
**First Report of *Bothriocephalus rarus*
(Bothriocephalidea: Bothriocephalidae) from
a Cave Salamander, *Eurycea lucifuga* and
Grotto Salamanders, *Eurycea spelaea* (Caudata:
Plethodontidae) from Oklahoma, with a Summary
of Helminths from these Hosts**

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The cave salamander, *Eurycea lucifuga* Rafinesque, 1822, as its name implies, is restricted to moist woodlands, cliff fissures, and damp limestone caves in the Central Highlands of North America from western Virginia and central Indiana southward to northern Georgia and west to eastern Oklahoma (Powell et al. 2016). In Oklahoma, *E. lucifuga* is restricted to karst systems in the northeastern portion of the state (Sievert and Sievert 2011).

The grotto salamander, *Eurycea spelaea* (Stejneger) is, as an adult, a troglobitic

species that occurs in darker zones of caves, underground streams and sinkholes in the Salem and Springfield plateaus in the Ozark region of southwestern Missouri to southeastern Kansas and adjacent areas from northern Arkansas to northeastern Oklahoma (Powell et al. 2016). Larval grotto salamanders can be found outside of caves in surface springs and in the entrance zone of caves but can also be found living deeper in cave systems (Fenolio et al. 2004; Trauth et al. 2004). In Oklahoma, *E. spelaea* is restricted to limestone caves and adjacent springs and seeps in the extreme northeastern corner of the state

(Sievert and Sievert 2011).

Although a moderate amount of information is available on the natural history of *E. lucifuga* (Juterbock 2005) and *E. spelaea* (Fenolio and Trauth 2005), comparatively little is known about their helminth parasites. Several studies have reported helminth parasites of *E. lucifuga* from some of its range, including Dyer and Brandon (1973) in Illinois, Dyer and Peck (1975) from several localities in the southeastern USA, Castle et al. (1987) in Kentucky, McAllister et al. (1991, 2007) in Arkansas and Tennessee, respectively, and McAllister and Bursey (2004) in Arkansas. The two largest studies, to date on *E. spelaea*, were by Dyer (1975) who examined over 100 specimens from Missouri, and McAllister et al. (2006) from a survey of 48 larval and adult grotto salamanders from Arkansas and Missouri. Additional reports of endoparasites from *E. spelaea* include those of Reeves (1949), Schaefer and Self (1978), Bonett et al. (2011) and McAllister et al. (2011) in Oklahoma, and Smith (1948) and Fenolio et al. (2013) in Missouri. Here we report a new host and distributional record for a tapeworm collected from *E. lucifuga* and *E. spelaea* from northeastern Oklahoma, and provide a first summary of helminths (Table 1) known from these hosts.

On 31 March 2016, six larval *E. spelaea* (mean \pm 1SD snout-vent length [SVL] = 38.7 \pm 3.4, range 33–43 mm) were collected by dipnet from Adair Cave (Christian School Cave), Adair County (latitude and longitude not given to protect location). In addition, three *E. lucifuga* were collected on 15 November 2015 and nine (five adult and four larval, 45.9 \pm 7.1, 38–58 mm SVL) were collected on 2 April 2016 from Flint Cave, Delaware County (36°12'27.83"N, 94°42'15.78"W). They were placed in cave water and transported to the laboratory for necropsy. Salamanders were killed by immersion in a concentrated Chloretone solution and measured for SVL. A midventral incision was made from the cloaca to throat and the tissue placed in a Petri dish containing 0.6% NaCl where it was split lengthwise and examined for helminths using a stereomicroscope. The liver, gonads,

and other organs were examined similarly. Tapeworms found in the small intestine were heat-fixed in near boiling water without coverslip pressure. They were transferred to 70–85% (v/v) ethanol, stained in acetocarmine, and mounted entire in Canada Balsam. Nematodes were fixed similarly, preserved in 70% (v/v) ethanol, and studied as temporary mounts in glycerol. Voucher specimens of salamanders were deposited in the Arkansas State University Museum of Zoology (ASUMZ), State University, Arkansas, and voucher specimens of parasites were either retained for future DNA analyses or deposited in the Harold W. Manter Laboratory of Parasitology (HWML), University of Nebraska State Museum, Lincoln, Nebraska.

Two of six (33%) *E. spelaea* (37 and 43 mm SVL) were found to harbor three tapeworms fitting the description of *Bothriocephalus rarus* Thomas (Thomas 1937). In addition, one of 12 (8%) *E. lucifuga* ([larvae], 41 mm SVL) was also infected with a single *B. rarus*. This cestode has been reported from several states (Fig. 1) and a variety of hosts (see McAllister et al. 2015); however, this is the first time it has been documented in *E. lucifuga* and *E. spelaea*. *Bothriocephalus rarus* has also been reported from two freshwater fishes, bluegill (*Lepomis macrochirus*) from Virginia and banded killifish (*Fundulus diaphanus*) from Maine (Meyer 1954; Bogitsh 1958); however, because this tapeworm has not been reported for over more than half a

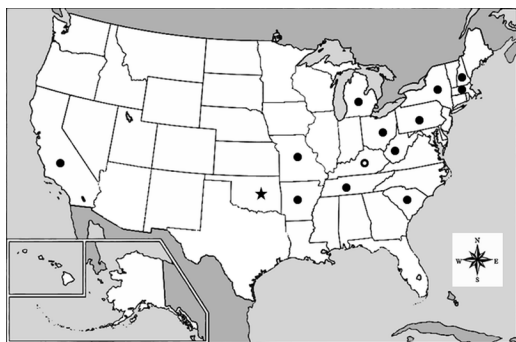


Figure 1. States with geographic records of *Bothriocephalus rarus*. Dots = previous records; open dot = unpublished thesis record; star = new record.

Table 1. Summary of helminth parasites of *Eurycea lucifuga* and *Eurycea spelaea*.

Host and Parasite	Locality	Prevalence*	Reference
<i>Eurycea lucifuga</i>			
Trematoda			
<i>Brachycoelium</i> sp.	Illinois	1/17 (6%)	Dyer and Brandon (1973)
	SE USA†	24/255 (9%)	Dyer and Peck (1975)
<i>B. salamandrae</i>	Kentucky	14/74 (19%)	Castle et al. (1987)
<i>Cainocreadium pseudotritoni</i>	SE USA†	1/255 (0.4%)	Dyer and Peck (1975)
<i>Clinostomum complanatum</i>	Tennessee	1/549 (0.2%)	McAllister et al. (2007)
<i>Sphyranura euryceae</i>	Arkansas	10/10 (100%)	McAllister et al. (1991)
Cestoda			
<i>Batrachotaenia cryptobranchi</i>	SE USA†	1/255 (0.4%)	Dyer and Peck (1975)
<i>Bothriocephalus rarus</i>	Oklahoma	1/12 (8%)	This study
Nematoda			
<i>Amphibiocapillaria tritonipunctati</i>	Kentucky	49/74 66%	Castle et al. (1987)‡
	SE USA†	13/255 (5%)	Dyer and Peck (1975)‡
<i>Batracholandros magnavulvaris</i>	Kentucky	7/74 (9%)	Castle et al. (1987)¶
	SE USA†	2/255 (1%)	Dyer and Peck (1975)¶
<i>Cosmocercoides dukael</i>	Illinois	3/17 (18%)	Dyer and Brandon (1973)
	SE USA†	62/255 (24%)	Dyer and Peck (1975)
<i>C. variabilis</i>	Arkansas	1/5 (20%)	McAllister and Bursey (2004)
<i>Omeia papillocauda</i>	SE USA†	1/255 (0.4%)	Dyer and Peck (1975)
	Oklahoma	1/12 (8%)	This study
<i>Oswaldocruzia euryceae</i>	Arkansas	1/5 (20%)	McAllister and Bursey (2004)
	Oklahoma	1/12 (8%)	This study
<i>O. pipiens</i>	Kentucky	26/74 (35%)	Castle et al. (1987)
	SE USA†	25/255 (10%)	Dyer and Peck (1975)
<i>Oxysomatium</i> sp.	Illinois	1/17 (6%)	Dyer and Brandon (1973)
<i>Rhabdias</i> sp.	SE USA†	1/255 (0.4%)	Dyer and Peck (1975)
Spirurid cysts	SE USA†	6/255 (2%)	Dyer and Peck (1975)
<i>Trichoskrjabinia</i> sp.	Kentucky	26/74 (35%)	Castle et al. (1987)
<i>Eurycea spelaea</i>			
Trematoda			
<i>B. salamandrae</i>	Missouri	2/119 (2%)	Dyer (1975)
<i>Clinostomum marginatum</i>	Oklahoma	1/12 (8%)	Bonett et al. (2011)
<i>Plagioporus gyrinophili</i>	Missouri	1/38 (3%)	McAllister et al. (2006)
<i>Sphyranura</i> sp.	Missouri	1/1 (100%)	Ashley (2004)
<i>S. euryceae</i>	Oklahoma	1/12 (8%)	McAllister et al. (2011)
Strigeoid metacercaria	Arkansas	8/8 (100%)	McAllister et al. (2006)
	Missouri	1/1 (100%)	Fenolio et al. (2013)

Table 1. Continued

Cestoda			
<i>B. rarus</i>	Oklahoma	2/6 (33%)	This study
<i>B. typhlotritonis</i>	Oklahoma	2/3 (67%)	Reeves (1949)
	Arkansas	3/40 (8%)	McAllister et al. (2006)
<i>Ophiotaenia</i> sp.	Missouri	9/31 (29%)	Smith (1948)
Nematoda			
<i>A. tritonipunctati</i>	Missouri	7/119 (6%)	Dyer (1975)‡
	Arkansas	4/13 (31%)	McAllister et al. (2006)
<i>Falcaustra catesbeiana</i>	Missouri	1/119 (1%)	Dyer (1975)
<i>Omeia papillocauda</i>	Arkansas	1/40 (3%)	McAllister et al. (2006)
<i>Oswaldocruzia</i> sp.	Missouri	2/119 (2%)	Dyer (1975)
Acanthocephala			
<i>Fessisentis vanleavei</i>	Arkansas	1/40 (3%)	McAllister et al. (2006)
	Oklahoma	1/12 (8%)	McAllister et al. (2011)

*Number infected/number examined = %.

†SE U.S.A. = sites in Alabama, Georgia, Illinois, Kentucky, Missouri, Tennessee, Virginia, and West Virginia.

‡Originally reported as *Capillaria inequalis* Walton, 1935, a synonym of *A. tritonipunctati* (see Moravec 1982).

¶Originally reported as *Thelandros magnavulvaris*; genus now referred to *Batracholandros* Freitas and Ibáñez, 1965.

‖Most likely a misidentification as *C. dukae* occurs in snails and *C. variabilis* is found in amphibians.

century in any other fish, we suspect that these findings could be misidentifications as several other *Bothriocephalus* spp. naturally occur in North American fishes (see Hoffman 1999) or represent pseudoparasites passing through the digestive tract from prey (newts?) naturally infected with *B. rarus*.

Interestingly, a similar tapeworm, *Bothriocephalus typhlotritonis* Reeves has been reported in grotto salamanders from Oklahoma (Reeves 1949) and Arkansas (McAllister et al. 2006). Another species, *Bothriocephalus euryciensis* Schaefer and Self was reported from five of five (100%) dark-sided salamanders, *Eurycea longicauda melanopleura* from the same cave site in Adair County (Schaefer and Self 1978) where we collected *E. spelaea*. In fact, we collected specifically from this type locality in search of *B. euryciensis*. However, surveys on *E. l. melanopleura* in Arkansas (McAllister and Bursey 2004; McAllister et al. 2015) failed to find any infected with *B. euryciensis* although several *B. rarus* were found in two of 13 (15%) and eight of 47 (17%) of specimens, respectively. *Bothriocephalus euryciensis* remains an enigma

of sort as it has not been reported in any host since its original description nearly 40 yr ago. Although these three cestodes are currently differentiated using morphological characters (e.g., size and scolex shape), additional work is needed to help unravel differences between *B. rarus*, *B. typhlotritonis* and *B. euryciensis* using more powerful molecular techniques previously used on other Bothriocephalidea (Brabec et al. 2015).

A single *E. lucifuga* (58 mm SVL) collected on 2 April 2016 harbored one female (HWML 99911) *Omeia papillocauda* Rankin, 1937. It has previously been reported from *E. lucifuga* from the SE USA (Dyer and Peck 1975). This nematode has also been reported from several other members of the genus *Eurycea* as well as *Desmognathus* and *Gyrinophilus* from Alabama, North Carolina, Ohio, and Tennessee (see McAllister and Bursey 2010). We document a new state record for *O. papillocauda*.

Another *E. lucifuga* (43 mm SVL) collected on 15 November 2015 harbored two female *Oswaldocruzia euryceae* Reiber, Byrd and

Parker, 1940. This nematode has previously been reported from *E. lucifuga* from Arkansas (McAllister and Bursey 2004) and from Rich Mountain salamander (*Plethodon ouachitae*) from Oklahoma as well as several other plethodontids from Georgia and Arkansas (McAllister and Bursey 2012).

A summary of the helminth parasites of *E. lucifuga* and *E. spelaea* is provided in Table 1. Seventeen helminths, including five trematodes, two cestodes, and 10 nematodes have been reported from *E. lucifuga* whereas a total of 14 helminths have thus far been found to infect grotto salamanders from Arkansas (five species), Missouri (eight species), and Oklahoma (five species), including six trematodes, three cestodes, four nematodes, and an acanthocephalan. Examination of larval specimens of *E. spelaea* from the only county in Kansas known to support them (Cherokee County, see Collins et al. 2010) would complete a parasite survey within its range and possibly provide new host and distributional records. However, *E. spelaea* is listed as endangered and critically imperiled (S1) in that state (NatureServe 2015) so only examination of limited museum specimens should be done.

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First Report of the Plant Bug *Collaria oculata* (Reuter, 1871) (Hemiptera: Miridae) from Oklahoma

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Collaria oculata (Reuter, 1871) (Hemiptera: Miridae: Mirinae) is a grass-feeding plant bug (Knight 1941) previously reported from 23 U.S. States and three Provinces of Canada (Fig. 1) (the Alberta literature record was questioned by Maw et al. [2000]; we follow their listing) (Henry and Wheeler 1988; Maw et al. 2000; Chordas et al. 2011). A report of *C. oculata* from neighboring Arkansas (Chordas et al. 2011) prompted our search for specimens in

Oklahoma because the presence of this species was considered probable for the state. Here, we document *C. oculata* as a new state record.

During August 2016, various hemipterans were observed by CTM below a night light at a residence in Hochatown, McCurtain County. Specimens were collected with fine forceps and placed in individual vials containing 70% (v/v) ethanol. They were subsequently shipped to



Figure 1. Distribution of *Collaria oculata* in North America north of Mexico. Light shade = prior literature records (Henry and Wheeler 1988; Maw et al. 2000; Chordas et al. 2011); dark shade = new state record.

SWC for identification. Our single specimen of *C. oculata* was deposited in the C.A. Triplehorn Collection at The Ohio State University, Columbus, Ohio, as a voucher specimen.

We collected a single female specimen of *C. oculata* with the following collection data: **Oklahoma:** McCurtain County, off Halibut Bay Road in Hochatown (34° 10' 17.0286"N, 94° 45' 5.7414"W); 21 VIII 2016; C. T. McAllister, collector (unique museum specimen code: OSUC 620934). Surrounding habitat consisted of various hardwoods (*Quercus* spp.) and pines (*Pinus* spp.) in Ouachita uplands. Several other Hemiptera species were also collected, including *Jalysus spinosus* (Say, 1824), *Myodocha serripes* Oliver, 1811, *Ozophora picturata* Uhler, 1871, and *Ptochiomera nodosa* Say, 1832. All four species have been previously reported from Oklahoma.

Collaria oculata has two distinctive dark ovoid spots on the posterior lateral aspect of the pronotum (see color Fig. 16 of this species in Chordas et al. [2011]). This plant bug had not previously been documented for Oklahoma. With additional fieldwork, many other hemipteran species recorded from surrounding states (see Chordas et al. 2011) probably can be added to the mirid fauna of Oklahoma.

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