B A N I S T E R I A

A JOURNAL DEVOTED TO THE NATURAL HISTORY OF VIRGINIA

ISSN 1066-0712

Published by the Virginia Natural History Society

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Banisteria 54: 127–132

RESEARCH ARTICLE

PORROCAECUM ENCAPSULATUM (NEMATODA: ASCARIDIDA: TOXOCARIDAE) IN NORTHERN SHORT-TAILED SHREWS FROM VIRGINIA

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Editor: T. Fredericksen | Received 3 November 2020 | Accepted 5 November 2020 | Published 1 December 2020

https://virginianaturalhistorysociety.com/banisteria/banisteria.htm#ban54

Citation: Eckerlin, R. P., D. M. Feldman, and J. F. Pagels. 2020. *Porrocaecum encapsulatum* (Nematoda: Ascaridida: Toxocaridae) in Northern Short-tailed Shrews from Virginia. Banisteria 54: 127–132.

ABSTRACT

Northern short-tailed shrews collected in six counties in Virginia were examined for the presence of subcutaneous encysted larvae of nematodes. Fifty-three of 266 (19.9%) shrews were found infected with from 1 to 17 larval *Porrocaecum encapsulatum* cysts. Worms were always one per cyst and 39.6% had one cyst per infected shrew. However, 32 shrews (60.4%) contained 2 or more cysts and sometimes of different size classes. This is the first report of this nematode from Virginia.

Keywords: *Blarina brevicauda,* cysts, larvae, nematode, parasite, subcutaneous.

INTRODUCTION

Encysted larvae of three species of ascarid nematodes of the genus *Porrocaecum* are known from shrews and moles in eastern United States. Adult *Porrocaecum* worms have been reported from birds from Asia, Europe, North America, and South America but no life cycle data link the North American larval forms in mammals with adult worms in birds. Bird hosts of species of *Porrocaecum* include accipiters, strigids, ardeids, anatids, and passerines (Yamaguti, 1961). The few life cycles that are known for species of *Porrocaecum* include two hosts. Adult worms in the intestine of a bird release eggs that enter the soil in the bird feces. Earthworms ingest the eggs, and

development to an infectious stage occurs. When the earthworm is ingested by the bird, adult worms develop in the intestine of the definitive host (Levin, 1961; Yamaguti, 1961).

The three species found in shrews and moles in the United States are 1. *Porrocaecum ensicaudatum* (Zeder, 1800) found unencysted in the intestinal lumen of *Blarina brevicauda* (Say) (Oswald, 1958; Wittrock & Hendrickson, 1979), 2. *P. americanum* (Schwartz, 1925), whose cysts are found attached to mesenteries or abdominal organs of *B. brevicauda* (Chandler & Melvin, 1951; Oswald, 1958; Wittrock & Hendrickson, 1979), and 3. *P. encapsulatum* Schwartz, 1925, whose cysts are typically found in subcutaneous sites in *B. brevicauda* and a mole (Schwartz, 1925; Chandler & Melvin, 1951; Oswald, 1958; Huffman & Penner, 1981). We document the first report of *Porrocaecum encapsulatum* from the Northern short-tailed shrew, *Blarina brevicauda*, in Virginia, with some observations on its biology.

MATERIALS AND METHODS

We captured 266 Northern short-tailed shrews, using live traps, snap traps, and pitfall traps in six counties in Virginia between 1985 and 1992. Some were prepared as museum specimen study skins and some were kept as fluid preserved specimens. From fresh or fluid preserved shrews we removed the skin and nematode cysts were searched for adhered to the connective tissue covering the dorsal musculature. Cysts were pulled off with forceps and preserved in vials containing clean 70% ethanol (Appendix 1).

We measured eighty-six preserved cysts that were not ruptured or distorted by forceps pressure using a metric ruler and dissecting microscope at 7X magnification. All cysts were opened and the number of worms was counted. Because the worms were coiled and fragile, only 12 worms were measured and some were cleared in lacto-phenol to confirm specific identification. The worms were identified accurately because of these criteria: encysted, subcutaneous, large size (20mm or more), pointed posterior end. The shrews and the nematodes were deposited into the Virginia Commonwealth University Mammal Collection which has subsequently been acquired by and incorporated into collections of the Virginia Museum of Natural History, Martinsville, VA.

RESULTS

We found encysted larvae in 53 (19.9%) of the 266 shrews examined. Infected shrews had one or more cysts that were all collected from subcutaneous sites (listed in Appendix 1). All the nematode larvae, numbering 134, were identified as *Porrocaecum encapsulatum*. Each cyst contained a single worm that was coiled in the cyst sometimes with the anterior end and sometimes with the posterior end outermost. All the worms were larval forms. Cysts measured 1.5-4.0mm in diameter. Mean cyst size was 2.75mm (SD 0.69).The number of cysts per host animal varied from 1-17. Most shrews (21 = 39.6%) had a single cyst but 15 had 2 cysts, 5 had 3 cysts, 6 had 4 cysts, 4 had 5 cysts, and one each had 7 and 17 cysts. The mean number of cysts per host = 2.6 (SD 1.55).

For the 32 samples containing 2 or more cysts from a single host shrew, 22 had all the cysts of about equal size. But 10 samples with 2 (n=6) or 3 (n=4) worms had multiple size cysts. For example, shrew 5984 had 4 cysts, 2 of which measured 1.5mm and 1.6mm in length and 2 that measured 2.5 and 3.0 mm in length. The coiled condition of the worms made it difficult to measure them. Twelve worms ranged from 21mm to 45mm in length with mean of 30.1mm (SD 7.1).

The geographic occurrences of the infected shrews by county in Virginia are summarized as follow: Augusta Co. 5; Bath Co. 2; Cumberland Co. 17; Grayson Co. 1; Highland Co. 22; and Rockingham Co. 6. It was an animal from Cumberland County that had the 17 cyst infection.

DISCUSSION

Reports of the occurrence of *P. encapsulatum* have been made from Washington, D.C. which is the type locality (Schwartz, 1925), Pennsylvania (Chandler & Melvin, 1951), Ohio (Oswald, 1958), North Carolina (Miller, et al., 1974), and Connecticut (Huffman & Penner, 1981). This is the first record of *P. encapsulatum* from Virginia. The infections seem to be fairly widespread in the eastern United States and in Virginia. The prevalence of infections in Virginia is 19.9% and where it has been recorded it is generally low: 4.8% in Connecticut, 4.3% in North Carolina, and 12.9% in Ohio.

Our nematode cysts were recovered only from subcutaneous sites as were those of Oswald (1958), Huffman & Penner (1981), and Schwartz (1925), but Miller et al. (1974) reported some encysted *P. encapsulatum* from abdominal mesenteries in *Blarina brevicauda.* We did not examine abdominal sites. An additional host with subcutaneous cysts, the Hairy-tailed mole, *Parascalops breweri* (Bachman) was reported from Pennsylvania by Chandler & Melvin (1951).

Our data indicate that infections may result from multiple exposures to infection resulting in 2 or more size classes of cysts and larvae in one shrew. The disparity of size of the enclosed larvae indicates that considerable growth occurs during the cyst stage in the shrew host.

Although Northern short-tailed shrews may be active at any time of day, they are primarily active nocturnally (Linzey, 1998). Because owls are also nocturnal and are known to ingest shrews as a regular part of their diet (Mumford & Whitaker, 1982), and George et al. (1986) list 6 genera of owls with species known to prey on *B. brevicauda*, we suggest that *P. encapsulatum* larvae may mature to adult worms in the intestine of owls. Schwartz (1925) had suggested that hawks and owls were the likely definitive hosts. If earthworms are the required invertebrate hosts of these nematodes then the shrew or mole is a paratenic host that is important in transmission dynamics of the infection but not a required part of the life cycle. Oswald (1958) fed cysts of *P. encapsulatum* to chicks (*Gallus gallus* L.) and to two screech owls [*Otus asio* (L.)] but no infections resulted. Such animal studies are difficult today often because of institutional restrictions (IACUC) but molecular studies may be the best way to connect the larval forms to the adult worms to complete the life cycle.

ACKNOWLEDGEMENTS

We thank Nancy Moncrief of the Virginia Museum of Natural History for making shrew collection records available to us. Some shrews and all nematode cysts were collected by David M. Feldman as part of his Master of Science Thesis, Ecological significance of brown adipose tissue in the Northern short-tailed shrew (*Blarina brevicauda*). May 1993, Viii+54pp. Department of Biology, Virginia Commonwealth University. The Virginia Division of Game and Inland Fisheries provided collecting permits to J. Pagels. Valuable comments by two reviewers greatly improved the manuscript.

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Appendix 1. Collection data for *Blarina brevicauda* in Virginia and number of *Porrocaecum encapsulatum* cysts in each shrew.

Accession Number	County	Date of capture	Fluid (F) or unspecified (X)	Number of cysts
VCU-04349	Highland	18 Jul 1985	F	2
VCU-04897	Highland	07 Sep 1985	F	3
VCU-04905	Highland	07 Sep 1985	F	4
VCU-04909	Highland	16 Nov 1985	F	1
VCU-04915	Highland	10 May 1986	F	2
VCU-04940	Highland	18 Apr 1986	F	2
VCU-05128	Highland	28 Sep1985	F	1
VCU-05604	Grayson	20 Sep 1988	F	1
VCU-05638	Cumberland	05 Oct 1989	F	2
VCU-05795	Highland	13 Oct 1989	X	1
VCU-05950	Cumberland	16 Apr 1990	X	1
VCU-05980	Cumberland	01 Jun 1990	X	2
VCU-05983	Cumberland	01 Jun 1990	X	4
VCU-05984	Cumberland	01 Jun 1990	X	4
VCU-06007	Cumberland	16 Jun 1990	X	2
VCU-06008	Cumberland	16 Jun 1990	X	1
VCU-07214	Cumberland	2 Sep 1990	X	2
VCU-07231	Cumberland	16 Sep 1990	X	7
VCU-07232	Cumberland	30 Sep 1990	X	5
VCU-07600	Rockingham	06 Jul 1987	F	1
VCU-07601	Rockingham	8 May 1987	F	1
VCU-07612	Rockingham	27 Oct 1987	F	1
VCU-07617	Augusta	13 Oct 1989	F	2
VCU-07620	Augusta	31 Aug 1987	F	1
VCU-07679	Highland	05 Oct 1991	F	1
VCU-07700	Highland	05 Oct 1991	F	2
VCU-07702	Highland	05 Oct 1991	F	1
VCU-07710	Highland	05 Oct 1991	F	1
VCU-07728	Highland	06 Oct 1991	F	3
VCU-07729	Highland	06 Oct 1991	F	1
VCU-07731	Highland	06 Oct 1991	F	1
VCU-07733	Highland	06 Oct 1991	F	4
VCU-08305	Rockingham	14 Apr 1988	X	3
VCU-08310	Rockingham	02 Oct 1988	X	1
VCU-08324	Cumberland	29 Feb 1992	X	2
VCU-08334	Cumberland	12 Mar 1992	X	1
VCU-08336	Augusta	08 Mar 1992	X	1
VCU-08337	Augusta	08 Mar 1992	X	5
VCU-08392	Augusta	19 Dec 1991	X	4
VCU-08400	Cumberland	11 Dec 1991	X	17

Appendix 1
Continued

Accession Number	County	Date of capture	Fluid (F) or unspecified (X)	Number of cysts
VCU-08404	Cumberland	12 Dec 1991	X	2
VCU-08415	Cumberland	26 Jan 1992	X	5
VCU-08420	Highland	21 Sep 1990	X	3
VCU-08421	Highland	21 Sep 1990	X	1
VCU-08423	Highland	21 Sep 1990	X	1
VCU-08425	Highland	21 Sep 1990	X	2
VCU-08534	Cumberland	04 Apr 1992	F	2
VCU-09020	Highland	17 May 1992	F	4
VCU-09021	Highland	17 May 1992	F	2
VCU-09113	Rockingham	14 Sep 1991	F	1
VCU-10034	Highland	May-Jul 1992	X	2
VCU-10127	Bath	24 Jul 1992	X	3