The Prevalence of *Sebekia mississippiensis* (Pentastomida) in American Alligators (*Alligator mississippiensis*) in North Florida and Experimental Infection of Paratenic Hosts

WALTER M. BOYCE  
Department of Infectious Diseases, College of Veterinary Medicine, University of Florida, Gainesville, Florida 32610

**ABSTRACT:** The pentastomid *Sebekia mississippiensis* was found in 29 of 31 alligators examined from two lakes in Alachua County, Florida. The majority of parasites found in the lungs were nymphs and no eggs were found on fecal examination.

Nymphs obtained from naturally infected mosquitofish, *Gambusia affinis*, survived in two species of laboratory rodents, two species of turtles, and one frog species when administered by oral gavage. Live nymphs were recovered 28 and 120 days after infection from the rodents and turtles, respectively, and 24 hr after administration in the frog. Hemorrhage due to nymphal migration killed the single infected frog within 24 hr and resulted in significant intra-abdominal adhesions in other experimentally infected animals. There was no apparent development beyond the nymphal stage in any of the experimentally infected animals.

Studies on the prevalence and intensity of parasites infecting the American Alligator (*Alligator mississippiensis* Daudin) have reported infection rates by the pentastomid *Sebekia oxycephala* (Desing, 1835) to exceed 93% (Hazen et al., 1978; Cherry and Ager, 1982). This pentastomid occurring in American alligators has recently been described as *Sebekia mississippiensis* Overstreet, Self, and Vliet, 1985, to distinguish it from *Sebekia oxycephala*, which occurs in South American crocodilians (Overstreet et al., 1985). Adults of *S. mississippiensis* occur in the respiratory passages of crocodilians and nymphal stages are found in crocodiles, turtles, mammals, and several species of fish (Vernard and Bangham, 1941; Dukes et al., 1971; Overstreet et al., 1985). The entire life cycle is not known; however, adults of *S. mississippiensis* mature in the lungs of alligators and shed eggs that are passed with the feces (Deakins, 1971) into the aquatic environment and serve as the source of infection for fish. Alligators acquire infections by ingesting infected fish (Boyce et al., 1984).

The high incidence of infection of *S. mississippiensis* in alligators, coupled with the diversity of species harboring nymphs, suggests that numerous opportunities may exist for species associated with aquatic environments to serve as paratenic hosts of *S. mississippiensis*. This paper reports the prevalence of *S. mississippiensis* in alligators from north Florida, and the results of experimental studies designed to determine whether or not warm-blooded vertebrates (rodents), turtles, and frogs could serve as paratenic hosts when infected with nymphs obtained from naturally infected fish.

**Materials and Methods**

Alligators were collected from Orange Lake (*N* = 21) and Newnan’s Lake (*N* = 10) in Alachua County, Florida, as part of an experimental alligator hunt sponsored by the Florida Game and Freshwater Fish Commission during September 1983. Most of the alligators were male (*N* = 21) and weights ranged from 18 to 234 kg at Newnan’s Lake and from 6 to 170 kg at Orange Lake. Alligators were killed at night and stored under refrigeration until the following morning when the lungs were removed and frozen. Fecal samples were obtained per rectum and examined by both flotation and sedimentation techniques. Later, the lungs were thawed, teased apart under a magnifying lamp, and pentastomes recovered and preserved in 70% glycerin alcohol. Specimens were cleared in lactophenol and nymphs and adults differentiated by the presence or absence of accessory hooks on each of the four principal hooks.

Prevalence and intensity of infection of *S. mississippiensis* were determined in mosquitofish (*Gambusia affinis* (Baird and Girard)) from a manmade lake heavily populated by adult alligators in Hillsborough County, Florida. Mosquitofish were collected and examined in October 1983 (*N* = 30); March 1984 (*N* = 127); and July 1984 (*N* = 28). The nymphs used in the experimental infections were obtained from mosquitofish from this manmade lake in October 1984. The mosquitofish were maintained in aquaria for up to 1 wk prior to dissection and recovery of viable nymphs. Upon dissection nymphs were placed in tap water and administered via tube directly into the stomach of the experimental host.

Six female golden hamsters (*Mesocricetus auratus* (Waterhouse)) were each given 30 nymphs of *S. mississippiensis* and two other rats served as uninfected controls. All hamsters were full siblings and 1 mo of
age at time of infection. One infected hamster was necropsied at 1 day and 7 days post-infection, and two infected hamsters were necropsied 14 and 28 days after infection. One control hamster was necropsied at 14 and 28 days post-infection.

Six male Sprague Dawley rats (Rattus norvegicus (Berkenhaut)) were each given 30 nymphs and two other rats served as uninfected controls. All rats were 6 wk old at the time of infection. Two infected rats were necropsied at 7, 14, and 28 days post-infection. One control rat was necropsied at 14 and 28 days post-infection.

Ten Florida cooters (Pseudemys nelsoni Carr) and one Florida softshell (Trionyx ferox Schneider) were each given 10 nymphs; four additional cooters and one additional softshell served as uninfected controls. All turtles were hatched in captivity from eggs obtained from the wild and were 1 mo of age at time of infection. Both species of turtles were maintained in aquaria and fed a commercial diet (Tetra ReptoMin, TetraWerke, West Germany). Three infected cooters and one uninfected control were necropsied at 7 days post-infection, two infected cooters and an accompanying uninfected control were necropsied at both 14 and 28 days post-infection, and three infected cooters and one uninfected control were necropsied 120 days post-infection. The infected and uninfected softshell turtles were necropsied 14 days after infection.

A single wild caught pig frog (Rana grylio Stejneger) was dosed with 20 nymphs and maintained in an aquarium for 24 hr at which time it died and was necropsied.

All experimental animals, except for the pig frog, were killed with an overdose of methoxyflurane (Metofane, Pittman-Moore Inc., Washington Crossing, New Jersey) prior to necropsy. At necropsy, tissues were examined for gross lesions and then teased apart to recover intact nymphs. Viability of recovered nymphs was assessed under a dissecting microscope at 10× by the presence or absence of movement. Histopathologic examination was not attempted due to the destructive nature of the nymphal recovery procedure.

**Results**

The prevalence and intensity of *Sebekia mississippiensis* in alligators from Alachua County, Florida, are presented in Table 1. Pentastome eggs were not recovered on fecal examination from any of the 31 alligators examined; however, eggs were present within the uteri of five adult females of *S. mississippiensis* recovered from the lungs. Representative specimens have been deposited in the U.S. National Parasite Collection in Beltsville, Maryland, and given the accession number 78415. The prevalence and intensity of nymphs of *S. mississippiensis* in mosquitofish from Hillsborough County, Florida, are presented in Table 2. Nymphs were encapsulated and located primarily in the body cavity.

**Experimental infections**

All nymphs of *S. mississippiensis* recovered at necropsy were viable and at the same developmental stage as at the time of administration, i.e., all nymphs still possessed accessory hooks on the principal hooks.

**Hamsters and Rats:** Nymphs of *S. mississippiensis* were recovered from all experimentally infected rats and hamsters and similar numbers were recovered at each time interval (Table 3). No nymphs were recovered and no pathologic lesions were noted in the non-infected controls of each species necropsied 14 and 28 days after infection.

Clinical signs of infection were not detected in the infected rats whereas the infected hamsters became markedly lethargic and depressed in the 24-hr period immediately following infection. One hamster became moribund during this period and was euthanized. On necropsy adhesions were found between the stomach, liver, and mesentery, and three nymphs were found penetrating the stomach wall in the region of the adhesions. Marked hemorrhage surrounded these lesions and there was a small amount of blood free in the peritoneal cavity.

Lesions were remarkably consistent among the

---

**Table 1. Prevalence and intensity of *Sebekia mississippiensis* in alligators from Alachua County, Florida.**

<table>
<thead>
<tr>
<th>Lake</th>
<th>N</th>
<th>Prevalence</th>
<th>Mean (SD)</th>
<th>Range</th>
<th>Adults</th>
<th>Nymphs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orange</td>
<td>21</td>
<td>90.4</td>
<td>14.0 (14.0)</td>
<td>1-53</td>
<td>9</td>
<td>258</td>
</tr>
<tr>
<td>Newnan's</td>
<td>10</td>
<td>100</td>
<td>25.6 (30.4)</td>
<td>4-107</td>
<td>10</td>
<td>252</td>
</tr>
</tbody>
</table>

---

**Table 2. Prevalence and intensity of *Sebekia mississippiensis* in mosquitofish from Hillsborough County, Florida.**

<table>
<thead>
<tr>
<th>Date</th>
<th>N</th>
<th>Prevalence</th>
<th>Mean (SD)</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>October 1983</td>
<td>30</td>
<td>60.0</td>
<td>9.06 (7.47)</td>
<td>1-28</td>
</tr>
<tr>
<td>March 1984</td>
<td>127</td>
<td>71.6</td>
<td>4.48 (7.11)</td>
<td>1-51</td>
</tr>
<tr>
<td>July 1984</td>
<td>28</td>
<td>85.7</td>
<td>9.86 (6.26)</td>
<td>1-79</td>
</tr>
</tbody>
</table>

Copyright © 2011, The Helminthological Society of Washington
remaining infected rats and hamsters necropsied at later time intervals. Adhesions between the stomach and surrounding tissues were a universal finding and were usually associated with the presence of nymphs. Nymphs were recovered mainly from the stomach wall and adjacent organs and tissues (liver and mesentery); however, some nymphs were found within skeletal muscle and subcutaneous tissues in both hamsters and rats. A single nymph was recovered from the lungs of an infected rat necropsied 28 days after infection, whereas nymphs were not found in the lungs of any of the hamsters. Nymphs were usually folded within a fibrous capsule in host tissues from which they began to actively exit upon death of the host. Therefore, it was not possible to determine if all nymphs were encapsulated prior to euthanasia.

**Pig Frog and Turtles:** The single infected pig frog became markedly lethargic soon after infection and died within 24 hr. At necropsy the oral cavity contained a bloody froth and nymphs were found free in the body cavity along with a substantial volume of bloody fluid. Nymphs were also found penetrating the stomach wall and within muscle tissues.

Nymphs were recovered from all experimentally infected turtles, whereas no nymphs or lesions were found in the noninfected controls. Marked adhesions were noted among visceral organs usually associated with the presence of nymphs. The infected Florida softshell displayed a unilateral swelling on its neck that was found to contain a single nymph located just under the skin at necropsy 14 days post-infection. Nymphs were found in the stomach walls, body cavities, and lungs of both the Florida softshell and Florida cooters. Nymphs were also present in the musculature of all infected Florida cooters.

**Discussion**

The high prevalence of infection of *S. mississippiensis* seen in alligators from Alachua County, Florida (Table 1) is consistent with infection rates reported from South Carolina (Hazan et al., 1978) and south Florida (Cherry and Ager, 1982). Although adults were recovered from 6 of 10 alligators from Newnan’s Lake and 5 of 21 alligators from Orange Lake, the vast majority of parasites found in the lungs were nymphs. Overstreet et al. (1985) reported finding small numbers of adults (1–14) of *S. mississippiensis* in alligators collected during the months of March, May, July, and September from Mississippi and Louisiana, and Deakins (1971) found large numbers (30–40) of adults in the lungs and eggs in the feces of seven alligators from McIntosh County, Georgia. Pentastome eggs were not found on fecal examination of the 31 alligators in the present study, and eggs were found in the uteri of only 5 of 529 parasites found in the lungs. However, nymphs were found in mosquitofish in October, March, and July in Hillsborough County, Florida (Table 2), and infected mosquitofish and turtles (unpubl. data) have been maintained in laboratory aquaria for over 6 mo demonstrating that infective nymphs probably occur in natural environments year round.

These results suggest that there may be a seasonal cycle in the occurrence of nymphs and adults in the lungs and in the shedding of eggs in the feces, possibly related to the feeding habits of the alligator. Food consumption decreases with decreasing ambient temperature (Overstreet et al., 1985), and although nymphs are present in fish throughout the year they are less likely to be ingested during colder months. Therefore, in the southeastern United States, one might expect to find higher numbers of nymphs in alligators during and after the warm summer months when alligators are feeding most actively. Further studies are needed to determine the longevity and maturation of nymphs and adults of *S. mississippiensis* to clarify the epidemiological picture.

Nymphs of *S. mississippiensis* were recovered from a variety of locations from all experimental

---

**Table 3. Intensity of nymphs of *Sebekia mississippiensis* recovered from individual experimentally infected hosts.**

<table>
<thead>
<tr>
<th>Host species*</th>
<th>Intensity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 day</td>
</tr>
<tr>
<td><em>M. auratus</em> (30) hamster</td>
<td>9</td>
</tr>
<tr>
<td><em>R. norvegicus</em> (30) rat</td>
<td>-</td>
</tr>
<tr>
<td><em>P. nelsoni</em> (10) Florida cooter</td>
<td>-</td>
</tr>
<tr>
<td><em>T. ferox</em> (10) Florida softshell</td>
<td>-</td>
</tr>
<tr>
<td><em>R. grylio</em> (20) pig frog</td>
<td>14</td>
</tr>
</tbody>
</table>

* Size of infective dose of *S. mississippiensis* nymphs.
hosts and resulted in a larval migrans syndrome similar to that described by Sprent (1963). In alligators, a natural host of *S. mississippiensis*, nymphs are found predominantly in the liver and lungs in both natural and experimental infections soon after infection (Boyce et al., 1984). This suggests that the parasite utilizes some type of cue in alligators to orient its migratory route anteriorly towards the lungs where it will eventually reside as an adult. The lack of such a cueing system in these experimentally infected hosts was suggested from the location of recovered nymphs.

The distribution of nymphs in the rodent hosts was fairly uniform with the majority of nymphs occurring in the stomach wall or other tissues in the abdomen. Significant numbers of nymphs were also found in liver, muscle, and subcutaneous tissues; however, only a single nymph was found in the lungs. Apparently, nymphs penetrated through the stomach wall soon after ingestion and migrated randomly throughout the tissues. Most nymphs ceased migration near the region of the stomach whereas others continued to migrate into the muscles or through the body wall into the subcutaneous tissues. Distribution of nymphs of *S. mississippiensis* in the hamster and rat was similar to the distribution of nymphs of *Poroccephalus crotali* (Humboldt, 1808) reported by Layne (1967) in the Florida mouse (*Peromyscus floridanus* (Chapman)), the cotton mouse (*Peromyscus gossypinus* (Le Conte)), and the cotton rat (*Sigmodon hispidus* Say and Ord). The pentastomid *P. crotali* occurs as an adult in crotaline snakes and utilizes a wide variety of mammals as intermediate hosts. The behavior of *S. mississippiensis* in these experimentally infected rodents suggests that it also is capable of utilizing mammals as transport hosts.

The distribution of nymphs in the frog and turtles was similar to that seen in the rats and hamsters, with the majority of nymphs located in the stomach wall or nearby in the body cavity. Although nymphs were recovered from the lungs in both species of turtles it is not clear whether this represents a predilection for this site. Dukes et al. (1971) were able to successfully infect a snapping turtle (*Chelydra serpentina* (Linnaeus)) by force feeding largemouth bass (*Micropterus salmoides* (Lacépède)) tissues containing viable nymphs of *S. mississippiensis* and they recovered healthy nymphs, at the same stage of development, 1 mo later from the lungs. In the present study, viable nymphs were recovered 4 mo after infection, and further studies are underway to determine if nymphs of *S. mississippiensis* will develop into adults in turtles over a longer period of time. Whether or not they serve as definitive hosts it appears likely that fish-eating turtles could become infected with nymphs of *S. mississippiensis* and serve as a source of infection for alligators, especially large adults, which commonly feed on turtles.

Moderate numbers of nymphs were recovered from the musculature of the frog and turtles in this study and they have been reported from several important game fish (Vernard and Bangham, 1941; Dukes et al., 1971). This is significant in that this study demonstrates that warm-blooded vertebrates are susceptible to infection, and fish, frogs, turtles, and alligators are an important diet item for many species including man. Pentastomid infections, sometimes fatal, have been reported in a variety of species including man, and further work is needed to determine the role this particular parasite plays in human and animal health (Cosgrove et al., 1970; Self et al., 1972; Boyce et al., 1984).

Acknowledgments

I thank M. F. Delaney and A. R. Woodward of the Florida Game and Freshwater Fish Commission for obtaining alligators and providing advice and assistance. I also thank J. T. Self and R. M. Overstreet for confirming the identification of nymphs and adults of *Sebekia mississippiensis* and C. H. Courtney for use of laboratory facilities. Tracy Howell, of Plant City Gator Jungle, provided infected mosquitofish and Ramiro Isaza provided technical assistance. Florida Agricultural Experiment Stations Journal Series No. 6111.

Literature Cited


Dukes, G. H., R. M. Shealy, and W. A. Rogers. 1971. *Sebekia oxycephala* (Pentastomida) in large-
mouth bass from Lake St. John, Concordia Parish, Louisiana. J. Parasitol. 57:1028.


