Washington. Douglas Booth, Paul Dominguez, and Rana Tawil assisted in collection of parasites.

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Research Note

Biology of Cave Crickets, *Hadenoecus subterraneus,* and Camel Crickets, *Ceuthophilus stygius* (Insecta: Orthoptera): Parasitism by Hairworms (Nematomorpha)

EUGENE H. STUDIER,[1] KATHLEEN H. LAVOIE,[1] AND CLAY M. CHANDLER[2]

[1] Biology Department, University of Michigan–Flint, Flint, Michigan 48502-2186 and

[2] Department of Biology, Middle Tennessee State University, Murfreesboro, Tennessee 37132

ABSTRACT: Gordiid hairworms identified as *Chordodes morgani* were collected from a rivulet in Floyd Collins' Crystal Cave, Kentucky, and the hemocoel of camel crickets, *Ceuthophilus stygius,* and cave crickets, *Hadenoecus subterraneus.* These collections extend the range for *C. morgani* to include Kentucky and add 2 new host species for this parasite. Infection prevalences for adult camel crickets were 16.9% for females and 2.9% for males. Adult cave crickets showed low infection rates of 0.8% and 0.9% for males and females, respectively. Based on average hairworm biomass, growth was slow during the summer while hosts were sexually immature and then became very rapid as host crickets matured. Repression of ova development was seen in parasitized female camel crickets (34.0 ova/female vs. 2.2 ova/parasitized female).

KEY WORDS: *Chordodes morgani, Hadenoecus subterraneus, Ceuthophilus stygius,* parasite load, hairworm growth rate, crickets, Nematomorpha.

The occurrence of internal helminths (unidentified gordiid hairworms) in the camel cricket, *Ceuthophilus stygius,* and cave cricket *Hadenoecus subterraneus,* was very briefly mentioned in Hubbell (1936) and in Hubbell and Norton (1978), respectively. Hubbell (1936) also indicated fly larvae of *Oedematocera flaveola* Coquillet as frequent parasites of camel crickets.

From March 1986 through July 1987, nearly monthly collections of cave and camel crickets were made in several caves in or near Mammoth Cave National Park, Kentucky (Walnut Hill, Great Onyx, White, and Floyd Collins' Crystal Caves as well as the Frozen Niagara and Austin Entrances to and Sophys and Marion Avenues of Mammoth Cave). In association with ongoing studies of the biology of these crickets (Studier et al., 1986, 1987a), collected individuals were dissected for several purposes including examination for macroscopic internal parasites.

Juvenile horsehair worms were found in some crickets of both species in the May through December samples. Additionally, 2 adult hair-

worms were collected on the floor of the entrance to Floyd Collins' Crystal Cave from a temporary rivulet created by heavy epigean rain in late July 1987. These adult hairworms and 1 juvenile from the hemocoel of an adult female *C. stygius* were identified as *Chordodes morgani*. A second juvenile worm from an adult female *C. stygius* hemocoel was tentatively identified as *C. morgani*. These collections extend the range for *C. morgani* (Chandler, 1985) to include Kentucky and add 2 new host species for this parasite. The voucher specimens are deposited in the U.S. National Parasite Collection, accession numbers USNM Helm. Coll. Nos. 81287–81289.

Although details of reproductive and population biology will be presented elsewhere, cave crickets (*Hadenoecus subterraneus*) reproduce throughout the year and adult life span exceeds 1 year. Individuals of all age classes are, therefore, present in all seasons. Only 2 hairworm juveniles were found in adult cave crickets: 1 in a male (of 106 examined = 0.9%) and 1 in a female (of 130 = 0.8%) both collected on 9 December 1986 from Floyd Collins' Crystal Cave. Of 153 juvenile cave crickets examined (49 in May, 50 in August, and 54 in November), none was parasitized by hairworms.

Camel crickets (*Ceuthophilus stygius*) complete their life cycle in 1 year and reproduce only in the fall, so adults were found only in the July through October collections. Of 70 males examined, 2 (2.9%) harbored hairworms while 11 of 65 (16.9%) females were parasitized; thus, females are hosts more frequently than males. Parasitized individuals came from several caves, representing where collection efforts were made in any given month. The 3 May and 4 October crickets came from Great Onyx Cave; the 24 October crickets, 1 each from Frozen Niagara and Austin Entrances, and 4 from Great Onyx Cave.

O'Brien and Etges (1981) reported that camel crickets collected about 100 mi northeast of Mammoth Cave National Park function as common intermediate hosts for the roundworm, *Pterygodermatites coloradensis,* but they make no mention of the occurrence of hairworms in the animals they examined. In addition to the horse-hair worms, we collected 1 unidentified roundworm from a *Hadenoecus* and 1 unidentified fly larva from a *Ceuthophilus*. No voucher specimens of either parasite are available.

Including all age hosts, camel crickets (9.6%) are much more heavily parasitized than cave crickets (0.5%). The higher prevalence of hairworms in camel crickets may relate to their need to drink water to maintain water balance whereas cave crickets do not (Studier et al., 1987b). Of parasitized male camel crickets, 1 contained 1 hairworm while the other harbored 2. Of 11 parasitized females, 7 contained 1, 3 contained 2, and 1 contained 3 juvenile hairworms. Hairworm parasite load in individual camel crickets (1.46) is somewhat higher than in cave crickets (1.00).

Some indication of growth rate of the hairworms can be determined by following changes in average worm biomass with time. Among camel crickets, average hairworm biomass was 46.3 mg in 2 parasitized individuals on 3 May 1986, 67.4 mg in 5 individuals on 4 October 1986, and 168.8 mg in 6 individuals on 24 October 1986. Based on these limited data, hairworms grow very slowly during the summer, while the host camel crickets are subadults and young adults and grow very rapidly when host crickets rapidly develop gonads and become sexually active.

Energy which would be devoted to ova growth appears to be diverted to parasite nutrition in adult camel crickets. Seven nonparasitized female camel crickets collected in October 1986 contained an average of 34.0 ova, whereas 9 parasitized females collected at the same time contained an average of 2.2 ova. In fact, 7 parasitized females contained no ova at all. A similar phenomenon has been reported for Mormon crickets parasitized by hairworms (Thorne, 1940).

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Research Note

Development of a *Sarcocystis*-like Apicomplexan Protozoan in the Brain of a Raccoon (*Procyon lotor*)

J. P. DUBEY,[1] C. A. SPEER,[2] A. N. HAMIR,[3] M. J. TOPPER,[4] C. BROWN,[4] AND C. E. RUPPRECHT[5]

[1] Zoonotic Diseases Laboratory, Livestock and Poultry Sciences Institute, Agricultural Research Service, U.S. Department of Agriculture, BARC-East, Beltsville, Maryland 20705,
[2] Veterinary Molecular Biology, Montana State University Bozeman, Montana 59717,
[3] New Bolton Center, School of Veterinary Medicine, University of Pennsylvania, 382 West Street Road, Kennett Square, Pennsylvania 19348,
[4] U.S. Army Medical Research Institute of Infectious Diseases, Fort Detrick, Maryland 21702, and
[5] The Wistar Institute of Anatomy and Biology, 3601 Spruce Street, Philadelphia, Pennsylvania 19104

ABSTRACT: Schizonts of a *Sarcocystis*-like protozoan were found in the brain of a raccoon (*Procyon lotor*). The parasites, located directly in the cytoplasm of macrophages, neurons, and multinucleated giant cells, were not surrounded by a parasitophorous vacuole. The parasite divided by endopolygeny, leaving a residual body. Schizonts were 5–35 × 5–20 μm and contained up to 35 merozoites. The merozoites had no rhoptries. The parasite was antigenically and structurally similar to *Sarcocystis neurona,* the organism of equine protozoal myeloencephalitis.

KEY WORDS: Protozoa, Apicomplexa, coccidia, *Sarcocystis,* encephalitis, schizonts, merozoites.

Toxoplasma gondii and *Neospora caninum* are the only known apicomplexan coccidians to cause fatal encephalomyelitis in carnivores (Dubey and Beattie, 1988). Recently Dubey et al. (1990) reported encephalitis in a raccoon associated with a *Sarcocystis*-like protozoan distinct from *T. gondii* and *N. caninum.* In this paper we report the development of the protozoan from the raccoon, *Procyon lotor* (L.), from Ohio.

Specimens of cerebrum were fixed in 10% buffered neutral formalin. Paraffin-embedded sections were cut at 3–6 μm, stained with hematoxylin and eosin (H&E), and examined microscopically. Selected specimens were embedded in glycol methacrylate and 2–3-μm sections were stained with H&E or periodic acid-Schiff hematoxylin (PASH). Formalin-fixed tissue was also processed for transmission electron microscopy. All measurements are given in micrometers.

Only asexual stages were seen (Figs. 1–12). Schizonts were located in neurons and macrophages. Individual merozoites were seen in neutrophils and mononuclear cells in lesions and in mononuclear cells in meningeal blood vessels. Most organisms seen were in macrophages. The