explains the reason for only about 500 showing in the drawing; some are overlying others. The *vasa efferentia* (which were not visible on these slides) open into a distinct seminal vesicle, which is located on the pore side of the median stem of the uterus. This vesicle does not show so definitely in every mature proglottid, and in those in which it is definitely stained it is more anterior than Hall's illustration shows it to be. From the seminal vesicle the *vas deferens* goes through the cirrus pouch, which extends from the genital pore to and across the excretory canal, and often extends still farther inward.

**Female genitalia**—The ovaries are somewhat peniform but
but rather loose in structure. The ovary on the sporal side is slightly larger than the one on the pore side of the median uterus. The vitellarium is quite large, extending laterally past the outermost edges of the ovaries. The shell gland is spherical, and is located just anterior to the vitellarium and between the ovaries. The vagina extends inward from the genital pore, with only a slight curve in the region of the excretory canal. When it reaches the median field it bends posteriorly and continues down to the shell gland. In the mature proglottid the uterus is only a single median stem, which sends out lateral branches as the proglottid becomes gravid. The gravid proglottid is practically filled with this greatly branched uterus, every branch of which is filled with eggs. Most of all other reproductive organs have degenerated and only remnants of the vagina and the vas deferens remain. Each side of the main stem of the uterus may bear 6 to 14 branches (figure 3, Plate I), which produce smaller secondary branches.

_Taenia hydatigena_ Pallas, 1766.

**Synonyms--**

_Lumbricus hydropicus_ Tyson, 1691a, pre-Linnaean;

_Hydra hydatula_ Linnaeus, 1767a;

_Vermis vasicularis_ eremite Bloch, 1780a;

_Hydatigena orbicularis_ Goeze, 1782a;
Taenia marginata Batsch, 1786a;
Cysticercus temnicollis Rudolphi, 1810a.

Specific characteristics.

The head (figure 4, Plate II), which is somewhat larger than that of Taenia pisiformis, is very little broader than the short neck. The strong rostellum bears a crown of two rows of hooks. The number of hooks may vary between 26 and 44, but the most usual number was found to be 38 or 40. The hooks of Taenia hydatigena are somewhat smaller than those of T. pisiformis; and those of the more anterior row are a little larger than those of the second row. The four suckers are situated on the "corners" of the head, and measure a little less in diameter than those of T. pisiformis. Hall says the length of the strobila may be anything between 75 cm. and 5 meters; the average strobila being two meters long and consisting of 650-700 very thick segments. The specimens obtained from this group of dogs were no so long, but, though obtained in pieces, an estimate of a meter at least would be safe for average length. The segments immediately posterior to the head are quite wide and very short, these gradually get larger as they are pushed backward but even when mature, with 300 segments between them and the head, they are a little wider than long. A proglottid becomes gravid when there are about 500 or 600 proglottids anterior
to it. When gravid, the proglottids are quite long, being about twice as wide as long, measuring 10 mm. by 5 mm. The margins are quite smooth; since there is no serration and the genital papillae are very inconspicuous. The genital papillae are near the middle of the lateral margins of all the segments. They are very irregularly alternate. The excretory system is of the same nature as that of *T. pisiformis*.

All the details of the mature proglottid of *Taenia hydatigena* are shown in figure 5, Plate II.

**Male genitalia**-- The great number of 600 to 700 small testes is compactly placed in one plane (in a single stratum). These practically fill all the area between the longitudinal excretory canals not occupied by other reproductive organs. The vas deferens arises, without a seminal vesicle, in the median field of the segment, and its numerous coils and loops often overlap the vagina. The cirrus pouch extends inward from the genital pore to the longitudinal excretory canal, or it may extend about half way across it.

**Female genitalia**-- The ovary on the pore side is quite circular while that on the aporal side extends farther anteriorly. The vitellarium is rather large but does not extend beyond the lateral edges of the ovaries. The spherical shell gland lies just anterior to the vitellarium and between the ovaries. The vagina makes a distinct curve posteriorly and then returns to the level of the genital pore. This very characteristic curved portion is considerably thicker than the re-
mainder of the vagina. As it nears the median field it begins to curve posteriorly and ends in the shell gland region. The connections of the ovaries to the vagina, vitellarium and uterus could not be completely worked out from this material. The vagina frequently crosses over the uterus in the interovarian field. In the mature proglottid the uterus is only the one median stem, but as the proglottid ripens this uterus sends out numerous lateral branches (figure 6, Plate II), Some authorities give eight as the maximum number of lateral branches on each side but both Hall and Underhill consider ten as a frequent number. Figure 6 shows seven on one side and ten on the other.

According to Hall Stiles figured a striking median groove with a posterior notch on the gravid segment. Furthermore he reports that Deffke had apparently overlooked it and he himself had found no mention of it. Special examination was made of all material here with this in mind, but no trace of such a peculiar structure was ever found.

It was much more difficult to get good in toto mounts of *Taenia hydatigena* than of *Taenia pisiformis*. The proglottids of this species are thick and therefore hard to stain as well as difficult to flatten. The details of the above were worked out as a result of much labor in the making of only fairly good mounts.
Genus *Multiceps* Goeze, 1782a.

**Generic characteristics.**

The strobilat stage is similar to that of the genus *Taenia*. The vagina usually shows a reflexed loop in the vicinity of the lateral excretory canals. The larval stage is a coenurus, a bladderworm with a parent vesicle to which are attached numerous heads, internal or external daughter bladders being present or absent.

Type-species-- *Multiceps multiceps* (Leske, 1780a)
Hall, 1910.

*Multiceps serialis* (Gervais, 1847a) Stiles and Stevenson, 1905a.

**Synonyms--**

*Coenurus serialis* Gervais, 1847a;
*Taenia serialis* (Gervais, 1847a) Baillet, 1863a;
*Coenurus cuniculi* (Diesing, 1863b) Cobbold, 1864b;
*Coenurus lowzowi* Lindemann, 1867a;
*Multiplex serialis* (Gervais, 1847a) Liatard in Hall, 1911.

**Specific characteristics.**

The head (figure 7, Plate III) is smaller than those of the genus *Taenia* described above, though Hall describes it as being as large or larger. The rostellum bears a doub-
le crown of 26-32 hooks, usually 30 or 32. The more anterior row of hooks are slightly larger than those of the second row. These hooks are smaller than those of the genus *Taenia*. The suckers are of good size with muscular bulbs. The neck is fairly distinct and is about 1 mm. long. The length of the strobila may be 20 to 72 cm., with a maximum width of 5 mm. The mature proglottids are particularly thick dorso-ventrally and are wider than long, while the gravid segments are somewhat thinner and are considerably longer than wide—measuring 6-12 mm. by 3-4 mm. The margin is rather irregular due to the normal convexity of the segments and the prominence of the genital papillae. The genital papillae are very prominent and are a little posterior to the middle of the edge of the segment, and often they are much posterior in the gravid segments.

Figure 8. Plate III. shows a mature proglottid in detail. 

Male genitalia—The testes are numerous, 600-600, and are close together throughout the whole field between the longitudinal excretory canals of the segment. In the less mature segments they do not fill the median field and to depend upon the determination of the species by these segments only will not separate *Multiceps serialis* from *Multiceps multiceps*, which has few testes with the whole median area of the segment practically clear. Hall says the area between the vas deferens and the vagina is filled, but this was not observed to be
the case in any of the present author's material. The vas deferens arises somewhere in the median field on the pore side of the segment, and makes several though rather small loops as it extends to the genital pore. Hall says that the cirrus pouch is a very narrow elongated, nozzle-shaped structure. Such a cirrus pouch was seen in none of the specimens examined in making this study. On the contrary the cirrus pouch was found to be rather slender but short and sometimes it extends only about half way in to the longitudinal excretory canal, while in other cases it reaches the canal.

Female genitalia— The ovaries are somewhat reniform in shape, but the one on the aporal side of the segment is considerably larger. The vitellarium is rather short, horizontally, and is quite thick. The shell gland lies between the ovaries just anterior to the vitellarium. The vagina, as it extends toward the median field, makes a reflex loop near the longitudinal excretory canal. In nearly every in toto mount of this species several segments were found to have the vagina practically straight with only a graceful curve in this region, while the remainder would be either decidedly looped or intermediate between the two types. As it nears the median field the vagina curves posteriorly, and often it crosses the uterus before it reaches the vicinity of the shell gland. The uterus of the mature proglottid is only the long slender median stem while that of the gravid proglottid (figure 9, Plate III)
completely fills the area between the longitudinal excretory canal regions. Hall states that there are twenty or twenty-five lateral branches on each side of this stem or so many, which in turn sent out anastomosing branches, that a count is impossible due to their fusion. In the gravid proglottids examined here the anastomosing branches were certainly evident but the count of lateral branches was not always so great as given above. Some of the posterior margins of these segments had pronounced flaps which overlapped the anterior portions of succeeding segments.

This worm was also found to be a very difficult one to make into good in toto mounts. Hall also reports that "the thickness of this worm and the number of calcareous corpuscles make it an unfavorable subject for toto mounts". In spite of this fact some pretty good mounts were obtained after repeated attempts.

The illustration of the mature proglottid of *Multiceps serialis* in Hall's paper is at fault in many details. The accompanying drawing was the result of first hand observation. But the reflex loop of the vagina, the distribution of the testes, the number of hooks, and the pattern of the uterus make it certain that it is *M. serialis*.

When making this study a number of worms were sent to Dr. Hall, of the Bureau of Animal Industry, at Washington, D. C., for identification. According to external appearance
he thought that some of them had heads which resembled that of the species *Taenia brauni* Setti, 1897b, a species which had not been described from this country. He suggested that a careful study be made to determine whether or not such be the case. After making some in toto mounts, which were difficult because the worms were so thick, the result was doubtful. The matter was dropped for a while and then returned to after examining the *Multiceps serialis*. When careful comparisons had been made between these two series of specimens, they were found to be all of the one species *M. serialis*. The hooks of all were alike in shape, size and number. The region of the genital pore of the former was, at first, thought to be distinctly different from that of the *M. serialis*, but careful examination revealed some segments to have very decidedly reflexed vaginas, while some of the undoubted *M. serialis* had segments with practically straight lines in the vagina. The limits of such variations of the species *M. serialis* as may occur in the region of the genital pores of a single specimen was somewhat astounding. The prominence of the genital papillae in all was distinctly like *M. serialis* in nature. Setti does not describe the uterus of the gravid proglottid of *T. brauni*, but all that were observed here had the form of the other species. Setti does not give a very detailed description but this study leaves no doubt as to the certainty of the identification of these specimens.
Comparison of *Taenia pisiformis*, *Taenia hydatigena*, and *Multiceps serialis*.

Any one of the larger tapeworms of the dog generally proves to be one of these three species. Without a knowledge of the life history identification would have to be based upon examination of the external features, though resort to microscopic examination of an in toto mount would be necessary in order to be absolutely sure of the identification. Some of the external features are quite reliable, but if a single specimen only is at hand—no comparison being possible—the best method of identification is by a careful microscopic examination.

The following chart sets forth the most clearly differentiating features of the three species.

<table>
<thead>
<tr>
<th></th>
<th><em>Taenia pisiformis</em></th>
<th><em>Taenia hydatigena</em></th>
<th><em>Multiceps serialis</em></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Length</strong></td>
<td>60-100 cm.</td>
<td>75 cm. to 3 m.</td>
<td>20-72 cm.</td>
</tr>
<tr>
<td><strong>Margin</strong></td>
<td>Decidedly serrated.</td>
<td>Quite smooth and continuous.</td>
<td>Somewhat irregular.</td>
</tr>
<tr>
<td><strong>Genital papillae</strong></td>
<td>Quite prominent.</td>
<td>Very slightly prominent.</td>
<td>Very prominent.</td>
</tr>
<tr>
<td>Number of hooks and their length.</td>
<td>Number of testes.</td>
<td>Size of testes.</td>
<td></td>
</tr>
<tr>
<td>----------------------------------</td>
<td>------------------</td>
<td>----------------</td>
<td></td>
</tr>
<tr>
<td>34-48.</td>
<td>225-294 microns</td>
<td>122 by 96 microns in diameter.</td>
<td></td>
</tr>
<tr>
<td>1st. row--</td>
<td>2d. row-- 132-177 microns.</td>
<td>Over nearly all the field between the excretory canals not occupied by other genital structures; in two strata (two layers). Occasionally a few are found posterior to the vitellarium.</td>
<td></td>
</tr>
<tr>
<td>26-44.</td>
<td>170 to 220 microns</td>
<td>Very thickly distributed throughout all of the area between the excretory canals not otherwise occupied.</td>
<td></td>
</tr>
<tr>
<td>1st. row--</td>
<td>2d. row-- 110 to 160 microns</td>
<td>Extends to or just past the outer edge of the excretory canal.</td>
<td></td>
</tr>
<tr>
<td>26-32.</td>
<td>125-175 microns.</td>
<td>Sometimes extends only part way to and sometimes reaches excretory canal.</td>
<td></td>
</tr>
<tr>
<td>1st. row--</td>
<td>2d. row-- 78-120 microns.</td>
<td>Usually with a definite reflex loop in region of excretory canal. Sometimes almost straight.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Distribution of testes.</th>
<th>Length of cirrus pouch.</th>
<th>Vagina.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extends to or beyond the inner edge of the excretory canal.</td>
<td>Slightly dilated with a graceful curve in the region of the cirrus pouch.</td>
<td>Branches thicker. 5-10 on each side of median stem.</td>
</tr>
<tr>
<td>Extends to or just past the outer edge of the excretory canal.</td>
<td>Decidely dilated and a definite crescent-like curve in region of cirrus pouch.</td>
<td>Secondary branches.</td>
</tr>
<tr>
<td>Extends to or just past the outer edge of the excretory canal.</td>
<td>Sometimes extends only part way to and sometimes reaches excretory canal.</td>
<td>Usually with a definite reflex loop in region of excretory canal. Sometimes almost straight.</td>
</tr>
<tr>
<td>Extends to or just past the outer edge of the excretory canal.</td>
<td>Usually with a definite reflex loop in region of excretory canal. Sometimes almost straight.</td>
<td>Lateral branches numerous. Secondary branches anastomose.</td>
</tr>
</tbody>
</table>

Uterus of gravid proglottid. 8-14 lateral branches on each side of median stem. Many secondary branches.
Size and shape of eggs. | Elliptical. 37 by 32 microns in diameter. | Elliptical. 38 to 39 by 34 to 35 microns in diameter. | Elliptical. 31 to 34 by 29 to 30 microns in diameter.

Family Hymenolepididae Reilliet and Henry, 1909.
Subfamily Dipylidiinae Stiles, 1896.
Genus Dipylidium Leuckart, 1863.

The author considers Hall as authority for the genera Taenia and Multiceps, but in his discussion of the genus Dipylidium he fails to include Dipylidium walkeri. Dipylidium walkeri was described by Sondhi in 1923. It seems that without doubt Sondhi had sufficient reason for describing this as a new species. It, also, seems that without doubt this new species occurs in this locality.

Generic characteristics.

Rostellum is armed with several circlets of hooks which are of rose-thorn shape and usually provided with discoidal bases. A double set of reproductive organs in each segment. Genital pores are double and opposite. Testes are very numerous, scattered throughout the entire medullary parenchyma. Vas deferens is coiled, and the seminal vesicle is lacking. Gravid segments are usually longer than broad. Uterus is at first reticular, later breaking up into egg capsules, each containing one or more eggs. Adults
in mammals and birds.

Type-species—Dipylidium caninum (Linnaeus, 1758a)
Railliet, 1892v.

Synonyms—

Taenia caenera Linnaeus, 1758a;
T. moniliformis Pallas, 1761, no Batsch, 1786a;
T. cucumerina Bloch, 1782a;
T. cateniformis Goeze, 1782a;
T. elliptica Goeze, 1782a;
T. ellyptica Batsch, 1786a;
T. cateniformis canina Linnaeus of Gmelin, 1790a;
T. c. felis Gmelin, 1790a;
Alyselminthus ellypticus (Batsch, 1786a) Zeder 1800a;
Taenia cuneiceps Zeder, 1800a;
Holysis ellyptica (Batsch, 1786a) Zeder, 1803a;
Taenia canina (Linnaeus, 1758a) van Beneden, 1861a;
T. cucumerina (Bloch, 1782a) van Beneden, 1861a;
Taenia (Dipylidium) cucumerina Bloch of Leuckart, 1865;
Cryptocystis trichodectis Villot, 1882;
Dipylidium caninum (Linnaeus, 1758a) von Ratz, 1897.

Dipylidium caninum (Linnaeus, 1758a)
Railliet, 1892v.

Specific characteristics.

The small head (figures 10 and 11, Plate IV) bears a
very prominent rostellum. The head measures 350 to 460 microns in diameter, while the rostellum is about 185 microns long and 110 to 120 microns wide. The rostellum bears three or four, practically always four, circlets of about sixty hooks. In counting the number of rows of hooks of Dipylidium caninum it is often hard to determine the number. The hooks are somewhat alternately arranged and sometimes it is difficult to distinguish whether there are four or five rows, but four is the generally accepted number. The hooks of the most anterior row are larger than the others—length measurements range from 15 microns for the most anterior row to five microns for those of the fourth row. Hall notes that the hooks are very easily lost, but the present author had no difficulty in getting complete crowns. The neck is short. The first segments are very short while the following ones gradually become longer until the final or gravid ones are much longer than wide. The mature and gravid proglottids have the characteristic cucumber-seed shape. Gravid segments measure 8 to 11 mm. long and 1.5 to 3 mm. wide.

The details of the mature proglottid are shown in figure 12, Plate IV.

Male genitalia—The 200 or more testes of each mature segment fill all the space between the lateral excretory canals not occupied by other genital structures. Occasionally one is found outside of the lateral excretory canals. The vas
deferens is greatly coiled and it extends still further forward than does the cirrus pouch which extends anteriorly and medially from the genital pore.

Female genitalia—The lobes of each ovary are very distinct, but are somewhat irregular in form. The vitellaria lie considerably posterior to the ovaries; they are decidedly irregular in form, having no definite shape. The indistinct shell gland is between the ovary and the vitellarium. The vagina extends inward and then posteriorly between the lobes of the ovary. The posterior end dilates into a seminal receptacle.

Hall copies Neumann's illustration of the mature proglottid of *Dipylidium caninum*. This illustration shows a very distinct and perfect network of uterine material. This uterine network is pictured as fitting around the testes; each testis being in a compartment of its own. All authorities use this same figure, but none of them discuss this network, nor explain its formation or how it functions. At first the author was absolutely unable to see any such network, and became dubious as to whether or not it was really present. After hours of study of many slides it was observed in another species (*Dipylidium sexcoronatum*), where it was found to be quite distinct. Further investigations have finally convinced the present author of its actual existence, and, though, faintly stained, it is quite definite in *D. caninum*. Just how such a uterus functions is a question that is
difficult to answer. The meshes of this network become filled with eggs (figure 13, Plate IV) and later only capsules of eggs are seen in the parenchyma and the uterine network has disappeared. The uterus produces these capsules about the eggs, and then degenerates along with the rest of the genital structures.

**Dipylidium sexcoronatum** von Ratz, 19000.

**Specific characteristics.**

The head (figures 14 and 15, Plate V) is quite small—measures 330 microns in length and 370 microns wide; is oval in shape, and terminates conically anteriorly. The conical rostellum is usually retracted, and is 46 microns long and 54 microns wide at the base. The lower portion is covered with six rows of hooks, and the hooks of the most anterior rows are considerably larger than the posterior ones, which get smaller in each row. Suckers are quite prominent. The neck is quite short. The entire strobila is about 10 to 23.5 cm. long. The most anterior segments are very short, but those that follow gradually become longer until the mature ones are much longer than they are wide. Posterior to these long ones they become shorter, thicker, and wider as they become gravid. The longitudinal excretory canals are very prominent, even in young segments, and in the older segments they show up as rather wide and wavy canals.

Figure 16, Plate V, is of the mature proglottid.

**Male genitalia**—There are about 150 spherical testes in each mature proglottid. These occupy most of the space between the
longitudinal excretory canals, but are more scattered in the
anterior third of the segment. The vas deferens begins just
anterior to the median edge of the ovary and extends laterally
in many loops to the cirrus pouch. According to Hall in
young segments the cirrus pouch has the shape of an hour-
glass, but the present author found it be quite indefinitely
so; while in the mature segments it is piriform. The cirrus
pouch extends directly inward to the excretory canal and usual-
ly extends partly across it.

Female genitalia—Each of the two ovaries of the mature seg-
ment is in two distinct lobes. These lobes are of a loose
and irregular structure fitting into the convexity and con-
cavity of the curve of the vagina. The most anterior portion
of the ovaries is at the level of the genital pores. In the
younger segments, when the different structures are just de-
veloping, the vitellaria are somewhat irregular in form but
in the mature proglottid they are definitely reniform. They
occur just posterior to the ovaries. The rather large shell
gland is situated just anterior to the vitellarium and between
the two lobes of the ovary. The vagina with some slight cur-
ves extends inward and then posteriorly. It enlarges to form
a spindle-shaped seminal receptacle between the lobes of the
ovary. Hall says "the uterus is only seen in later segments
and is a fine tubular reticulum branching through the median
field and especially distinct between the female genitalia and
posterior of these. After the constriction of some parts it
forms egg capsules containing 2-3-8-15 eggs to a capsule. Examination of the present author's slides prove that the network is more definite in the median field. The eggs are spherical. The densest clumps are posterior to the oviducts, and the capsules are very few in the most anterior portion of the segment.

The life history is unknown.

*Dipylidium walkeri* Sondhi, 1923.

**Specific characteristics.**

The head (figures 17 and 18, Plate V) of this species is very like those of the above described species of this genus. The diameter varies from 185 to 360 microns according to degree of contraction. It has the shape of a blunt cone. The rostellum measures 63 to 100 microns in diameter. The rostellum bears 6 or 7 alternating ciracles of hooks. The size of the hooks varies from 12 microns in length in the case of the large anterior one to 22 microns in length in the case of the smallest posterior ones. The four suckers vary in size from 118 to 150 microns in diameter. The neck is short. The strobila is from 10 to 28 cm. long.

Sondhi says that as a rule the strobila is thinner than that of *Dipylidium sexcoronatum* or *Dipylidium caninum*. This was very evident in my in toto mounts which were so very transparent and clear. He says that in the anterior part of the strobila both dorsal and ventral excretory vessels
are present on each side, but from the mature proglottids on back there is only the ventral excretory vessel. The dorsal canals were not observed in this study. The genital pore is in a deep conical depression a little anterior to the center of the lateral margin of the immature proglottid, and about the center or slightly posterior in the mature and gravid proglottids.

The details of the mature proglottid are shown in figure 19, Plate V.

Male genitalia—Sondhi notes that there are approximately 225 ovoid testes in each mature proglottid, but those specimens examined here usually had about 200. Occasionally a few would be found laterad to the lateral excretory canals, otherwise all were mesad to these canals. Few testes occur in the most anterior part of proglottid, or between the ovaries. They are in a single layer dorso-ventrally. Each measures about 72-90 microns by 54-59 microns. The much coiled vas deferens is just anterior to the ovary, and it is so tortuous that it extends only about half way into the median field of the segment. The cirrus pouch is rather slender, and usually extends just to the lateral excretory canal.

Female genitalia—The ovaries begin at about the level of the genital pores and extend posteriorly; each is divided into two lobes, an outer smaller one and an inner larger one, along the course of the vagina. The vitellarium has the
appearance of a bunch of grapes and is just posterior to the ovary. It is generally larger than the outer lobe of the ovary. The shell gland is rather distinct and is located just anterior to the vitellarium and is somewhat between the posterior region of the two lobes of the ovary. In describing the uterus Sondhi says it "sends out lateral branches which form a network in the meshes of which lie the testes; it has definite walls and its branches first appear in the lateral fields of the segment, invading the median field later." The author finds many mature segments which have a perfect uterine network, which extends practically throughout. The egg capsules are not very tightly packed together, and extend beyond the lateral excretory canals, but leave the most anterior portion of the segment clear. The capsules lie in a single layer dorso-ventrally.

Many of the details of the above three species of the genus Dipylidium are included in the comparative chart below. Some of the details are practically identical in the three species, while others are the differences which are the basis for specific identification.

<table>
<thead>
<tr>
<th></th>
<th>Dipylidium caninum</th>
<th>Dipylidium sexcornutum</th>
<th>Dipylidium walkeri</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>15-40 cm.</td>
<td>10-23.5 cm.</td>
<td>10-28 cm.</td>
</tr>
<tr>
<td>Number of circlets of hooks.</td>
<td>3 or 4, usually 4.</td>
<td>6</td>
<td>6 or 7.</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>--------------------</td>
<td>---</td>
<td>------</td>
</tr>
<tr>
<td>Number of hooks.</td>
<td>60 or more.</td>
<td>100 or more.</td>
<td>100 or more.</td>
</tr>
<tr>
<td>Shape of mature pro-glottids.</td>
<td>At least twice as long as wide.</td>
<td>About three times as long as wide.</td>
<td>About three times as long as wide.</td>
</tr>
<tr>
<td>Shape of gravid pro-glottids.</td>
<td>Two or three times as long as wide.</td>
<td>Shorter and broader than mature ones.</td>
<td>Three times as long as wide.</td>
</tr>
<tr>
<td>Size of mature pro-glottids.</td>
<td>3-3.5 mm. by 1.5 mm.</td>
<td>6-7 mm. by 1-1.5 mm.</td>
<td>3-3.5 mm. by 1-1.5 mm.</td>
</tr>
<tr>
<td>Size of gravid pro-glottids.</td>
<td>6-11 mm. by 1.5-3 mm.</td>
<td>4-5 mm. by 2-2.5 mm.</td>
<td>4.5-8 mm. by 1.5-2.5 mm.</td>
</tr>
<tr>
<td>Position of genital pore.</td>
<td>At the middle or just posterior to middle of lateral margin.</td>
<td>Posterior to middle of lateral margin.</td>
<td>At the middle of lateral margin.</td>
</tr>
<tr>
<td>Length of cirrus pouch.</td>
<td>Crosses the lateral excretory canal. Slants forward.</td>
<td>Extends to the lateral excretory canal. Extends directly inward.</td>
<td>Extends practically straight inward to the lateral excretory canal.</td>
</tr>
<tr>
<td>Shape of vitellarian</td>
<td>Irregular.</td>
<td>Reniform.</td>
<td>Like a bunch of grapes.</td>
</tr>
<tr>
<td>Number and distribution of the Testes.</td>
<td>Usually 200 or more scattered practically throughout area between excretory canals.</td>
<td>150 or so between the longitudinal excretory canals.</td>
<td>175-200 practically filling the area between the excretory canals.</td>
</tr>
<tr>
<td>Number and Distribution of the Testes. (concl'd.)</td>
<td></td>
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<td>-----------------------------------------------</td>
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<tr>
<td>Distribution of egg capsules in gravid proglottids.</td>
<td></td>
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<td>Eggs in the Capsules.</td>
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<tr>
<td>Uterus of the mature proglottid.</td>
<td></td>
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<tr>
<td>Shape and Size of Eggs.</td>
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<table>
<thead>
<tr>
<th>Number of</th>
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<th>Eggs in the Capsules.</th>
<th>Uterus of the mature proglottid.</th>
<th>Uterus of the gravid proglottid.</th>
<th>Shape and Size of Eggs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td>Very numerous and tightly packed, and extend almost to edge. Most anterior region has few capsules.</td>
<td>Tightly packed. 4 to 22.</td>
<td>Network about testses very faintly visible in in tot mounts.</td>
<td>In younger ones it forms a perfect network about the eggs. Produces capsules and degenerates.</td>
<td>Globular. 43 to 50 microns in diameter.</td>
</tr>
<tr>
<td>Distribution</td>
<td>Somewhat tightly packed, and extend practically to the lateral margin.</td>
<td>Quite tightly packed. 3 to 20.</td>
<td>Quite evident as a network about the testes.</td>
<td>In older proglottids it is very much degenerated.</td>
<td>Spherical. 21 microns in diameter.</td>
</tr>
<tr>
<td>of segment</td>
<td>Only a very few ever found outside those canals. Few in anterior portion of segment. Few between the ovaries.</td>
<td>Usually not very tight. 5 to 15.</td>
<td>Network not so definite as in other species.</td>
<td>A perfect network in younger gravid ones, but it is soon broken up.</td>
<td>Spherical. 35 microns in diameter.</td>
</tr>
</tbody>
</table>

The process of the formation of the testes was better observed in *Dipylidium sexcoronatum* than in any other species of tapeworms studied. There is no visible testicular
material in the youngest proglottids just back of the head. When the proglottid is as long as it is wide hundreds of little masses of testicular material fill all the area between the excretory canals. Later the small masses begin grouping themselves together and by the time the proglottid is mature the testes are formed and are surrounded by the network of uterus. Connecting the testes are little fine ducts which lead to larger tubes which finally empty into the vas deferens. These ducts may be seen to the best advantage on slides of Dipyldium caninum. As soon as the female genitalia become mature the testes begin to break up. The smaller masses of each testis begin to separate gradually until the entire area seems to be nothing but a field of testicular material. Seemingly while the field is thus camouflaged the segment becomes filled with eggs, which are in groups within the mesh work of the uterus. It has been impossible to see exactly how the eggs become distributed. It is still a problem to be solved. By the time the uterus has produced capsules around the eggs the testes have completely disappeared. The breaking up of the testes was best observed in Dipyldium caninum.

Much of the following table was worked out by Ward in 1895. It includes only the most frequent and important dog tapeworms. All but two of the species included in this table have been discussed above.
Headd;

Genital pore very salient— Taenia pisi-
formis (T. serrata).

*130 to 290 microns long. Genital pore
80 to 175 microns not very salient— Multiceps
serialis (T. serialis).

110 to 220 microns long. Mature pro-
glottid longer than
wide— Taenia hydati-
genae (T. marginata).

150 to 170 microns long. Mature seg-
ments three times as
long as wide— Multiceps mul-
ticeps (T. coenurus).

3 or 4 segments; some millimeters long— Echinococcus gran-
ulosa (T. echinococcus).

Vitellarium irregular; 3 or 4 circllets of hooks— Dipylidium caninum.

Double, Vitellarium reniform; 6 circllets of hooks— Dipylidium sexcoronatum.

Vitellarium in form of a bunch of grapes; and 6 or 7 circllets of hooks— Dipylidium walkeri.

Head un-
armed; sexual orifices on the ventral surface— Mesocestoides linatus.

*The shorter measure is the minimum measurement for the smaller hooks, while the longer measure is the maximum of the large hooks.
CONCLUSIONS

1. Saturated aqueous solution of corrosive sublimate is an excellent killing and fixing fluid for tapeworms.

2. The technic of making in toto mounts of tapeworms is difficult, but a quite satisfactory method was worked out.

3. Eighty-three per cent. of this random selection of dogs of this locality were infected with tapeworms.

4. Three genera of cestodes were found in the thirty-five dogs examined.

5. Twelve of the dogs were infected with the genus *Taenia*. Thirty-one per cent. of the thirty-five were infected with *Taenia pisiformis*, while fourteen per cent. of them were infected with *Taenia hydatigena*.

6. Six of the group were infected with the genus *Multiceps*, and all were of the species *Multiceps serialis*. No *Multiceps multiceps* was found.

7. Twenty-three of the dogs were infected with the genus *Dipylidium*. *Dipylidium caninum* was not the most common species, but was found in twenty-six per cent. of the whole group. *Dipylidium sexcoronatum*, the most common species of this genus, was found in sixteen dogs. *Dipylidium walkeri*, which had not been known to occur in this country, was found in four of the
The elimination of vagrant dogs and proper control of all other dogs is an important problem of the live stock owners.

There seems to be no such a structure in *Taenia hydatigena* as "the median groove with a posterior notch" figured by Stiles.

The head of *Multiceps serialis* is smaller than the head of either *Taenia pisiformis* or *Taenia hydatigena*.

It is very difficult to distinguish between *Taenia brauni* and *Multiceps serialis*.

The difference in number of cirricals of hooks on the rostellum is the best diagnostic feature for the species of the genus *Dipylidium*.

The specific anatomical details of genus *Dipylidium* are very difficult to discern.
All microscopic work was done with a new Bausch and Lomb microscope. Low power was satisfactory for most details.

Many drawings were made with the aid of a camera lucida. If drawings had been made at stage level the magnification would have been seventy-five times natural size, since a 7.5X ocular piece was used with a 10X objective. But drawings were made at table level, and therefore the magnification was increased to one hundred and ten times natural size.

Pictures were made of the original plates. A reduction to a little less than half the size of the originals was necessary.
PLATE I.

Figure 1—*Taenia pisiformis*. Head. Drawn with the aid of a camera lucida and then reduced to about fifty times natural size.

Figure 2—*Taenia pisiformis*. Mature proglottid. Enlarged.

Figure 3—*Taenia pisiformis*. Gravid proglottid. Enlarged.
PLATE II.

Figure 4—Taenia hydatigena. Head. Drawn with the aid of a camera lucida and then reduced to about fifty times natural size.

Figure 5—Taenia hydatigena. Mature proglottid. Enlarged.

Figure 6—Taenia hydatigena. Gravid proglottid. Enlarged.
PLATE III.

Figure 7—*Multiceps serialis*. Head. Drawn with the aid of a camera lucida and then reduced to about fifty times natural size.

Figure 8—*Multiceps serialis*. Mature proglottid. Enlarged.

Figure 9—*Multiceps serialis*. Gravid proglottid. Enlarged.
PLATE IV.

Figure 10— *Dipyldium caninum*. Head with rostellum extended. Drawn with the aid of a camera lucida and then reduced to about fifty times natural size.

Figure 11— *Dipyldium caninum*. Head with rostellum contracted. Drawn with the aid of a camera lucida and then reduced to about fifty times natural size.

Figure 12— *Dipyldium caninum*. Mature proglottid. Note the small dorsal excretory canals. Enlarged to about thirty times natural size.

Figure 13— *Dipyldium caninum*. A section through the mid-region of a gravid proglottid. Note the eggs in clusters in the uterine network. The structure is practically the same in the other other two species of this genus discussed—though the clusters of eggs are not so numerous. This network produces capsules around the eggs. Enlarged.
PLATE V.

(all figures on this plate were drawn with the aid of a camera lucida and then reduced to about fifty times natural size).

Figure 14-- Dipylidium sexcoronatum. Head with the rostellum extended.

Figure 15-- Dipylidium sexcoronatum. Head with the rostellum contracted.

Figure 16-- Dipylidium sexcoronatum. Mature proglottid.

Figure 17-- Dipylidium walkeri. Head with the rostellum extended.

Figure 18-- Dipylidium walkeri. Head with the rostellum contracted.

Figure 19-- Dipylidium walkeri. Mature proglottid.
PLATE V

Figure 14

Figure 15

Figure 17

Figure 18

Figure 16

Figure 19
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