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## HELMINTH PARASITES OF THE SHORT-TAILED SHREW IN CENTRAL OHIO

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A number of helminth parasites have been reported for the short-tailed shrew, *Blarina brevicauda*. These reports are scattered, and there has been no attempt to bring this literature together to aid in the identification of the parasites of this host.

Ninety-three short-tailed shrews from central Ohio have been examined for helminth parasites since 1950. Eighty-three of these shrews were collected in Franklin County; six were collected in Hocking County; two were collected in Delaware County; and two were collected in Licking County. Helminth parasites were recovered from seventy-eight (83.9%) of the shrews.

Six species of tapeworms, four species of flukes, eight species of roundworms, and one acanthocephalan were recovered in this study. Several of these parasites represent new host records, and one tapeworm and one fluke appear to be new species. In both of the latter cases, however, the specimens were not in a condition favorable for detailed study. Only one helminth which has been reported for *Blarina brevicauda* was not recovered in this study, i. e., *Oochoristica pennsylvanica* Chandler and Melvin, 1951.

### Cestoda

### List of Parasites

#### Hymenolepididae

- Hymenolepis anthocephalus* Van Gundy, 1935
- H. blarinae* Rausch and Kuns, 1950
- Hymenolepis* sp.
- Pseudodiorchis reynoldsi* (Jones, 1944)
- Protogynella blarinae* Jones, 1943
- P. pauciova* Oswald, 1955

### Trematoda

#### Brachylaimatidae

- Entosiphonus thompsoni* Sinitzin, 1931
- Brachylaima rhomboideus* (Sinitzin, 1931)
- Panopistus pricei* Sinitzin, 1931

#### Troglorematidae (?)

- Undetermined fluke

### Nematoda

#### Strongyloididae

- Parastrongyloides winchesi* Morgan, 1928

#### Trichostrongylidae

- Longistriata depressa* (Dujardin, 1845)

#### Metastrongylidae

- Angiostrongylus blarini* Ogren, 1954

#### Ascarididae

- Porrocaecum americanum* Schwartz, 1925 (larva)
- P. encapsulatum* Schwartz, 1925 (larva)
- P. ensicaudatum* (Zeder, 1800) (larva)

#### Physalopteridae

- Physaloptera limbata* Leidy, 1856

#### Trichuridae

- Capillaria blarinae* Ogren, 1953

#### Acanthocephala

#### Polymorphidae

- Centrorhynchus conspectus* Van Cleave and Pratt, 1940 (cystacanth)

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*Cestoda**Hymenolepis anthocephalus* Van Gundy, 1935

This tapeworm was originally described from the short-tailed shrew in Michigan and has been reported subsequently for the same host in Ohio, Michigan, and Wisconsin by Rausch and Kuns (1950). Skrjabin and Matevosian (1948) erected the genus *Cryptocotylepis* with *C. anthocephalus* (Van Gundy) as the type and only species. This genus is differentiated from *Hymenolepis* entirely on the basis of scolex characters. Since the anatomy of the proglottid of *H. anthocephalus* is typical of other members of the genus *Hymenolepis*, there would appear to be little advantage in placing this species in a separate genus.

*H. anthocephalus* was encountered in the intestine of 29 shrews from Franklin Co., 2 from Delaware Co., 1 from Licking Co., and 1 from Hocking Co. Each host harbored from 1 to 15 worms.

*Hymenolepis blarinae* Rausch and Kuns, 1950

The species was originally described from *Blarina brevicauda* in Wisconsin. One shrew collected in Hocking County harbored 5 specimens of this species.

*Hymenolepis* sp.

A single, rather badly decomposed tapeworm which appeared to belong to the genus *Hymenolepis* was obtained from a shrew collected in Franklin County. The scolex of this specimen was armed with ten hooks 76 to 82  $\mu$  long (fig. 1). On the basis of the size, number, and shape of these hooks, this specimen appears to belong to an undescribed species. However, suitable specimens must be collected before this species can be thoroughly studied and named.

*Pseudodiorchis reynoldsi* (Jones, 1944)

This species was originally placed in the genus *Diorchis* by Jones (1944) who obtained it from *Blarina brevicauda* in Virginia. Skrjabin and Matevosian (1948) erected the genus *Pseudodiorchis* and designated *P. reynoldsi* (Jones) as the type. *P. reynoldsi* has recently been redescribed by Oswald (1957) from specimens collected in Ohio.

*P. reynoldsi* has been collected in Franklin, Hocking, and Delaware Counties in 17, 1, and 1 shrews, respectively. Each infected host harbored from 1 to 47 worms.

*Protogynella* spp.

The genus *Protogynella* was erected by Jones (1943) for a minute tapeworm, *P. blarinae*, from *Blarina brevicauda* collected in Virginia. An additional species, *P. pauciova*, was described by Oswald (1955) from the short-tailed shrew in Ohio. *P. blarinae* has also been reported for *Blarina brevicauda* in Wisconsin by Rausch and Kuns (1950) and from *Sorex vagrans* in Oregon by Locker and Rausch (1952). According to Oswald (1955), *Protogynella* occurring in *Sorex* spp. differs from both *P. blarinae* and *P. pauciova*, and probably represents one or two additional species.

*P. blarinae* was encountered in two short-tailed shrews from Hocking Co., the shrews harboring 43 and 260 worms, respectively. Twenty-nine specimens of *P. pauciova* were obtained from a shrew in Franklin Co., and 295 specimens were obtained from a shrew in Hocking Co. In the latter case, the specimens differed from the original description of *P. pauciova* in that there were occasionally three eggs per proglottid rather than two as reported originally. An additional shrew from Hocking County harbored *Protogynella*, but these specimens were so badly decomposed that they could not be identified to species.

*Oochoristica pennsylvanica* Chandler and Melvin, 1951

This species, which was reported for *Blarina brevicauda* in Pennsylvania, is the only tapeworm from the short-tailed shrew which was not encountered in this study. However, it is reasonable to expect it to occur in Ohio.

*Trematoda**Entosiphonus thompsoni* Sinitsin, 1931

*E. thompsoni* was originally described from *Blarina brevicauda* in Virginia and Maryland.

It was found in Franklin, Delaware, Hocking, and Licking Counties in 30, 2, 2, and 2 shrews, respectively. Each shrew harbored from 1 to 17 flukes in the small intestine.

*Panopistus pricei* Sinitzin, 1931

The fluke was described also from the short-tailed shrew in Virginia. In the present study, it was found in 9 shrews from Franklin Co., 1 shrew from Delaware Co., and 1 shrew from Licking Co. It was found in the large intestine; from 1 to 9 specimens were obtained from each host.

*Brachylaima rhomboideus* (Sinitzin, 1931) Villella, 1953

Mason (1953) described a fluke from *Blarina brevicauda* in Tennessee which he named *Brachylaima dolichodirus*. However, Villella (1953) found that the adult of *Ectosiphonus rhomboideus*, which Sinitzin (1931) had described from rediae, cercariae, and metacercariae occurring in *Ventridens ligera* in the vicinity of Washington, D. C., was identical to Mason's *B. dolichodirus*. Villella retained this species in the genus *Brachylaima*, but *B. dolichodirus* of Mason becomes a synonym of *E. rhombioides* of Sinitzin.

*B. rhomboideus* was found in 6 shrews from Franklin Co., 2 from Delaware Co., and 1 from Licking Co. It was taken most frequently in the duodenum, but specimens were occasionally found in the stomach. From 1 to 8 specimens were found in each host.

Sinitzin (1931) described *Ectosiphonus ovatus* from *Blarina brevicauda* in Minnesota, and Odlaug (1952) described *Brachylaima condylura* from a star-nosed mole, *Condylura cristata*, also in Minnesota. Since the descriptions and illustrations of these two species were similar to *B. rhomboideus* in several respects, a direct comparison of these three species appeared to be desirable. Mr. Allen McIntosh, Agricultural Research Center, Beltsville, Maryland kindly furnished the type specimens of *B. condylura* and *E. ovatus*, together with three additional specimens of the latter species. Dr. T. O. Odlaug, University of Minnesota, Duluth Branch, very kindly furnished two paratype specimens of *B. condylura*.

A comparison of the type specimens of *B. condylura* and *E. ovatus* with my specimens of *B. rhomboideus* revealed no differences which could not be accounted for when the different degrees of contraction of the specimens were taken into consideration. Odlaug states that the ovary of *B. condylura* is on the right side of the body, although in his illustration the ovary would appear to be on the left side of the body. A comparison of his illustration with the type specimen indicated that the drawing should be labeled as a dorsal view rather than a ventral view. In addition, the anterior end of the type specimen is somewhat contracted and folded, giving the impression that the distance between the oral sucker and the acetabulum is relatively short. In the two paratype specimens of *B. condylura*, the neck region is relaxed and relatively long.

The specimens of *Ectosiphonus ovatus*, which consist of three whole mounts and one sectioned specimen, are all extremely contracted and are very poor taxonomic material. In Sinitzin's figure 37 which illustrates a whole specimen of *E. ovatus*, the impression of a ventral view is obtained. However, a comparison of this figure with the type specimen showed that this drawing is also a dorsal view.

In all three groups of specimens, the size of the body and the organs overlap; the ovary is located to the right of the testis; the genital pore is located just anterior to the anterior testis; the vitellaria extend from the posterior testis to a point midway between the acetabulum and the anterior testis; a loop of the uterus extends to the left between the ovary and the anterior testis; and the vitelline reservoir is located to the left of the ovary with the right vitelline duct passing between the ovary and the posterior testis. The location of the uterus in relation to the acetabulum appears to be variable; in some of my specimens it passes to the left of the acetabulum, but occasionally it passes to the right or one branch may pass to the left while the other passes to the right.

Since Sinitzin erected the genus *Ectosiphonus* for *E. rhomboideus* and *E. ovatus* and since these two names apparently apply to the same species of fluke, there is some question as to which of these specific names has priority. Although Sinitzin did not designate directly the type species for the genus *Ectosiphonus*, the description of *E. rhomboideus* is the first species description following the generic diagnosis, and it is, therefore, the implied type of the genus and has priority over *ovatus*. Since Villella, Odlaug, and Mason have rejected either directly or in-

directly Sinitzin's genus *Ectosiphonus*, this genus must now be considered a synonym of *Brachylaima*. Therefore, the correct name for this fluke is *Brachylaima rhomboideus* (Sinitzin, 1931) Vilella, 1953, and the synonyms would include *Ectosiphonus ovatus*, *Brachylaima condylura*, and *B. dolichodirus*.

#### Unidentified Fluke

Two specimens of an unidentified fluke were obtained from the large intestine of a short-tailed shrew collected in Franklin County. The extensive and heavily developed vitellaria and the uterus obscured much of the internal anatomy. Therefore, an outline drawing was made from a whole mount after which the flukes were sectioned, and the internal anatomy was reconstructed from these serial sections. A brief description of this fluke follows.

#### Unidentified Fluke

##### Figure 2

*Diagnosis:* Body pyriform, 2.04 mm long and 0.524 mm wide just anterior to acetabulum. Cuticle without spines. Oral sucker 235 to 248  $\mu$  in diameter, oral opening subventral. A small, poorly developed pharynx present, followed by a larger, thin-walled esophagus. Esophagus opens into the intestinal ceca ventrally; ceca very distinct, extending to the posterior end of worm. Acetabulum 221 to 228  $\mu$  in diameter, located posterior to mid-point of body. Vitellaria extensive, composed of closely packed follicles 50 to 70  $\mu$  in diameter. Vitellaria enveloping the body from just behind oral sucker to tip of tail, except for the region on the ventral surface between the acetabulum and cirrus sac. Cirrus sac located to right of mid-line, anterior to acetabulum and ovary. Cirrus protruded in both specimens; an internal seminal vesicle present. Two testes present, one on the left just anterior to acetabulum and one directly dorsal to acetabulum. Testes 148 to 175  $\mu$  in diameter. Ovary located on the right, just anterior to acetabulum, about 117  $\mu$  in diameter. Uterus extending between the intestinal ceca from middle of acetabulum to a point slightly anterior to cirrus sac. Uterus passes ventral to ovary and dorsal to both testes. Eggs 70 to 76  $\mu$  long and 30 to 33  $\mu$  wide, provided with an operculum. Excretory bladder tubular, extending to middle of acetabulum. Excretory pore subterminal.

It is impossible from the material at hand to assign this fluke to any known genus. It appears to have some features in common with the small, intestinal flukes of the family Troglotrematidae although the location of the genital pore and the arrangement of the ovary and testes would seem to exclude this species from the family. Therefore, the status of this fluke must be left unsettled until additional material has been studied.

#### Nematoda

##### *Parastrongyloides winchesi* Morgan, 1928

This species was described by Morgan (1928) from the intestine of the mole, *Talpa europaea*, in England. He also recorded it from a "shrew" in the same area.

*P. winchesi* was found in the intestine of seven short-tailed shrews collected in Franklin County. It is possible that the incidence of infection is much greater since this worm is small and could have been overlooked in a number of instances. Morgan noted that the females of this species fell into two groups. In one group, the females had an average length of 1.46 mm and contained only a few eggs, usually less than ten. Females in the second group had an average length of 2.2 mm and contained a larger number of eggs. This same condition was found in the specimens from *Blarina*, females of both types occurring in the same host.

The occurrence of *P. winchesi* in *Blarina brevicauda* is apparently a new host record and is the first record of this species in North America.

##### *Longistriata depressa* (Dujardin, 1845)

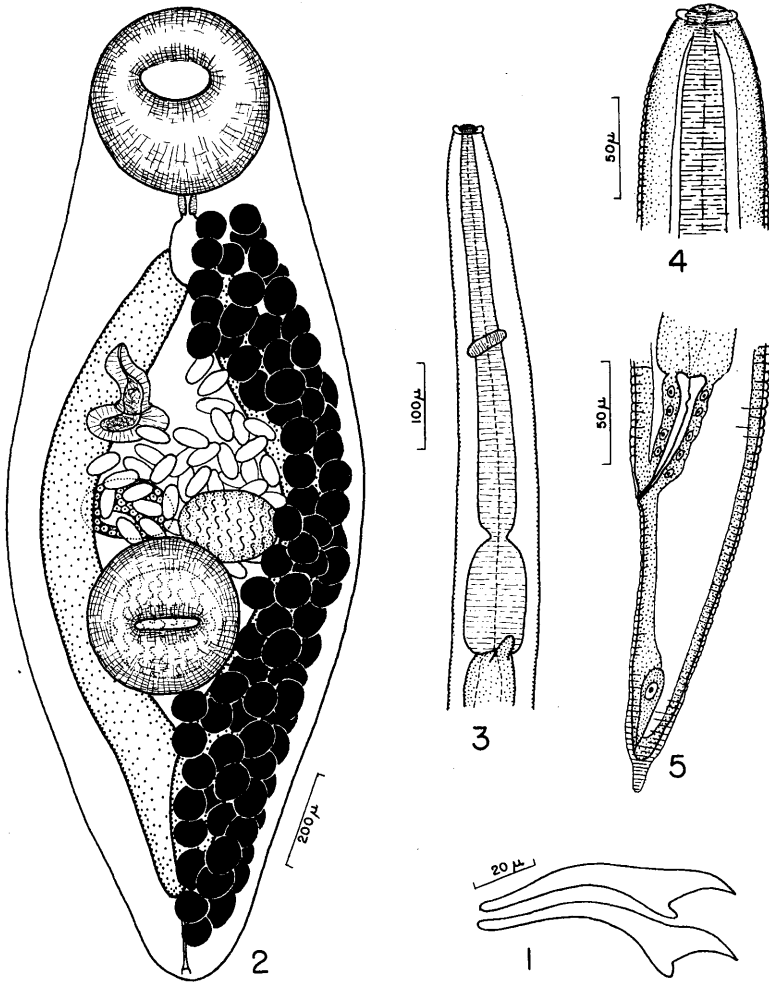
*Longistriata depressa* has been reported for a number of European insectivores, including *Sorex araneus*, *Crocidura leucodon*, and *C. russula*. Dikmans (1946) described a similar species, *Longistriata caudabullata*, from *Blarina brevicauda* in Maryland. Thomas (1953) considered Dikmans' species to be a synonym of *L. depressa*.

*L. depressa* was found in the intestine of ten shrews from Franklin County and two shrews

from Hocking County. Because of the small size of this parasite, it could have been overlooked in a number of hosts.

*Angiostrongylus blarini* Ogren, 1954

This species, originally described from cysts in the lungs of *Blarina brevicauda* from Illinois, was found in five shrews from Franklin County. Each infected shrew had one or two cysts in the lungs. This parasite may be more prevalent than indicated since the lungs of a number of shrews were not examined.



Figures made with the aid of a camera lucida.

1. Rostellar hooks of *Hymenolepis* sp.
2. Unidentified fluke. Internal organs reconstructed from serial sections; vitellaria omitted on left side of drawing.
3. *Porrocaecum ensicaudatum*, anterior end of third-stage larva showing ventriculus and intestinal caecum.
4. *P. ensicaudatum*, head of third-stage larva.
5. *P. ensicaudatum*, tail of third-stage larva.

*Porrocaecum spp.*

Third-stage larvae of three species of the genus *Porrocaecum* were encountered in this study. Two of these, *P. encapsulatum* and *P. americanum*, occur in cysts. The third species, which has been identified tentatively as *P. ensicaudatum*, was found free in the intestine.

Schwartz (1925) described *P. encapsulatum* from subcutaneous cysts in *Blarina brevicauda* and *P. americanum* from subcutaneous cysts in *Scalopus aquaticus*. Chandler and Melvin (1951) found *P. encapsulatum* in cysts located both subcutaneously and in the mesenteries of *B. brevicauda* and *Parascalops breweri*. *P. americanum* was found in cysts attached to the small intestine of *B. brevicauda*, on the outer wall of the stomach in *Sorex (fumaris?)*, and in the mesenteries of *Parascalops breweri*. It would appear from these reports that these larvae can be accommodated by a number of species of Insectivora, and that the tissue site is not very specific.

In the present study, *P. encapsulatum* was found in subcutaneous cysts in twelve shrews collected in Franklin County. Each shrew harbored from one to eight larvae. *P. americanum* was found in twenty shrews from Franklin County and in one from Hocking County. In twelve shrews the cysts were found in the mesenteries; in three shrews the cysts were attached to the stomach; and in six shrews the cysts were found in both the mesenteries and on the stomach wall. The cysts occurring in the mesenteries were more or less free in a fingerlike tube of mesentery located at the junction of the stomach and intestine. The cysts on the stomach wall were at times firmly imbedded under the serosa and at other times they were attached to the stomach wall by a peduncle of connective tissue. Each infected host harbored from one to nine larvae.

Schwartz (1925) suggested that *P. americanum* and *P. encapsulatum* probably occur as adults in birds of prey. He also pointed out the similarity between *P. americanum* and *Ascaris incisa* (Zeder, 1803) which is found encysted in European insectivores. Chandler and Melvin (1951) also suggest that *P. americanum* may be identical to *Ascaris incisa*.

Leukart (1876) suggested that *Ascaris incisa* was the larval stage of *Porrocaecum depressum* which is found as an adult in various birds of prey. This suggestion has become generally accepted in parasitological literature. Although the larvae in European insectivores have been referred to commonly as "*Ascaris incisa*," Osche (1955) points out that the correct name for this larva is actually *Porrocaecum talpae* (Schränk, 1788). Osche also determined by feeding experiments that *P. talpae* is actually the larva of *P. angusticolle* (Molin, 1860) rather than the larva of *P. depressum*. Unfortunately, the law of priority requires that *P. angusticolle* (Molin, 1860) become a synonym of *P. talpae* (Schränk, 1788).

My specimens of *P. americanum* compare favorably with the description of *P. talpae* presented by Osche, although my specimens seem to be somewhat smaller (3.79 to 8.72 mm in total length). *P. talpae*=*P. angusticolle* is known to occur in North America; it has been reported for six species of hawks by Morgan and Schiller (1950). Although a morphological comparison of larval *P. talpae* with *P. americanum* would tend to indicate that they are identical, feeding trials should be undertaken to establish this identity definitely.

The author has made several unsuccessful attempts to determine the adults of the larval *Porrocaecum* encysted in *Blarina*. Six week old chicks were employed in the first experiment. One chick was fed eight encysted *P. americanum*. It was negative when examined after eleven days. A second chick was fed two cysts containing *P. encapsulatum*. This chick was also negative when examined after twenty-three days. Newly-hatched chicks were employed in a second experiment. One chick was fed four and a second chick was fed seven encysted *P. encapsulatum*. These chicks were negative when examined after four and seven days, respectively. In the third experiment, two screech owls (*Otus asio*) were fed seven and eight cysts containing *P. encapsulatum*. These owls were examined at intervals of seventeen and forty days, respectively, and were negative. Two additional owls were fed five and six cysts containing *P. americanum*. These owls were negative when examined after intervals of eighty-five and sixty-four days, respectively. The failure to establish an infection in these owls is not conclusive. These owls had been maintained in the laboratory for over two years before attempts were made to infect them, and they could have been refractive to infection.

In addition to the larvae encysted in the shrews, ten *Blarina* from Franklin County harbored from one to four larval *Porrocaecum* in the intestine. Osche (1955) found third-stage larvae which he identified as *P. ensicaudatum* in the circulatory system of the European earthworm

(*Lumbricus herculeus*). The larvae from the intestine of *Blarina* compare very favorably with the description which Osche gives for *P. ensicaudatum* and is tentatively identified as this species. The adult of *P. ensicaudatum* occurs in a number of passeriform birds, including the starling and the robin. The presence of the larvae in the intestine of *Blarina* must be considered an accidental infection which is obtained when the shrew eats an infected earthworm. Following is a brief description of the larvae from the shrew.

*Porrocaecum ensicaudatum* (Zeder, 1800)

Figures 3, 4 and 5

*Diagnosis:* Third-stage larva. Total length 3.60 to 4.63 mm; maximum diameter 97 to 148  $\mu$ . Cuticle with conspicuous transverse striations. Esophagus 379 to 462  $\mu$  long; ventriculus 106 to 129  $\mu$  long and 55 to 70  $\mu$  in diameter. Intestinal caecum very short, 12 to 47  $\mu$  long, usually located dorsolaterally on the left side of the larva. Nerve ring 198 to 246  $\mu$  from anterior end. Tail 117 to 153  $\mu$  long. A brown pigment, probably derived from hemoglobin, is present in the lumen of the intestine, the cells of the intestine, and in the dorsal, ventral, and lateral chords. The region from the ventriculus to the anterior end of the larva and from the rectum to the tip of the tail is free of pigment.

*Physaloptera limbata* Leidy, 1856

This species was originally described by Leidy (1851) under the name of *Spiroptera scalopsis canadensis* from a mole (*Scalopus aquaticus*). Later, Leidy (1856) renamed this parasite *Physaloptera limbata*. Morgan (1946) redescribed this species from specimens obtained from *Scalopus a. aquaticus*, *S. aquaticus machrinus*, *S. aquaticus machrinoides*, and *Parascalops breweri*.

This worm was encountered in one shrew from Franklin County. Four specimens were found in the stomach.

*Capillaria blarinae* Ogren, 1953

*C. blarinae* was described by Ogren (1953) from the esophagus of *Blarina brevicauda* in Illinois. In the present study, it was found in the esophagus of fourteen shrews collected in Franklin County. This incidence is probably lower than is actually the case since the esophagus was not examined in a number of hosts. The exact number of worms per host was not determined, but they were quite numerous in some shrews.

*Acanthocephala*

*Centrorhynchus conspectus* Van Cleave and Pratt, 1940

A single, juvenile, male acanthocephalan was recovered from a cyst in the mesenteries of a short-tailed shrew collected in Hocking County. This specimen was identified as belonging to the genus *Centrorhynchus*. There are only three recognized species of *Centrorhynchus* in North American hosts. These include *C. californicus* Millzner, 1924, a larval form encysted in *Hyla regilla*; *C. spinosus* (Kaiser, 1893) from the egret, *Herodias egretta*; and *C. conspectus* Van Cleave and Pratt, 1940 from the barred owl, *Strix v. varia*.

The juvenile from the shrew was tentatively identified as *C. conspectus*. According to the original description of this species, the proboscis is armed with 26 to 28 (rarely 30 or 32) longitudinal rows of hooks with 17 to 18 (rarely 16 or 19) hooks in each row. In each row of hooks, the anterior 4 or 5 hooks are large, and the posterior 12 to 15 hooks are small. In the specimen from the shrew, there were 29 longitudinal rows of hooks with 13 small and 4 or possibly 5 large hooks in each row. The proboscis was not entirely everted which made it difficult to determine exactly the number of large hooks per row. Nevertheless, the number and arrangement of the hooks fall within the range given for *C. conspectus*.

There is apparently only one record of an acanthocephalan occurring in North American shrews. Van Cleave (1953) lists a juvenile specimen of *Centrorhynchus* sp. from the intestine of *Sorex palustris navigator* from Oregon. Cystacanths of apparently the same species were found in several species of Amphibia in the same area which suggested that the specimen found in the shrew as an accidental infection resulting from eating an infected amphibian.

## DISCUSSION

The large number of species of helminths which parasitize *Blarina brevicauda* and the high percent infection of this host can probably be correlated directly with the food habits of this animal. Hamilton (1930) analyzed the stomach contents of 244 short-tailed shrews. He gives the following figures based upon bulk: insects, 47.8 percent; plant material, 11.4 percent; annelids, 7.2 percent; sowbugs, 6.7 percent; snails and slugs, 5.4 percent; vertebrates, 4.1 percent; centipedes, 3.8 percent; arachnids, 2.0 percent; millipedes, 1.7 percent; undetermined, 5.2 percent; inorganic matter, 2.3 percent; and empty, 1.7 percent. Since a large number of helminths utilize an intermediate host such as an insect, earthworm, or mollusk in their life cycle, it is apparent from the data above that shrews might commonly ingest the intermediate stages of helminths with their food.

No life cycles are known for the cestodes which parasitize *Blarina*, although Van Gundy (1935) found very immature specimens of *Hymenolepis anthocephalus* associated with larval elaterids in the stomach of a shrew. The hymenolepidids very frequently utilize an arthropod as an intermediate host which probably explains the large number of species of hymenolepidids which are found in insectivorous animals such as shrews. Insects are utilized in all of the life cycles which are known for the genus *Oochoristica*, and we can assume that the life cycle of *O. pennsylvanica* is similar.

There are a number of studies on the life histories of the brachylaimatid flukes occurring in *Blarina* (Sinitsin, 1931; Krull, 1935; Reynolds, 1938; and Villella, 1953a, 1953b, 1954). The metacercariae of these flukes occur in a number of land pulmonates, and consequently *Blarina* would pick up the infection directly by eating these infected mollusks.

A number of the nematodes which parasitize *Blarina* can be accounted for directly by considering the feeding habits of the shrew. Life cycle studies on these nematode parasites are sparse, but by considering life cycle studies of related species, a general idea of a number of these cycles can be obtained.

Ogren (1954) found third-stage larvae of *Angiostrongylus blarini* in the foot muscle and epithelial folds of the slug, *Philomycus carolinianus*. As was pointed out earlier in this paper, the third-stage larvae of *Porrocaecum ensicaudatum* which are found in the intestine of *Blarina* are probably accidental infections obtained by eating infected earthworms. The method by which *Blarina* becomes infected with *P. encapsulatum* and *P. americanum* is not known. However, it is possible that the eggs are picked up first by some invertebrate such as an earthworm and that the shrew becomes infected by ingesting the eggs or very early developmental stages in the invertebrate animal.

*Physaloptera limbata* is probably obtained directly from an infected arthropod intermediate host since such a host is utilized in all of the life cycles which are known in this genus.

The method by which infections of *Capillaria blarinae* are acquired is not known although some species in this genus require earthworms as intermediate hosts (Hyman, 1951).

The life cycle of *Longistriata depressa* is not known. According to the treatment of the trichostrongyloides in Hyman (1951), infections in this group come about either by direct skin penetration or by ingesting the infective larvae together with food.

Morgan (1928) pointed out the morphological similarity of *Parastrongyloides winchesi* and members of the genus *Strongyloides*. In the latter group, the life cycle consists of an alternation between a free-living generation which reproduces sexually and a parasitic generation which consists entirely of parthenogenetic females. The infection of the definitive host is accomplished by direct skin penetration by infective larvae. *Parastrongyloides winchesi* differs from *Strongy-*



*loides* in that both males and females are present in the parasitic generation. Whether a free-living generation occurs and whether infection of the shrew is accomplished directly by skin penetration is not known.

Although the life cycle of *Centrorhynchus conspectus* is not known, the cystacanth of this species which was found in one shrew suggests that *Blarina* may serve as the second intermediate host of this acanthocephalan. Van Cleave and Pratt (1940) state that an arthropod undoubtedly acts as the first intermediate host of this species, but they suggested that an amphibian probably serves as the second intermediate host. From a predator-prey relationship, however, *Blarina* would appear to represent a suitable second intermediate host. The shrew could easily become infected by eating the arthropod intermediate host, and *Blarina* in turn forms a frequent article in the diet of owls.

We may conclude from this discussion that the large and varied helminth fauna of the shrew can be attributed largely to the feeding habits of this animal. With the possible exception of several of the parasites discussed, the helminths occurring in the shrew require an intermediate host, and these hosts are frequently preyed upon by the shrew.

#### SUMMARY

Six species of tapeworms, four species of flukes, eight species of roundworms, and one acanthocephalan were recovered from ninety-three short-tailed shrews examined from central Ohio. One fluke and one tapeworm appear to represent new species, but in both cases the material did not permit a detailed study of these worms.

*Ectosiphonus ovatus* Sinitsin, 1931 and *Brachylaima condylura* Odlaug, 1952 were found to be synonyms of *Brachylaima rhomboideus* (Sinitsin, 1931). The finding of *Parastrongyloides winchesi* represents a new host and distribution record. The third-stage larva of *Porrocaecum ensicaudatum* was reported for the first time from the intestine of *Blarina*, but this is apparently an accidental infection. A cystacanth of *Centrorhynchus conspectus* was reported for the first time from *Blarina*.

The helminth fauna of the shrew is discussed from the standpoint of the life cycles of the parasites and the feeding habits of the shrew.

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