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Research Note

Seasonal Occurrence of *Cosmocercoides dukae* and Prey Analysis in the Blue-Spotted Salamander, *Ambystoma laterale*, in Southeastern Wisconsin

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ABSTRACT: From April to October 1993, 83 blue-spotted salamanders, *Ambystoma laterale*, were collected from Waukesha County, Wisconsin, and examined for helminth parasites. Twelve percent of salamanders were infected with the nematode *Cosmocercoides dukae* Holl, 1928. Monthly parasite prevalence and mean intensity remained low from April through July, ranging from 6% prevalence in July to 13% in May. The highest prevalence was in September, when 50% (5/10) of the salamanders were infected. Forty-four percent of the salamanders contained identifiable stomach contents. Amphibians may acquire temporary infections of *C. dukae* by ingesting gastropods. Prevalence of infection increased proportionally with the number of slugs recovered from stomach contents, suggesting that this gastropod may be a primary reservoir of *C. dukae* observed in *A. laterale*.

KEY WORDS: Nematoda, *Cosmocercoides dukae*, amphibia, *Ambystoma laterale*, Gastropoda, stomach content, seasonal study, Wisconsin.

Although there is extensive literature on parasites of amphibians of the United States, most reports have concentrated on anurans (Aho, 1990). Excluding new species descriptions, little work has been done on helminth ecology of salamanders (Rankin, 1937, 1945; Fischthal, 1955; Coggins and Sajdak, 1982; Goater et al., 1987; Aho, 1990; Muzzall, 1990; Muzzall, 1991; Muzzall and Schinderle, 1992). The only published reports of helminths from the blue-spotted salamander, *Ambystoma laterale* Hallowell, 1856, are those by Coggins and Sajdak (1982), who examined 26 specimens from Wisconsin, and Muzzall and Schinderle (1992), on the helminths of the salamanders *A. t. tigrinum* Green, 1825, and *A. laterale* from southern Michigan.

Ambystoma laterale were collected during April–October 1993 from Waukesha County, Wisconsin. Salamanders were hand-captured by overturning rocks and logs during the day or by collecting while they foraged at night. Each monthly sample included between 10 and 17 specimens except for October, when only 1 individual was collected. Animals were put on ice or pithed and preserved in 10% neutral-buffered formalin (NBF) within 12 hr after capture. Snout–vent length (SVL) was recorded for each individual, and sex was determined and recorded for adults. The digestive tract, body wall musculature, and internal organs were examined for helminths using standard necropsy techniques (Pritchard and Kruse, 1982). Nematodes were preserved in 10% NBF, dehydrated to 70% ethanol, cleared in glycerol, and identified as temporary mounts using descriptions provided by Anderson (1960). All undigested stomach content was preserved in 10% NBF and identified to class or order following Barnes et al. (1993). Prevalence is the percentage of infected hosts in the sample; mean intensity is the mean number of parasites divided by the number of infected hosts. Voucher specimens have been deposited in the H. Manter Helminth Collection, University of Nebraska, Lincoln (accession No. HWML 39184).

Ten (12%) of 83 *Ambystoma laterale* were infected with 1 or more individuals of *Cosmocercoides dukae* Holl, 1928. A total of 13 nematode individuals were found: 4 adult males, 3 adult females, 1 L_4 larva, and 5 L_3 larvae. All nematodes were found in the small and large intestine. Monthly parasite prevalence and mean intensity remained low from April through July, ranging from 6% prevalence in July to 13% in May (Table 1). The highest prevalence was in September, when 50% (5/10) of the salamanders were infected. Mean intensity remained low dur-

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Table 1. Monthly and overall prevalence and mean intensity of *C. dukae* in *A. laterale*.

Month	No. examined	Prevalence*	Mean intensity (range)	Mean SVL (mm) ± 1 SD (range) of *A. laterale*
April	10	1 (10.0)	1 (1)	44.38 ± 10.30 (30.55–60.00)
May	15	2 (13.3)	2 (1–3)	42.29 ± 8.98 (30.15–57.00)
June	14	1 (7.1)	1 (1)	36.80 ± 7.81 (27.10–52.90)
July	16	1 (6.3)	1 (1)	31.53 ± 6.96 (26.55–56.45)
August	17	0 (0)	— (0)	31.01 ± 2.23 (28.35–36.20)
September	10	5 (50.0)	1.2 (1–2)	37.83 ± 5.41 (31.15–50.50)
October	1	0 (0)	— (0)	34.14
Overall	83	10 (12.0)	1.3 (1–3)	36.59 ± 8.56 (26.55–60.00)

* Number infected (percent infected).

ing this collection period averaging 1.3 worms per infected host. No parasites were found in August or October; however, the October collection represented only 1 host. Due to low prevalence and mean intensity values, no statistical analysis was performed.

Mean SVL of the salamanders also differed during the 7-mo collection (Table 1). The greatest mean SVL was recorded in April (44.38) and decreased each month, reaching its minimum value in August (31.01), before increasing in September (37.83). Statistically significant differences in mean SVL were observed for April and July, April and August, May and July, and May and August ($P < 0.001$, single-factor, independent measure ANOVA; $P = 0.05$ for all pairwise comparisons, Scheffe's test).

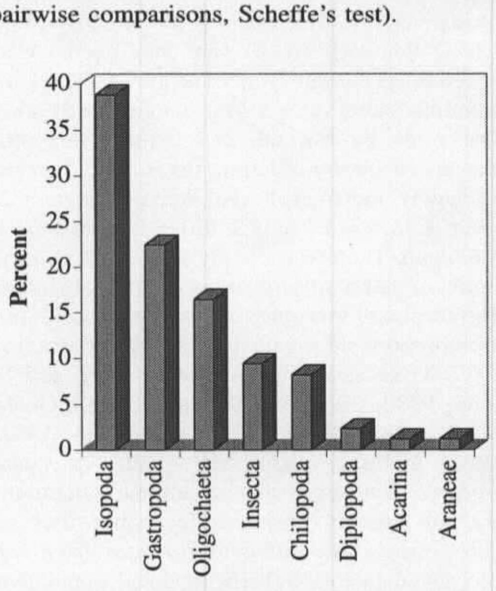

Figure 1. Undigested stomach content of *A. laterale* from 1993.

In the present study, 44% of salamanders contained identifiable stomach contents. Ambystomid salamanders have a broad prey base and do not concentrate on any specific prey items (Vogt, 1981). Stomach content analysis of *A. laterale* revealed a broad range of invertebrates (Fig. 1). Terrestrial isopods, gastropods, and oligochaetes made up the largest portion of the diet, respectively, followed by insects, chilopods, diplopods, and other arthropods. These results are similar to those of other investigators (Minton, 1972; Gilhen, 1974). Gastropods appear to be an important food item in the diet of the blue-spotted salamander. Gilhen (1974) recorded slugs as being the most common food item recovered from salamanders in Nova Scotia, whereas they were the secondmost common item found in the present study.

Salamanders are ectothermic insectivore generalists (Goater et al., 1987). Their parasite fauna and parasite prevalence may reflect the number of invertebrate prey available to the salamanders. As found in this study and other previous work, it is suggested that salamanders have both a low parasite prevalence and mean intensity (Rankin, 1937, 1945; Fischthal, 1955; Coggins and Sajdak, 1982; Goater et al., 1987). These patterns of prevalence and intensity of infection seem to indicate that salamander helminths are not host-specific but are opportunistic generalists. Their distribution can be correlated to habitat type used by the salamanders and prey availability to the hosts, which in turn depends on ecological factors influencing variation in life history traits in local populations (Aho, 1990). The pattern of different helminth communities found in the study by Muzzall and Schinderle (1992) and the present study of *A. laterale* support this hypothesis. Possible explanations for these observed differences can range from the absence of the parasite in the study area, the lack of an appropriate intermediate host, or both.

The nematode *C. dukae* has been reported from numerous gastropods, amphibians, and reptiles in North America (Harwood, 1930; Ogren, 1953; Anderson, 1960; Lewis, 1973; Baker, 1978; Vanderburgh and Anderson, 1986a, b). Recently, it has been shown by Vanderburgh and Anderson (1986a) that *C. dukae* is a parasite of terrestrial molluscs with inadvertent occurrence in animals feeding upon terrestrial molluscs. *Cosmocercoides variabilis* is considered to be a parasite of amphibians. This nematode has a direct life cycle by skin penetration, molting in the lungs or body cavity and maturing in the intestine (Baker, 1978; Vanderburgh and Anderson, 1986a). It was suggested that this parasite may be restricted to certain amphibian groups such as representatives of the Hylidae, Microhylidae, and Bufonidae (Vanderburgh and Anderson, 1986a). More recently, *C. variabilis* has been shown to infect *Plethodon cinereus*, the red-backed salamander, in Virginia (Bursey and Schibli, 1995), extending its occurrence into the Caudata. The major difference in the 2 species is the number of rosette papillae: *C. dukae* with 12 pairs of rosette papilla and *C. variabilis* with 14–20 pairs (Travassos, 1931). Each male specimen in the present study possessed 12 pairs of rosette papillae, and no larva were found in the host lungs or body cavity. The parasite prevalence of this nematode was also low, and mean intensity was very low. Thus, it is felt that the specimens are accidental infections of *C. dukae*.

The present report of *C. dukae* in *A. laterale* may be due to ingesting infected gastropods (Anderson, 1960). Larval *C. dukae* were found in salamanders in months when gastropods were commonly found in the stomach contents for all months except August (see Fig. 2). However, all salamanders collected during the month of August (Table 1) were newly metamorphosed larva that did not have enough time to feed heavily and acquire the infection. Newly metamorphosed salamanders in the study by Muzzall and Schinderle (1992) also contained little food in the gastrointestinal tract; they indicated that they were collected before the onset of heavy feeding. Although statistical analyses was not performed due to small sample sizes, these results show a proportional increase in prevalence of *C.*

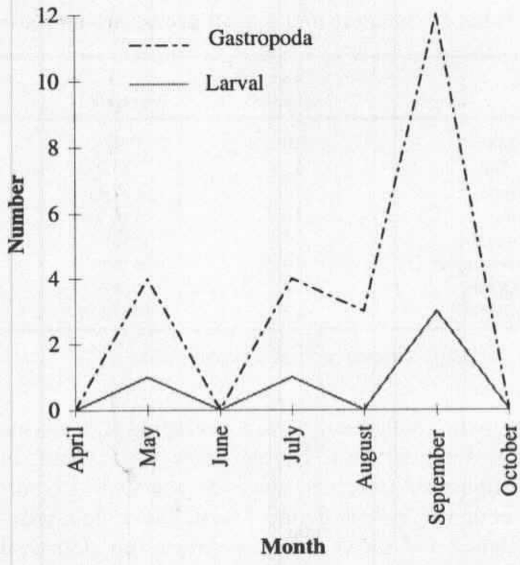

Figure 2. Combined larval *C. dukae* and Gastropoda recovered from monthly salamander samples in 1993.

dukae in *A. laterale* and number of gastropods recovered from stomach content.

The lack of seasonal data on salamander parasites may indicate the difficulty in collecting these animals throughout the year. Coggins and Sajdak (1982) collected their animals during the spring rains or after melting of the snows. Collecting this early in the year may not have allowed hosts enough time to acquire their regular helminth fauna after a long winter hibernation. The study by Muzzall and Schinderle (1992) was also a survey of helminths from 257 larvae, 24 newly metamorphosed individuals, and 21 adult *A. laterale* from 2 different locations in Michigan. The present study is the first seasonal study of helminths of Wisconsin salamanders. The results of this study are consistent with previous reports of salamander parasites (Rankin, 1937; Dyer and Brandon, 1973; Price and St. John, 1980; Coggins and Sajdak, 1982; Goater et al., 1987; Muzzall and Schinderle, 1992). These findings support the results of earlier workers, indicating that salamander helminths are not strongly host-specific; rather, they are generalists whose distribution is correlated with ecological factors influencing local populations and their diet.

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