Acanthocephalans (Eoacanthocephala: Neoechinorhynchida: Neoechinorhynchidae) of Common Snapping Turtles (*Chelydra serpentina*) from Arkansas and Oklahoma, with Observations on Host Suitability

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Abstract: Eighteen common snapping turtles (*Chelydra serpentina*) were collected from Arkansas (*n* = 5) and Oklahoma (*n* = 13) and examined for acanthocephalans. Three (17%) were found to harbor infections, including one from Arkansas with a *Neoechinorhynchus* sp., and two from Oklahoma with *Neoechinorhynchus emyditoides* Fisher, 1960. We document one of the few instances of *C. serpentina* harboring acanthocephalans and discuss host suitability.

Introduction

Acanthocephalans are highly specialized, dioecious metazoan parasites of the intestinal tract of a variety of vertebrates. The life cycle requires either an aquatic intermediate host (amphipods, copepods, isopods, and ostracods) or a terrestrial intermediate host (insects, crustaceans, and myriapods) and a vertebrate definitive host (Crompton and Nickol 1985). These "spiny- or thorny-headed worms" are relatively common in a variety of fresh and brackish water fishes (Pinacho-Pinacho et al. 2018) as well as aquatic turtles, and 10 species of *Neoechinorhynchus* have been previously reported from North American chelonian hosts (Barger 2004, 2005; Barger and Nickol 2004). One turtle species that has often been surveyed for helminth parasites is one of the most widespread native North American reptiles, the common snapping turtle, *Chelydra serpentina* L. (see summary in Ernst and Ernst 1977; Moravec and Little 2004; Zelmer and Platt 2009; Bursey and Brooks 2011; McAllister et al. 2015), but it has rarely been reported to harbor acanthocephalans. Four species have been reported from this host and states, including *Neoechinorhynchus chrysemydis* Cable and Hopp, 1954 from one of 26 (4%) from Indiana (Fisher 1960); *N. emydis* (Leidy, 1851) Van Cleave, 1916 from three of 30 (10%) from Oklahoma (Williams 1953); *N. emyditoides* Fisher, 1960 from Virginia (Zelmer and Platt 2009); *N. pseudemydis* Cable and Hopp, 1954 from one of 17 (6%) from Illinois (Martin 1973); two of 15 (13%) from Tennessee (Limsuwan and Dunn 1978); and immature specimens of a *Neoechinorhynchus* sp. from one of 13 (7%) from Louisiana (Acholonu 1969). Here, we document the second report of a certain species of acanthocephalan from *C. serpentina* from Oklahoma, with insight regarding the scarcity of reports.

Methods

Between April 2013 and October 2019, 18

juvenile and adult *C. serpentina* (Table 1) were collected from five counties of Arkansas (n = 5) and four counties of Oklahoma (n = 13) by hand, with hoop nets baited with fish, or collected opportunistically as dead on the road (DOR) specimens. Turtles were overdosed with an intraperitoneal injection of sodium pentobarbital (Nembutal®), and an electric saw was used to open their plastron to expose the internal organs. The intestinal tract was removed, sectioned, and placed in Petri dishes containing 0.9% saline. Intestinal contents were scraped from the lumen of the tract and examined with a stereomicroscope. When acanthocephalans were found, they were rinsed of mucus and placed in dishes containing distilled water for 24 h in a refrigerator to evert their proboscides. Each worm was placed on a glass slide, and a wet mount was prepared by adding a drop of tap water and a coverslip. All worms were examined at 100 to 400× with an Olympus BX-51 upright research microscope configured for Brightfield (BF) and Differential Interference-Contrast (DIC) microscopy. Digital images were taken of all worms using an Olympus 5-megapixel digital camera, and total length and greatest width of each worm were measured with ImageJ software (Schneider et al. 2012). All measurements are reported in millimeters (mm), including the mean ± 1 standard deviation.

We follow the reptile database (Uetz et al. 2019) for all turtle common and scientific names. We also follow Amin's (2013) classification of the Acanthocephala and Barger and Nickol (2004) for further species identification. Voucher specimens of acanthocephalans were deposited in the Harold W. Manter Laboratory of Parasitology (HWML), University of Nebraska, Lincoln, Nebraska. A voucher host was deposited in the Arkansas State University Museum of Zoology (ASUMZ), Herpetological Collection, State University, Arkansas.

Results and Discussion

Three of 18 (17%) *C. serpentina* were infected with acanthocephalans (Table 1). A single *C. serpentina* from St. Francis County, Arkansas, harbored immature *Neoechinorhynchus* sp., with an unknown intensity. Worms from two *C. serpentina*, collected from McCurtain County, Oklahoma, were identified as *Neoechinorhynchus emyditoides* Fisher, 1960 (HWML 111443), based on posterior end morphology of non-gravid females (Fig. 1) (Barger and Nickol 2004). Each of these two turtles were infected with two individual acanthocephalans, for a total of four worms, with lengths of 8.3 ± 0.42 mm (range = 8.0–8.6) and widths of 0.51 ± 0.04 mm (range = 0.48–0.54).

Neoechinorhynchus emyditoides was originally described by Fisher (1960) from red-eared sliders (*Trachemys scripta elegans*) from Arkansas. To date, *N. emyditoides* has been reported from at least 14 species and/or subspecies of turtle hosts from four families across the United States and México (Table 2), including a *C. serpentina* from Virginia (Zelmer and Platt 2009). Barger (2004) previously reported *N. emyditoides* from *T. s. elegans* from McIntosh and Pittsburg counties, Oklahoma. In addition, McAllister et al. (2015) reported a *Neoechinorhynchus* sp. from an eastern river cooter (*Pseudemys concinna concinna*) from McCurtain County, Oklahoma, thought to represent either *N. emyditoides* or *N. pseudemydis*; however, because no fully developed eggs were present in specimens

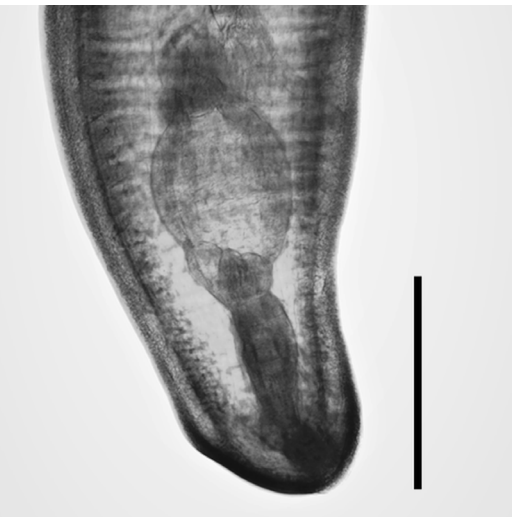

Figure 1. Posterior end of non-gravid female *Neoechinorhynchus emyditoides* from *Chelydra serpentina*. Scale bar = 100 µm.

Table 1. Eighteen common snapping turtles collected between 2013 and 2019 from Arkansas (AR) and Oklahoma (OK) and examined for acanthocephalans.

Date collected	Carapace length (mm)	Sex	Locality	Infected?
20 April 2013	92	F	AR:Franklin Co., off St. Hwy. 23	No
9 May 2013	225	F	AR:Union Co., El Dorado	No
14 May 2013	260	F	OK:McCurtain Co., Yashau Creek	No
15 May 2015	235	M	OK:McCurtain Co., vic. Idabel	No
30 April 2016	195	M	OK:McCurtain Co., N of Broken Bow	No
21 April 2017	165	M	AR:St Francis Co., jct. St. Hwys. 255/261	Yes
20 June 2018	220	M	AR:Sevier Co., Mill Creek at Horatio	No
8 July 2018	265	M	OK:McCurtain Co., Hochatown	No
21 March 2019	205	F	OK:McCurtain Co., Yashau Creek	Yes
15 May 2019	219	F	OK:Payne Co., Stillwater	No
16 May 2019	195	M	OK:McCurtain Co., E of Broken Bow	Yes
24 May 2019	295	F	OK:Payne Co., Stillwater	No
10 June 2019	320	M	OK:McCurtain Co., 3.2 km N Broken Bow	No
12 June 2019	200	M	AR:Polk Co., vic. Board Camp	No
	218	F	OK:Payne Co., Stillwater	No
19 June 2019	225	F	OK:Lincoln Co., Stillwater	No
18 July 2019	275	M	OK:Payne Co., Stillwater	No
1 October 2019	260	M	OK:Choctaw Co., Ft. Towson	No

(HWML 91960), species identification was problematic and, unfortunately, remains unknown. Here, we document the second report of *N. emyditoides* in *C. serpentina*, comprising a total of four species of *Neoechinorhynchus* reported from common snapping turtles.

Of the seven previous reports of *Neoechinorhynchus* spp. from common snapping turtles, prevalence and intensities of infections were low, and all worms were non-gravid or immature females. This is in contrast to reports of species of *Neoechinorhynchus* from aquatic emydid turtles where prevalence and mean intensity can range from one to 100% (average 50.2%) and one to 2,337 (average 82.2), respectively (Fisher 1960; Martin 1973; Esch et al. 1979; Lindeman and Barger 2005). Results from the present study also report low prevalence (17%) and mean intensity (two) of *Neoechinorhynchus* spp. from snapping turtles from Arkansas and Oklahoma. Additionally, none of the *Neoechinorhynchus* spp. from this study were mature and/or gravid, and the four female *N. emyditoides* averaged 8.3 ± 0.42 mm in length and 0.51 ± 0.04 mm in width, much smaller than the original species description (females, length = 34.3 mm; females, width = 0.94 mm), but from red-eared sliders (Fisher 1960). Taken together, these results suggest that common snapping turtles are unsuitable hosts for acanthocephalans.

There are various factors that may influence host suitability for parasites. However, one likely factor could be due to the food habits of *C. serpentina*, as they are more carnivorous, specifically, piscivorous, compared to other species of emydid turtles (Lagler 1943). Additionally, the foraging behavior of *C. serpentina* shifts from opportunistic predation in juveniles to ambush predation in adults (Ernst et al. 1994). However, because four of the 10 turtle acanthocephalan species have

Table 2. Previous reports of *Neoechinorhynchus emyditoides* from four families of North American turtles.

Family/Host	Locality	Prevalence*	Reference
CHELYDRIDAE			
Chelydra serpentina	Virginia	–	Zelmer and Platt (2009)
	Oklahoma	2/13 (15%)	This study
EMYDIDAE			
Chrysemys picta	Indiana	–	Barger (2004)
Emydoidea blandingii	Massachusetts	–	Fisher (1960)
Graptemys geographica	not reported	–	Barger (2004)
Graptemys pseudogeographica	Tennessee	–	Barger (2004)
Pseudemys concinna	Louisiana	8/12 (67%)	Acholonu (1969)
Pseudemys floridana	Louisiana	–	Acholonu (1969)
Trachemys gaigeae	New Mexico	3/5 (60%)	McAllister et al. (2008)
	México (Nuevo León)	–	Garcia-Varela et al. (2011)
Trachemys ornata	México (Tabasco)	–	Bravo-Hollis (1946)
Trachemys scripta elegans	Arkansas†	17/24 (71%)	Fisher (1960)
		91/94 (97%)	Rosen and Marquardt (1978)
		–	Barger (2004)
	Alabama	–	Johnson (1969)
	California	–	Fischer (1960)
	Indiana	–	Barger (2004)
	Louisiana	6/12 (50%)	Fisher (1960)
		44/78 (56%)	Acholonu (1969)
	Mississippi	12/12 (100%)	Fisher (1960)
		–	Barger (2004)
	New York	–	Fisher (1960)
	North Carolina	–	Johnson (1969)
	Oklahoma	–	Barger (2004)
	South Carolina	–	Aho et al. (1992)
	Tennessee	–	Barger (2004)
	Texas	–	Fisher (1960)
		10/10 (100%)	Little and Hopkins (1968)
	Virginia	–	Fisher (1960)
	México (Veracruz)	–	García-Varela et al. (2011)
Trachemys scripta scripta	South Carolina	42/106 (40%)	Esch et al. (1979)
Trachemys scripta troostii	not reported	–	Barger (2004)
TRIONYCHIDAE			
Apalone spinifera	Louisiana	9/18 (50%)	Acholonu (1969)
KINOSTERNIDAE			
Kinosternon sp.	not reported	–	Barger (2004)

*Number infected/number examined (%).

†Type locality.

been reported from *C. serpentina*, and because worms were never reported as gravid or mature, these data suggest that this host must also have various physiological constraints preventing acanthocephalans from establishing in the intestine. Given that various aquatic turtles, in addition to *C. serpentina*, have been reported with *Neoechinorhynchus* spp. in North America (Barger 2004, 2005), it appears that *C. serpentina* remains an outlier host, regardless of the overlap in habitat. Interestingly, a report (West et al. 2000) of three *Neoechinorhynchus* species, including *N. chrysemydis*, *N. emydis*, and *N. pseudemydis*, from alligator snapping turtles (*Macroclemys temminckii*) from Arkansas and Louisiana indicates a low prevalence of 9% and mean intensity of 26, suggesting that other chelydrid turtle species may also be unsuitable hosts for *Neoechinorhynchus* species.

The exact reason for the unsuitability of *C. serpentina* for acanthocephalans remains unknown yet hints toward both historical events of host-parasite evolution and current ecological conditions, such as host diet. Finally, although the intermediate and paratenic hosts are not known for *N. emyditoides*, other turtle *Neoechinorhynchus* species use ostracods and snails as intermediate and paratenic hosts, respectively (Hopp 1954). This suggests that snapping turtles do not ingest as many suitable ostracods and/or snails compared to red-eared sliders. Future work should aim to survey turtles for acanthocephalans, keeping *C. serpentina* in mind due to the rarity of reports.

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