

Prevalence of Eustrongylidosis in Wading Birds From Colonies in California, Texas, and Rhode Island, USA

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Abstract.—Snowy Egret (*Egretta thula*) and Black-crowned Night-Heron (*Nycticorax nycticorax*) nestlings from colonies in Texas, Rhode Island, and California and Great Egret (*Casmerodius albus*) nestlings from Texas were examined for eustrongylidosis, or infection by the parasitic nematode *Eustrongylides* spp. In 31% (24/77) of all broods examined, at least one nestling was infected. Snowy Egret broods from Texas were more frequently (100%) infected than those from California (20%) or Rhode Island (10%), and the prevalence of eustrongylidosis in 5- and 10-day-old Snowy Egret nestlings was higher in the Texas colony than the other two. Within the Texas colony, the frequency of eustrongylidosis was greater for Snowy Egret (100%) and Great Egret (80%) broods than for Black-crowned Night-Heron broods (12.5%). Also in Texas, eustrongylidosis was more frequent in 5-day-old Snowy Egret nestlings than 5-day-old Black-crowned Night-Heron or Great Egret nestlings, and in 10-day-old Snowy Egret nestlings than in 10-day-old Black-crowned Night-Heron nestlings. *Eustrongylides* spp. caused perforations of the gastrointestinal tract and peritonitis, particularly in Snowy Egrets. Received 9 June 1994, accepted 10 September 1994.

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Nematodes of the genus *Eustrongylides* spp. are parasites of piscivorous birds transmitted through two intermediate hosts; aquatic oligochaetes and fish (Karmanova 1968, Measures 1988a, Measures 1988b). The resulting infection is termed eustrongylidosis. *Eustrongylides* spp. larvae may burrow through the host's stomach wall (Spalding and Forrester 1993) and cause peritonitis that has been reported as the cause of death in a variety of wading birds at several locations (Locke 1961, Weise *et al.* 1977, Winterfield and Kazacos 1977, Roffe 1988, Spalding *et al.* 1993). Although fatal infections have been reported in adult birds (Bowdish 1948, Locke 1961), nestlings are often more severely affected (Weise *et al.* 1977, Roffe 1988, Spalding and Forrester 1993). Spalding *et al.* (1993) examined over 2,000 individuals of 15 species of Ciconiiformes in Florida for eustrongylidosis and found the greatest frequencies in Great Blue Herons (*Ardea herodias*), Great Egrets (*Cas-*

merodius albus), and Snowy Egrets (*Egretta thula*). They reported mortality rates as high as 80% in nestlings at one colony.

We report the prevalence of eustrongylidosis in Snowy Egrets, Great Egrets, and Black-crowned Night-Herons (*Nycticorax nycticorax*) from coastal colonies in Rhode Island, Texas, and California. We describe differences among and within colonies with regard to frequency of infection in 5-, 10-, and 15-day-old nestlings.

STUDY AREAS AND METHODS

In 1987, we collected 5-, 10-, and 15-day-old Snowy Egret and Black-crowned Night-Heron nestlings from colonies at Gould Island, Newport County, Rhode Island (41°37'N, 71°13'W); Goat Island, Harris County, Texas (29°45'N, 95°35'W); and West Marin Island, Marin County, California (37°58'N, 122°28'W). Great Egret nestlings of the same age were collected from the Texas colony, only. A total of 183 nestlings was collected, including 69 from Texas, 53 from Rhode Island, and 61 from California. Completed three-, four-, or five-egg clutches in early incubation were located and examined at 2 to 5 day intervals for 15 days after the first egg hatched. Nestlings within each nest were individually

marked and the nestling from the first egg to hatch was collected when 13 to 17 days old, the second to hatch was collected when 8 to 12 days old, and the third when 4 to 7 days old. The ages of nestlings were determined by observation on the day of hatch (day 0), or estimated by the date of pipping or morphologic measurements (Custer and Peterson 1991). Criteria for nestling selection and methods of euthanasia are described by Custer and Ohlendorf (1989).

Carcasses were frozen in the field and shipped to the Patuxent Wildlife Research Center Gulf Coast Field Station, Victoria, Texas for necropsy. Viscera and nematodes found free in the abdominal cavity were sent to the National Wildlife Health Research Center, Madison, Wisconsin for examination and identification. Nematodes recovered from the gastrointestinal tracts were fixed in ethanol-formalin-acetic acid, cleared in glycerine, and examined by light microscopy.

We used Fisher's exact test (Zar 1984) to compare the frequencies of eustrongylidosis among locations. Frequencies of infection for each species and colony were not compared among ages, because individuals among age groups were often siblings and thus the samples were not independent. The minimum alpha level was 0.05 for all tests.

RESULTS

Nematodes were recovered from fibrous tracts on the serosal surfaces of the ventriculus and intestines (Fig. 1) and identified as

Eustrongylides spp. based on larval anatomical characteristics. Identification to species is based on morphologic characteristics of sexually mature worms (Measures 1988c). Although adult forms have been recovered from nestling Ciconiiformes 8 days postinfection (Spalding and Forrester 1993), we were unable to find any adults in the carcasses we examined. However, based on host species and geographic locations, it is probable that the nematodes observed in this study were *Eustrongylides ignotus* (Measures 1988c).

In 31% (24/77) of all the broods that we examined, one or more nestlings were infected with *Eustrongylides* spp. (Table 1). At each of the three colonies, eustrongylidosis occurred in at least one Snowy Egret and Black-crowned Night-Heron brood and, at the Texas colony, infected nestlings were found in eight of 10 Great Egret broods. Snowy Egret broods from Texas were more frequently infected (100%) than those from Rhode Island (10%; $P < 0.001$) or California (20%; $P < 0.001$). The frequency of infection

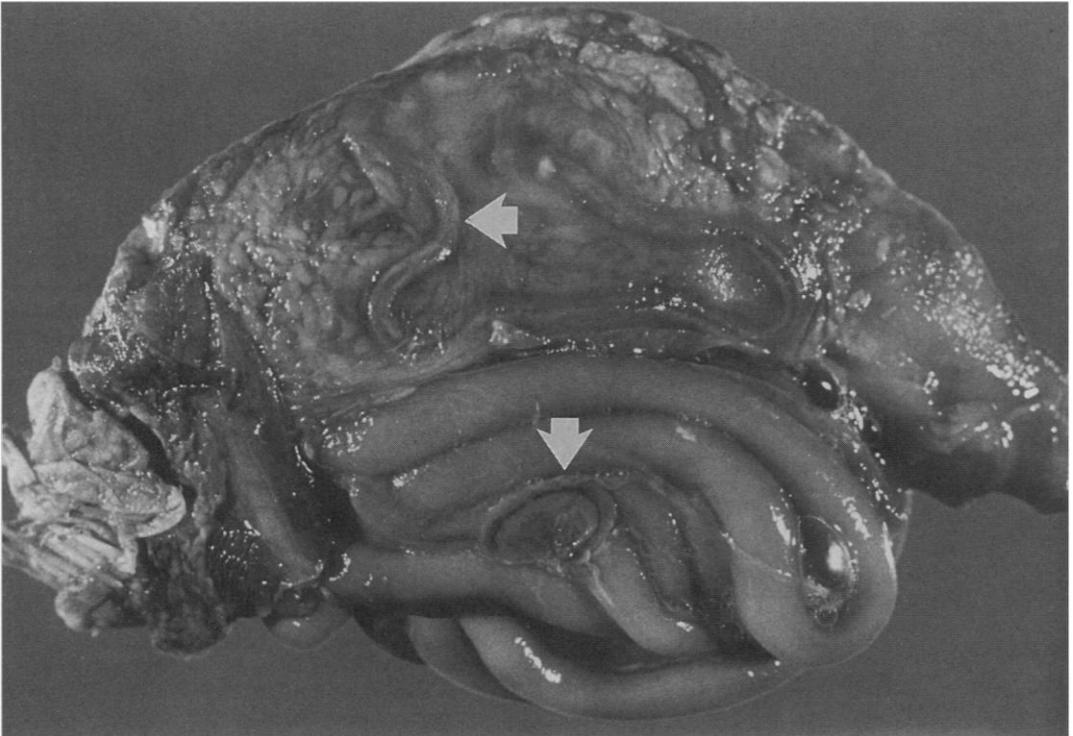


Figure 1. Stomach and loops of intestine from a 10-day-old Snowy Egret (*Egretta thula*) nestling collected in Texas. Fibrous tracts (arrows) contained *Eustrongylides* spp.

Table 1. Prevalence (no. observed/no. examined) of eustrongylidosis in broods of Snowy Egrets, Black-crowned Night-Herons, and Great Egrets from colonies in Texas, Rhode Island and California.

Location	No. broods infected/no. examined			P (species) ^a
	Snowy Egret	Black-crowned Night-Heron	Great Egret	
Texas	9/9	1/8	8/10	0.0214
Rhode Island	1/10	1/10	-	1.00
California	3/15	1/15	-	0.613
P (locations)	<0.001	1.00		

^aProbability that the frequencies of groups are different based on Fisher's exact test (Zar 1984).

did not differ between Snowy Egrets in Rhode Island and California, and no differences among locations were noted for frequency of infection of Black-crowned Night-Heron broods. In Texas, the prevalence of eustrongylidosis was greater in Snowy Egret (100%) and Great Egret (80%) broods than in Black-crowned Night-Heron broods (12.5%; Snowy Egrets vs. Black-crowned Night-Herons, $P = 0.001$; Great Egrets vs. Black-crowned Night-Herons, $P = 0.0055$). The frequency of infection for Snowy Egret and Great Egret broods in Texas was not different.

Overall, eustrongylidosis occurred in 16% (30/183) of nestlings examined (Table 2). Thirty-five percent (24/69) of nestlings collected at the Texas colony were infected, followed by 6% (4/61) in California, and 4% (2/53) at the Rhode Island colony. For 5- and 10-day-old Snowy Egrets, eustrongylidosis occurred more frequently in Texas than in Rhode Island or California. No frequency differences among colonies were noted for 15-day-old Snowy Egrets or Black-crowned Night-Herons of any age. In Texas, eustrongylidosis was more frequent ($P < 0.001$) in 5-day-old Snowy Egret nestlings than in 5-day-old nestlings of the other two species (Table 2). Eustrongylidosis was also more frequent in 10-day-old Snowy Egret nestlings than 10-day-old Black-crowned Night-Herons ($P = 0.01$), but no other frequency differences occurred. No species differences in frequency of infection occurred for nestlings of any age in Rhode Island or California.

Based on gross observation, perforations of the gastrointestinal tract by *Eustrongylides*

spp. caused peritonitis, characterized by fibrinous adhesions between intestinal loops and the ventriculus, in 11/183 (6%) of the nestlings examined. The severity of inflammation was variable but, particularly in Snowy Egrets, intestinal loops were often tightly adherent into a hard mass. Ten Snowy Egrets (5-day-old = 5; 10-day-old = 4; 15-day-old = 1) and one 15-day-old Great Egret were affected, all from the Texas colony.

DISCUSSION

The development of eustrongylidosis in fish-eating birds involves two intermediate hosts. Larvae of *Eustrongylides* spp. appear in blood vessels of aquatic oligochaetes after they ingest infective eggs (Measures 1988a). When fish consume these oligochaetes, larvae undergo further development and become encapsulated, often in the mesentery and intestines (Measures 1988d). In ardeids, worms may perforate the stomach within several hours after the ingestion of fish containing larvae (Spalding and Forrester 1993), and mortality of young birds may occur in as little as 2 days postinfection (Spalding *et al.* 1994).

Because the life cycle of *Eustrongylides* spp. in birds requires fish as intermediate hosts it follows that food habits may, in part, contribute to species differences in prevalence of infection of birds at the same location. The availability of both intermediate hosts could play a role in differences in frequencies of infection for the same species at different locations. For example, populations of oligochaetes could be low or nonex-

Table 2. Prevalence (no. observed/no. examined) of eustrongylidosis in nestling Snowy Egrets, Black-crowned Night-Herons, and Great Egrets from colonies in Texas, Rhode Island and California.

Age (d)	Location	No. infected/no. examined			P (species) ^a
		Snowy Egret	Black-crowned Night-Heron	Great Egret	
5	Texas	9/9	0/6	0/10	<0.001
	Rhode Island	0/8	0/7	-	nd ^b
	California	0/8	0/2	-	nd
	P (locations)	<0.001	nd		
10	Texas	5/6	1/9	3/10	0.021
	Rhode Island	1/10	0/10	-	1.000
	California	1/14	1/15	-	1.000
	P (locations)	<0.001	0.733		
15	Texas	1/2	0/7	5/10	0.058
	Rhode Island	0/9	1/9	-	1.000
	California	2/10	0/12	-	0.195
	P (locations)	0.199	0.571		

^aProbability that the frequencies of groups are different based on Fisher's exact test (Zar 1984).

^bnd = not determined because of the absence of eustrongylidosis in both groups.

istent and/or fish that are suitable intermediate hosts could be few in number. Snowy and Great Egrets in Texas had a greater frequency of eustrongylidosis than Black-Crowned Night-Herons, probably because they selected for food items that happened to be more frequently infected with encapsulated larvae. Similarly, we can speculate that Snowy Egrets in Texas had a higher frequency of eustrongylidosis than Snowy Egrets in Rhode Island and California because more infected fish were available for them to eat in Texas than at the other locations.

The Houston Ship Channel, within which the Texas colony was located, contains a variety of agricultural and industrial contaminants (King *et al.* 1987; Rice and Custer 1991; Custer *et al.* 1994). Nutrient pollution may be associated with these environmental contaminants, particularly agricultural runoff. Nutrient loading has been implicated in contributing to environments conducive to increased numbers of oligochaetes, thereby facilitating the transmission of *Eustrongylides* spp. through fish to birds (Spalding *et al.* 1993, Measures 1988d). Greater nutrient loading in the vicinity of the Texas colony may have been responsible for larger numbers of infected oligochaetes, and hence infected fish, than in Rhode Island and

California. Because of various biological characteristics, colonial waterbirds have been proposed as useful indicators of environmental change (Kushlan 1993). The prevalence of eustrongylidosis in colonial waterbirds may be another characteristic reflective of wetlands contamination.

Snowy Egret nestlings of 5 and 10 days of age were more frequently infected with eustrongylidosis at the Texas colony than in California or Rhode Island. No differences were noted among locations for 15-day-old Snowy Egrets, but only two 15-day-old birds of this species were available at the Texas colony for examination. Because of the severity of peritonitis noted in 5- and 10-day-old Snowy Egrets from Texas, it is possible that many infected nestlings died before reaching 15 days of age. This is consistent with the findings of Spalding *et al.* (1994) who reported proportionately greater mortality from eustrongylidosis in younger nestling wading birds.

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