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GASTROINTESTINAL HELMINTH PARASITES OF THE AMERICAN CROCODILE (*CROCODYLUS ACUTUS*) IN SOUTHERN QUINTANA ROO, MEXICO

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***Abstract.*—We stomach-flushed 26 American Crocodiles (*Crocodylus acutus*) from four different lagoons located near the southern coast of Quintana Roo, Mexico. At least one parasite species infested 17 (65%) of the *C. acutus*. We found seven helminth species: five nematodes (*Terranova crocodili, Dujardinascaris helicina, Contracaecum* sp. type 1, *Contracaecum* sp. type 2, *Pseudoterranova* sp.); one larval cestode (*Glossocercus* sp.); and one cystacanth (*Gorgorhynchoides* sp.). *Terranova crocodili* represents the most prevalent (61.53% of *C. acutus*) and most abundant species (mean = 4.3 ± 8.5, range 1-23 nematodes/crocodile). The remaining helminth genera showed lower prevalence and infested < 10% of crocodiles. *Terranova crocodili* is a new host record for *C. acutus*. This is the first helminthological survey from *C. acutus* in the region.**

Key Words.—American Crocodile; *Crocodylus acutus*; helminths; Mexico; parasites; stomach-flushing

INTRODUCTION

The American Crocodile (*Crocodylus acutus* Cuvier 1807; Fig. 1) is one of the three species of crocodilians occurring in Mexico (Alvarez del Toro 1974). This species occurs along the Atlantic and Pacific coasts of Mexico, South Florida, Central America, South America, and many Caribbean Islands (Thorbjarnarson 1989). Studies on the parasites of *C. acutus* are scarce and typically examine only one specimen. Only two studies report new nematode parasites in *C. acutus* from Mexico (Solger 1877) and museum specimens from elsewhere (Sprent 1977). Some trematodes and nematodes occurred in free-ranging North American crocodiles (Hughes et al. 1942) and in farmed juveniles and wild adults from Cuba (Pérez-Vigueras 1936, 1956; Groschaft and Baruš 1970; Pérez-Benítez et al. 1980). In Mexico, parasites of *C. acutus* are relatively unknown. Most investigations have examined the related Morelet's Crocodile, *C. moreletii* (see Alvarez del Toro 1974; Moravec and Vargas-Vázquez 1998; Moravec 2001). The purpose of this study was to describe more accurately the gastrointestinal parasites that infest *C. acutus* along the east coast of Quintana Roo, Mexico.

MATERIALS AND METHODS

From January-September 2006, we collected 26 *C. acutus* and one *C. moreletii* from four lagoons on the southern coast of Quintana Roo: Cementerio Lagoon (18°15'47"N, 87°50'40"W), Xcalak Lagoon (18°16'41"N, 87°50'15"W), Rio Huach (18°25'02"N, 87°46'27"W), and Bacalar Chico (18°11'32"N, 87°51'22"W; Fig. 2). We captured *C. acutus* from a boat by using our bare hands or a pole, depending on the size of individuals. Crocodiles were marked, weighed, measured, and released back into the lagoon. We flushed stomach contents as described by Fitzgerald (1989). We used PVC tubes to hold the jaws open and inserted a hose, of appropriate size (5 to 15 mm diameter) and coated with vegetable oil, into the esophagus and stomach of each crocodile. Water entered through the hose until the stomach filled and then abdominal massage was carried out (similar to the Heimlich maneuver; Heimlich 1975) causing the expulsion of stomach contents. Helminths along with food items were obtained during stomach flushing. We fixed and preserved helminths in 4% formalin.

We cleared nematodes with a glycerin-water dilution series, and stained acanthocephalans and cestodes with hydrochloric carmine (see Vidal-Martínez et al. 2001). We assessed prevalence and mean abundance of parasites according to Bush et al. (1997). Voucher specimens are in the Colección Nacional de Helmintos de la Universidad Nacional Autónoma de México and Colección de Parásitos, ECOSUR-Chetumal (ECOPA).

RESULTS

Of the 26 crocodiles examined, 17 (65%) harbored at least one helminth species. Seven taxa were present including five nematodes [*Terranova crocodili*; Taylor 1924), *Dujardinascaris helicina* Molin, 1860, *Contracaecum* sp. type 1, *Contracaecum* sp. type 2

FIGURE 1. The American Crocodile (*Crocodylus acutus*) in its natural habitat in Quintana Roo, Mexico (left) and during manipulations to obtain parasites (right). (Photographed by Alejandro Villegas)

and *Pseudoterranova* sp.], one larval cestode (*Glossocercus* sp.; Fig. 3) and one cystacanth (*Gorgorhynchoides* sp.). Adult and pre-adult parasites comprised 86% (n = 113) of the specimens we recovered. Only 14% (n = 18) of parasites were larval stages. *Terranova crocodili* was the most prevalent and abundant species with 110 individuals (44 adults and 66 juveniles). This parasite had the widest geographic range and we found it in all four lagoons. The remaining helminths occurred in one or two localities and with low prevalence and abundance (Table 1). We found three individuals (two females, one male) of *Dujardinascaris helicina* in the stomach of a Morelet's Crocodile captured during this investigation. This crocodile species normally inhabits freshwater; however, we caught it in a brackish water body, the Xcalak Lagoon.

DISCUSSION

Although stomach-flushing is an unusual method of obtaining helminth parasites, we obtained some interesting results. Of the seven taxa of helminths found, five were ascaridoid nematodes. These findings agree with those of Brooks and O'Grady (1989) and Goldberg et al. (1991) who mentioned that most parasitic nematodes in crocodilians are ascaridoids. Our findings support the contention that the helminth fauna of crocodiles is depauperate.

Terranova crocodili was the most widespread species reported in this survey. This nematode also occurs in two species of Australian crocodiles

TABLE 1. Infection parameters of the helminth fauna found in the American Crocodile (*Crocodylus acutus*; n = 26) in southern Quintana Roo, Mexico.

Helminth	Collection Nos.	Males	Females	Juveniles	Larvae	Locations (Lagoons)	Prevalence (%)	Mean abundance
Nematoda *Terranova crocodili*	070 071 072 073	30	14	66	-	Cementerio, Xcalak, Río Huach, Bacalar Chico	61.53	4.3
Dujardinascaris helicina	074	1	-	-	-	Bacalar Chico	3.85	0.04
Contracaecum sp. type 1	075	-	-	-	1	Río Huach	3.85	0.04
Contracaecum sp. type 2	076	-	-	-	1	Río Huach	3.85	0.08
Pseudoterranova sp.	077 078	-	-	-	4	Cementerio, Río Huach	7.69	0.15
Cestoda *Glossocercus* sp.	079	-	-	-	8	Río Huach	3.85	0.31
Acanthocephala *Gorgorhynchoides* sp.	080	-	-	-	4	Río Huach	3.85	0.15

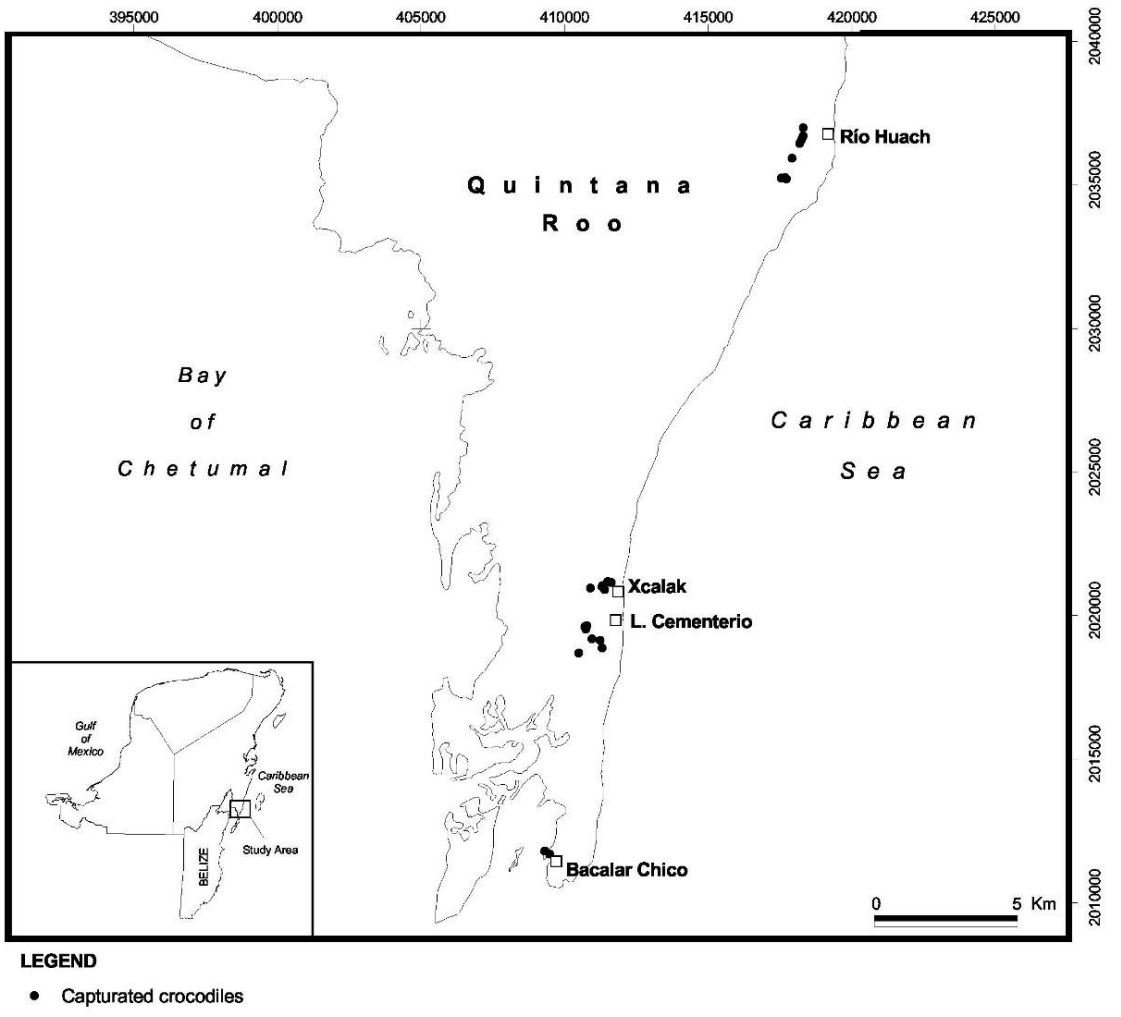

FIGURE 2. Study area where we captured American Crocodiles (*Crocodylus acutus*) in southern Quintana Roo, Mexico.

(*Crocodylus porosus* and *C. johnstoni*) and the Nile Crocodile (*C. niloticus*) (Sprent 1983; Machida et al. 1992). Its presence in *C. acutus* in the southern region of Quintana Roo, Mexico represents a new host and geographical record. To date, previous reports include 16 species of *Terranova* from fish and elasmobranchs (Fang and Luo 2006), and three from reptiles (see Sprent 1979). The latter species occurs in crocodilians, and in aquatic and terrestrial snakes from the coastal regions and islands of the Gulf of Mexico (Sprent 1979). Details on the life history of *T. crocodili* are available (Sprent 1979), and some crustaceans or small fish may be intermediate hosts.

In our samples, small fish (*Gambusia yucatana*, *Cyprinodon artifrons*), crustaceans (*Callinectes* sp., *Palaemonetes intermedius*, *Sesarma curacoense*) and birds (*Phalacrocorax auritus*, *P. brasilianus*) filled the stomachs of crocodiles harboring *T. crocodili*.

Another genus reported from fish and reptiles is *Dujardinascaris*. It is a cosmopolitan genus with 18 species described so far, and almost all species are restricted to Crocodylia (see Sprent 1977; Baker 1987; Goldberg et al. 1991; Sprent et al. 1998). The species *D. helicina* was originally described by Molin (1860) from *C. acutus* obtained as museum specimens. It is a common nematode in freshwater and saltwater crocodiles, i.e., *C. acutus*, *C. moreletii* and *C. rhombifer* (Groschaft and Baruš 1970; Moravec 2001). In Mexico, this species was prevalent and abundant in the digestive tracts of three *C. moreletii* from Yucatan (Moravec 2001). Whereas, reports of *D. antipini* in these species of crocodiles from the Nixtamalapan Lagoon near Veracruz, Mexico (García-Reynoso 1991) exist, later reports suggest that these are actually *D. helicina* (Moravec 2001). The life cycle of this species is unknown, but probably involves an encapsulated stage in the tissues of aquatic animals (fish or frogs) because fourth-stage larvae and adults are associated closely with the stomach mucosa (Goldberg et al. 1991). In our study the crocodiles harboring this nematode contained crustaceans, fish, and mammals.

FIGURE 3. An unidentified cestode recovered from an American Crocodile (*Crocodylus acutus*) in Quintana Roo, Mexico.

Terranova crocodili and *D. helicina* are common parasites of crocodiles world-wide. *Terranova* spp. is primarily a parasite of teleost fish that have secondarily transfered to sea snakes and crocodilians; whereas, *Dujardinascaris* ssp. typically infest crocodiles, with some species having recolonized teleosts (Brooks and O'Grady 1989).

Concerning the larval helminths, we found two anisakids genera: *Contracaecum* and *Pseudoterranova*. Adults of *Contracaecum* are parasites in the digestive tract of fish-eating birds and marine mammals, while larval stages often occur in fish that serve as the intermediate or paratenic hosts (Moravec 1998, 2001). This genus has ~ 121 species described from fish, birds, and mammals (Goldberg et al. 1991) with a life cycle commonly involving a copepod that is eaten by prey fish (Anderson 2000). The role of invertebrates (copepods) as the first intermediate host is not clear, although they carry second-stage larvae to fish, where development to the third-stage occurs (Anderson 2000). In Mexico, *Contracaecum* larvae occur in *C. moreletii* from Yucatan (Moravec 2001) and Veracruz (García-Reynoso 1991). *Contracaecum* larvae might branch into several types based on the presence and length of intestinal and ventricular appendices (Moravec 1998). *Contracaecum* sp. type 1 shows a relatively similar ratio of both caeca; whereas, type 2 has a longer intestinal caecum in comparison to the ventricular appendix.

Pseudoterranova includes nine described species (see Mattiucci et al. 1998; González-Solís et al. 2006), whose adult nematodes are parasitic in marine mammals (Pinnipedia; Williams and Jones 1994). Various species of marine crustaceans serve as first intermediate hosts and fish act as second intermediate hosts. *Pseudoterranova* sp. occurs in brackish-water fish from the Yucatan Peninsula (Vidal-Martínez et al. 2001); however, we report the first record of these anisakid larvae in crocodiles.

The two remaining larval forms recovered during this survey were *Glossocercus* sp. and *Gorgorhynchoides* sp. The former is a larval cestode that occurs in freshwater fish of various Mexican localities (Scholz and Salgado-Maldonado 2001; Vidal-Martínez et al. 2001). Its life cycle is unknown, but copepods and fish likely serve as the first and second intermediate hosts, respectively, and birds that are pisciverous constitute the definitive host (Vidal-Martínez et al. 2001). *Gorgorhynchoides* comprises a group of three species that as adults parasitize fish (Salgado-Maldonado 1979), whereas larval forms infest small fish. These larvae occur in various brackish water and marine fish from the Yucatan Peninsula (Salgado-Maldonado 1979; Sánchez-Ramírez and Vidal-Martínez 2002).

Because larval forms that belong to these four genera commonly occur in the region, perhaps crocodiles acquired the infestation after feeding on infected fish. Unidentified fish remains and crustaceans (*Paleomonetes intermedius*, *Callinectes* sp.) were present in the stomachs of crocodiles from which we identified these helminths. Considering that larval forms found in this survey usually mature in other vertebrates (birds, marine mammals, and predatory fish), crocodiles are probably accidental hosts. These helminths represent new host records for *C. acutus* in this region. This study contributes to our understanding of the poorly known parasites of the American Crocodile (*C. acutus*) in the tropics.

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