

# Gulf and Caribbean Research

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Volume 16 | Issue 1

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January 2004

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DOI: 10.18785/gcr.1601.19

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## Recommended Citation

Montoya-Mendoza, J., R. Chavez-Lopez and J. Franco-Lopez. 2004. Helminths from *Dormitator maculatus* (Pisces: Eleotridae) in Alvarado Lagoon, Veracruz, Mexico, and Supplemental Data for *Clinostomum complanatum* Rudolphi, 1814 from *Egretta caerulea* (Aves: Ardeidae). *Gulf and Caribbean Research* 16 (1): 115-127.  
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# HELMINTHS FROM *DORMITATOR MACULATUS* (PISCES: ELEOTRIDAE) IN ALVARADO LAGOON, VERACRUZ, MEXICO, AND SUPPLEMENTAL DATA FOR *CLINOSTOMUM COMPLANATUM* RUDOLPHI, 1814 FROM *EGRETTA CAERULEA* (AVES: ARDEIDAE)

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**ABSTRACT** Fishes are important hosts of helminths with aquatic life stages, yet little information is available on host-parasite relationships in tropical low salinity ecosystems. In this paper we report helminth parasites of the fat sleeper, *Dormitator maculatus*, in the Alvarado lagoon system, Veracruz, Mexico. Four parasite species were recorded from *D. maculatus*, including trematode metacercariae of *Clinostomum complanatum*, as well as nematode larvae of *Spyroxis* sp. and *Camallanus* sp. and adults of *Neochinorhynchus golvani*. In addition, we obtained adult *C. complanatum* from the esophagus of the little blue heron, *Egretta caerulea*. *Dormitator maculatus* is a new host for all helminth species reported, and the Alvarado lagoonal system is a new location for these parasite relationships. The prevalence of the 2 most commonly occurring parasites, *C. complanatum* and *N. golvani*, was high throughout the year (> 60% and > 43%, respectively). Intensity of infection was highest for *C. complanatum* in May (92 worms/host) and for *N. golvani* in October 1993 (33.8 worms/host). The trophic position and habits of *D. maculatus* contributes to recruitment of trematode and nematode larval stages.

## INTRODUCTION

Fishes represent an important component of the biomass and biodiversity within the ecosystem at Alvarado Lagoon in Veracruz, Mexico. The estuary serves as a rich feeding ground for both resident and migratory fishes, creating an ideal habitat for a variety of parasitic helminths to flourish. The fat sleeper, *Dormitator maculatus*, is an important species within the assemblage of fishes from Alvarado Lagoon that also includes mugilids, centropomids, ariids, and cichlids. *Dormitator maculatus* inhabits low salinity (0–21 psu) coastal areas of the subtropical and tropical western Atlantic between North Carolina (USA) and southeastern Brazil (Fisher 1978). While previous studies have documented the parasite assemblage of *D. maculatus* from temperate areas, none has done so in a highly productive tropical estuary like Alvarado Lagoon, an estuary with relatively stable environmental conditions during much of the year. The helminths of fat sleepers include trematodes, cestodes, acanthocephalans, nematodes, and leeches at various localities throughout its range (see Yamaguti 1971, Hoffmann 1999). However, some of these helminths, such as *Clinostomum* spp. Leidy, 1865 are present only in *D. maculatus* as metacercariae, making identification of species based solely on morphology difficult. The definitive hosts for *Clinostomum* spp. are piscivorous birds, and various egrets and herons have been reported as hosts for adults at other localities from Veracruz state (Hernández 1996). Thus, in order to have a

complete understanding of the helminthofauna of *D. maculatus*, parasites in the definitive host must also be examined.

In this study, our intention is to describe the helminths of *D. maculatus* in Alvarado Lagoon. Additionally, the prevalence and intensity of the dominant helminths are quantified.

## MATERIALS AND METHODS

### Helminth collections

A total of 184 *D. maculatus* were collected from the mouth of Rio Papaloapan in Alvarado Lagoon, Veracruz, Mexico (18°45.825 N, 95°49.137W) during monthly samples between October 1993 and October 1994. Each sample consisted of between 16 and 34 fish. The fish were captured with a dip net and transported live in river water to a field station in Alvarado where identification was confirmed as *D. maculatus* using Castro (1978) and Hubbs et al. (1991). The mouth, esophagus, stomach, intestine, mesentery, and liver of each fish were thoroughly examined for helminths. Each organ was removed and examined in a petri dish with 0.65% saline solution, using a stereoscopic dissecting microscope. Helminths were removed from tissues using a small paintbrush and placed in 0.65% saline solution prior to fixation. Fixation technique varied depending on the type of helminth. During the course of collecting *D. maculatus*, 2 little blue herons, *Egretta caerulea*, were also collected from Alvarado Lagoon. The

mouth and esophagus of each bird was examined, and adult specimens of *Clinostomum* sp. were collected using the same techniques as with fish. Trematodes were fixed in Bouin's solution in the cold with cover slip pressure for 24 h. The trematodes were then placed in distilled water which was slowly replaced with 70% ethanol. Trematodes were preserved in 70% ethanol until staining. Trematodes were stained with either Mayer's Paracarmin or Harris's Hematoxylin, cleared in methyl silicilate, and mounted on glass slides in Canada balsam. In contrast, live acanthocephalans were placed in 4 °C distilled water for 5 to 8 h in order to facilitate the eversion of the proboscis. They were then transferred to Bouin's solution for 24 h and finally preserved in 70% ethanol following the above procedures. Acanthocephalans were stained and mounted on glass slides using the same procedures described for trematodes. The cuticle was punctured to allow stain to penetrate the specimen. Nematodes were fixed in 50–60 °C 70% ethanol and preserved in unheated 70% ethanol. Temporal preparations of nematodes were made by mounting them on glass slides in Amman's Lactophenol.

Parasites were identified using Yamaguti (1961), Hoffman (1970), Petrochenko (1971), and Chabaud (1975). All specimens were examined using a compound light microscope, and drawings were made with the aid of a camera lucida. Measurements (mm) are given as a range followed by a mean in parentheses. Specimens of all taxa currently reside in the Colección de Helminthos del Instituto de Biología, UNAM (#1600, 1601, 3077, 3078, and 3079).

## RESULTS

### Taxonomic descriptions

#### Trematoda

#### Clinostomidae Lühe, 1901

#### *Clinostomum complanatum* Rudolphi, 1814

(Figure 1)

**Description:** Metacercaria (Figure 1B, Table 1): data based on 10 specimens. Metacercaria encysted in liver or mesentery; cyst white to pale-yellow, subspherical, 0.86–2.63 (2.03) long, 0.66–1.93 (1.33) wide, thick walled. Metacercaria white and yellow in life, moving vigorously when removed from cyst. Body unspined, 2.10–6.25 (3.87) long, 0.75–1.80 (1.10) wide at mid-body. Oral sucker subterminal, 0.27–0.32 (0.30) wide, surrounded by a cephalic ring. Prepharynx distinct, pharynx small, giving rise to 2 intestinal crura; crura lateral, running the length of the body, terminating near posterior end of body, walls projecting irregularly along lengths. Ventral sucker

0.47–0.85 (0.63) wide, lying 0.27–0.80 (0.54) posterior to the oral sucker. Ratio of oral sucker to ventral sucker width 1:1.62–2.5 (1:2.14). Reproductive structures in hindbody, incompletely developed; testes tandem; anterior testis, triangular, trilobed, 0.12–0.40 (0.25) long, 0.24–0.56 (0.36) wide; posterior testis similar in shape to anterior one, slightly larger, 0.12–0.40 (0.24) long, 0.28–0.46 (0.39) wide; ovary submedian between testes, closer to anterior testis, subspherical, 0.08–0.20 (0.15) long, 0.06–0.12 (0.09) wide.

**Adult** (Figure 1A, Table 2): data based on 9 specimens from the mouth and esophagus of 2 specimens of *E. caerulea*. Body unspined, reddish in color in life, sluggish in comparison to metacercaria, 3.9–6.15 (5.1) long, 1.20–1.50 (1.38) wide near mid-body. Oral sucker subterminal, 0.29–0.34 (0.31) wide, situated within a depressed cephalic ring. Prepharynx distinct, pharynx small, giving rise to 2 intestinal crura; crura lateral, running length of body, walls irregular along lengths, connecting to excretory vesicle at posterior end of body. Ventral sucker 0.62–1.02 (0.834) wide. Ratio of oral sucker to ventral sucker width 1:2.1–3.03 (1:2.68). Testes tandem, triangular; anterior testis 0.32–0.54 (0.42) long, 0.56–0.76 (0.62) wide; posterior testis 0.30–0.52 (0.40) long, 0.58–0.80 (0.68) wide. Cirrus sac crescent-shaped, thick walled, lying dextral to anterior testis, containing twisting seminal vesicle filled with sperm, prostatic duct surrounded by prostatic cells, and muscular ejaculatory duct; ejaculatory duct leading to genital atrium; genital atrium and ejaculatory duct eversible. Ovary submedian between testes, 0.20–0.32 (0.26) long, 0.12–0.20 (0.155) wide. Mehlis' gland lying next to ovary and anterior to posterior testis. Vitelline follicles filling most of hindbody, reaching anterior to mid-level of ventral sucker. Uterus intercaecal, extending anterior from ovarian level, reaching ventral sucker level, turning, and extending back to genital atrium, containing unembryonated, operculate eggs 0.10–0.12 (0.11) long, 0.05–0.07 (0.06) wide; genital atrium opening through submedian genital pore at level of anterior testis. Excretory vesicle V-shaped, indistinct, pore dorso-terminal.

**Intermediate host:** *Dormitor maculatus*

**Site within intermediate host:** Liver and mesenteries

**Definitive host:** *Egretta caerulea*

**Site within definitive host:** mouth and esophagus

**Locality:** Mouth of Rio Papaloapan, Alvarado Lagoon, Veracruz, Mexico.

**Specimens deposited:** UNAM No. 1600 (adult), 1601 (metacercaria)

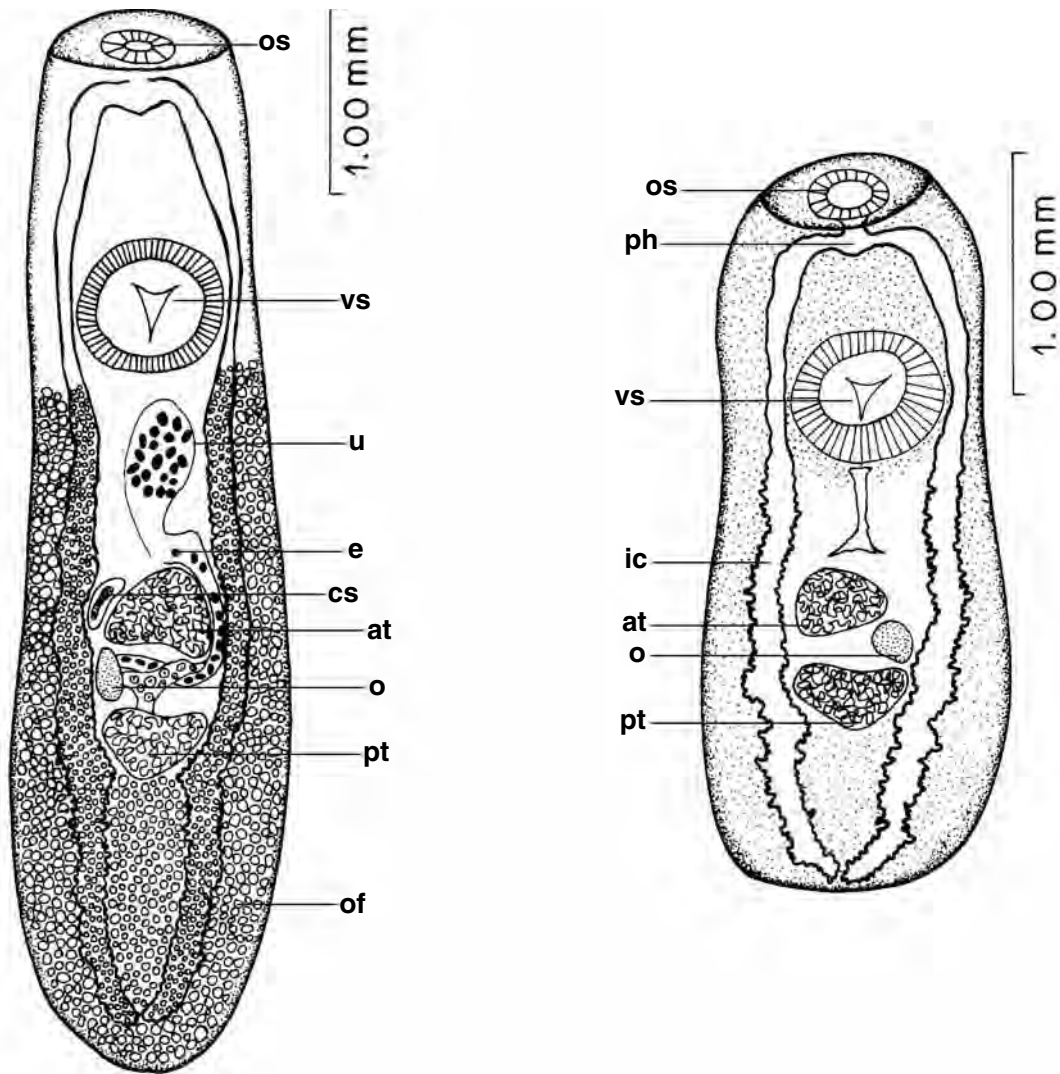


Figure 1. *Clinostomum complanatum* from *Dormitator maculatus* collected in Alvarado Lagoon, Veracruz. A) Adult. B) Metacercariae. vs = ventral sucker, os = oral sucker, ph = pharynx, of = ovary follicle, ic = intestinal caeca, at = anterior testis, pt = posterior testis, o = ovary, cs = cirrus sac, u = uterus, e = eggs.

**Acanthocephala**

**Neoechinorhynchidae Ward, 1917**

**Neoechinorhynchinae Travassos, 1926**

***Neoechinorhynchus golvani* Salgado-Maldonado, 1978**

(Figure 2)

**Description:** Data based on 20 adult specimens (10 males and 10 gravid females) from mucosa of anterior intestine. Adult females much larger than adult males. In both sexes, ovoid body, small apical cylindrical proboscis, 3 rows of hooks, apical row, medial row, and basal row, with 6 hooks each one; apical hooks much larger than others. Neck spindle shaped, not well defined; continuous with trunk, but slender at anterior end. Body wall thick, 5 gigantic nuclei on the dorsal surface and one on the ventral surface. Sac shaped proboscis receptacle with simple wall;

inserts in body wall base. Lemnisci sac-like with thick distal parts, longer than the proboscis receptacle length.

Body length (including proboscis) 1.21–3.50; trunk length 1.12–3.41. Maximum body width 0.375–1.17. Proboscis length 0.06–0.09, width 0.04–0.07. Apical proboscis hooks robust, 0.040–0.057 long, 0.006–0.008 wide at base. Medial hooks small, 0.012–0.014 long, 0.003–0.004 wide at base. Basal hooks small, 0.014–0.016 long, 0.003–0.004 wide. Proboscis receptacle length 0.15–0.31, width 0.05–0.10.

Male reproductive system consists of 2 tandem, contiguous testes, posterior testis touches cement gland which leads to the seminal vesicle, elongate, with 2 cement reservoirs (irregularly bulging sections, full of cement from the gland). Seminal vesicle leading to copulatory bursa. Saefftingen's pouch connects to proximal end of the copulatory bursa.

TABLE 1

Morphometric features of *Clinostomum complanatum* metacercariae. Values are presented in mm as mean with range in parentheses. *n* = number of individuals, ND = no data.

| Morphometric feature     |          | This Study ( <i>n</i> = 10)<br>Mean (min–max) | Mejia 1987<br>( <i>n</i> = 8) | Kagei et al. 1984<br>( <i>n</i> = ND) |
|--------------------------|----------|---|-------------------------------|---------------------------------------|
| Cyst                     | Length   | 2.030 (0.860–2.630)                           | 2.00                          | 2.00                                  |
|                          | Width    | 1.330 (0.660–1.930)                           | —                             | —                                     |
| Body                     | Length   | 3.870 (2.300–6.050)                           | (4.170–5.070)                 | (4.680–8.240)                         |
|                          | Width    | 1.105 (0.750–1.800)                           | (1.150–2.30)                  | (1.390–2.090)                         |
| Oral sucker              | Diameter | 0.297 (0.270–0.320)                           | 0.279                         | (0.277–0.493)                         |
| Ventral sucker           | Diameter | 0.630 (0.470–0.850)                           | (0.740–0.860)                 | (0.889–1.540)                         |
| Distance between suckers |          | 0.545 (0.270–0.800)                           | 0.900 (0.600–0.70)            | —                                     |
| Sucker ratio             |          | 1:2.14 (1:1.6–2.6)                            | 1:2.0                         | —                                     |
| Anterior testis          | Length   | 0.247 (0.120–0.400)                           | —                             | —                                     |
|                          | Width    | 0.362 (0.240–0.560)                           | 0.520 (0.450–0.560)           | —                                     |
| Posterior testis         | Length   | 0.244 (0.120–0.400)                           | —                             | —                                     |
|                          | Width    | 0.386 (0.280–0.600)                           | 0.490 (0.350–0.508)           | —                                     |
| Ovary                    | Length   | 0.155 (0.080–0.200)                           | 0.110                         | —                                     |
|                          | Width    | 0.095 (0.060–0.120)                           | 0.100 (0.090–0.110)           | —                                     |

Female reproductive system with great number of ovarian balls distributed in entire trunk cavity. Half-moon shaped eggs scattered inside the ovarian balls, measuring 0.028–0.031 (0.029) long, 0.008 (0.008) wide. Genital organs small, occupying posterior fifth of the trunk, measuring 0.29–0.33 (0.36) long. Uterine bell sub-spherical communicating with a short thick uterus; uterus leading to vagina and gonopore.

**Host:** *Dormitator maculatus*

**Site in host:** anterior intestine

**Locality:** Mouth of the Papaloapan River, Alvarado Lagoon, Veracruz, Mexico

**Collection Dates:** October 1993–October 1994.

**Specimens deposited:** UNAM 3077

TABLE 2

Morphometric features of *Clinostomum complanatum* adults. Values are presented in mm as mean with range in parentheses. *n* = number of individuals, ND = no data.

| Morphometric feature     |          | This Study ( <i>n</i> = 9)<br>Mean (min–max) | Lo et al. 1982<br>( <i>n</i> = ND) | Hernández 1995<br>( <i>n</i> = 13) |
|--------------------------|----------|--|------------------------------------|------------------------------------|
| Body                     | Length   | 5.100 (4.050–6.150)                          | (3.800–9.000)                      | 4.615                              |
|                          | Width    | 1.380 (1.200–1.550)                          | (1.300–2.000)                      | 1.260                              |
| Oral sucker              | Diameter | 0.310 (0.280–0.340)                          | (0.250–0.440)                      | 0.286                              |
| Ventral sucker           | Diameter | 0.839 (0.620–1.020)                          | (0.600–0.800)                      | 0.656                              |
| Distance between suckers |          | 0.788 (0.620–1.020)                          | —                                  | —                                  |
| Sucker ratio             |          | 1:2.68 (1:2.1–3.03)                          | —                                  | 1:2.55                             |
| Anterior testis          | Length   | 0.423 (0.320–0.540)                          | —                                  | 0.220                              |
|                          | Width    | 0.623 (0.560–0.760)                          | —                                  | 0.295                              |
| Posterior testis         | Length   | 0.396 (0.300–0.520)                          | —                                  | 0.260                              |
|                          | Width    | 0.685 (0.580–0.800)                          | —                                  | 0.316                              |
| Ovary                    | Length   | 0.260 (0.200–0.320)                          | 0.331                              | 0.061                              |
|                          | Width    | 0.115 (0.120–0.200)                          | 0.231                              | 0.066                              |
| Cirrus sac               | Length   | 0.403 (0.320–0.500)                          | —                                  | (0.212–0.625)                      |
|                          | Width    | 0.145 (0.120–0.180)                          | —                                  | (0.125–0.275)                      |
| Egg                      | length   | 0.108 (0.100–0.120)                          | 0.1198                             | (0.100–0.112)                      |
|                          | Width    | 0.058 (0.050–0.070)                          | 0.0721                             | (0.050–0.070)                      |

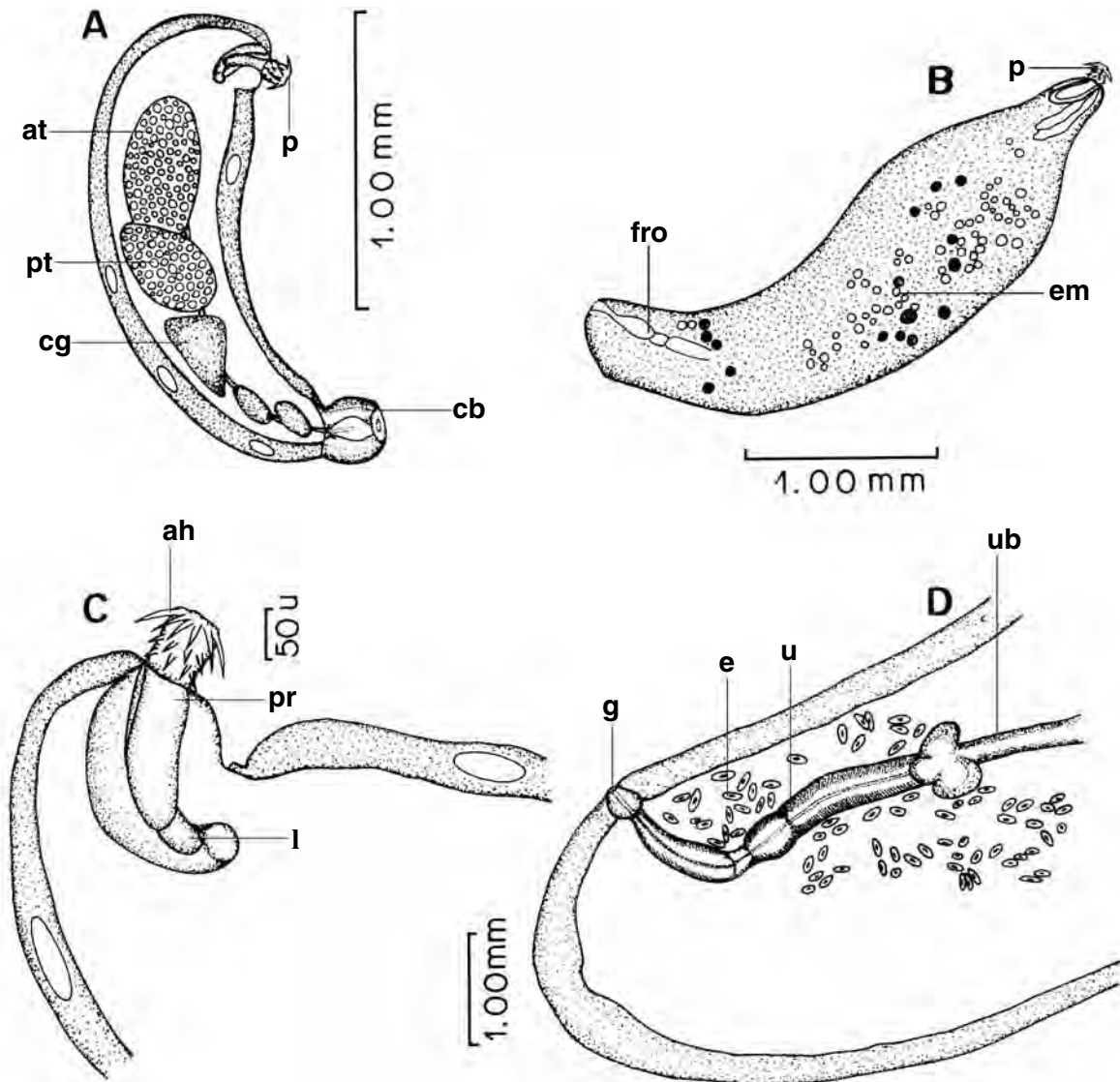


Figure 2. *Neoechinorhynchus golvani* from *Dormitator maculatus* in Alvarado Lagoon, Mexico. A) adult male. B) gravid female. C) male anterior end. D) female posterior end. fro = female reproductive organs, cb = copulatrix bursa, pr = proboscis receptacle, ub = uterine bell, g = gonopore, ah = apical hooks, cg = cement gland, e = eggs, l = lemnisci, em = egg mass, p = proboscis, at = anterior testis, pt = posterior testis, u = uterus.

**Nematoda**  
**Gnathostomatidae Railliet, 1895**  
*Spiroxys* sp. (larva)  
 (Figures 3A, B)

**Description:** Larvae described based on 7 specimens removed from thin-walled translucent host capsules located on muscular stomach wall of host. Worms white or opaque in host capsules, moved sluggishly when liberated, relaxed and white when fixed. Fixed body cylindrical, uniform thickness along most of the body length, with pointed ends; cuticle transversely grooved.

**Larvae:** Body 0.25–1.77 (1.39) long, 0.33–0.05 (0.04) wide. Bucal capsule confined to cephalic region,

with one pair of internal lips forming a triangle; internal lips 0.016–0.033 (0.022) long, surrounded by 2 pseudolabiae (lateral lips); pseudolabia 0.006–0.010 (0.008) long. The oral opening lacking an oral vestibule. Digestive tract consisting of esophagus, intestine, rectum, and anus. Esophagus divided into muscular anterior portion and glandular posterior portion, both portions measured together 0.133–0.425 (0.233) long. The intestine and short rectum together measure 0.223–1.24 (1.03) in length. Caudal end of the body conical, anus opens 0.053–0.068 (0.062) from the terminal end of the worm. No reproductive structures present.

**Host:** *Dormitator maculatus*

**Site in host:** muscular wall of stomach

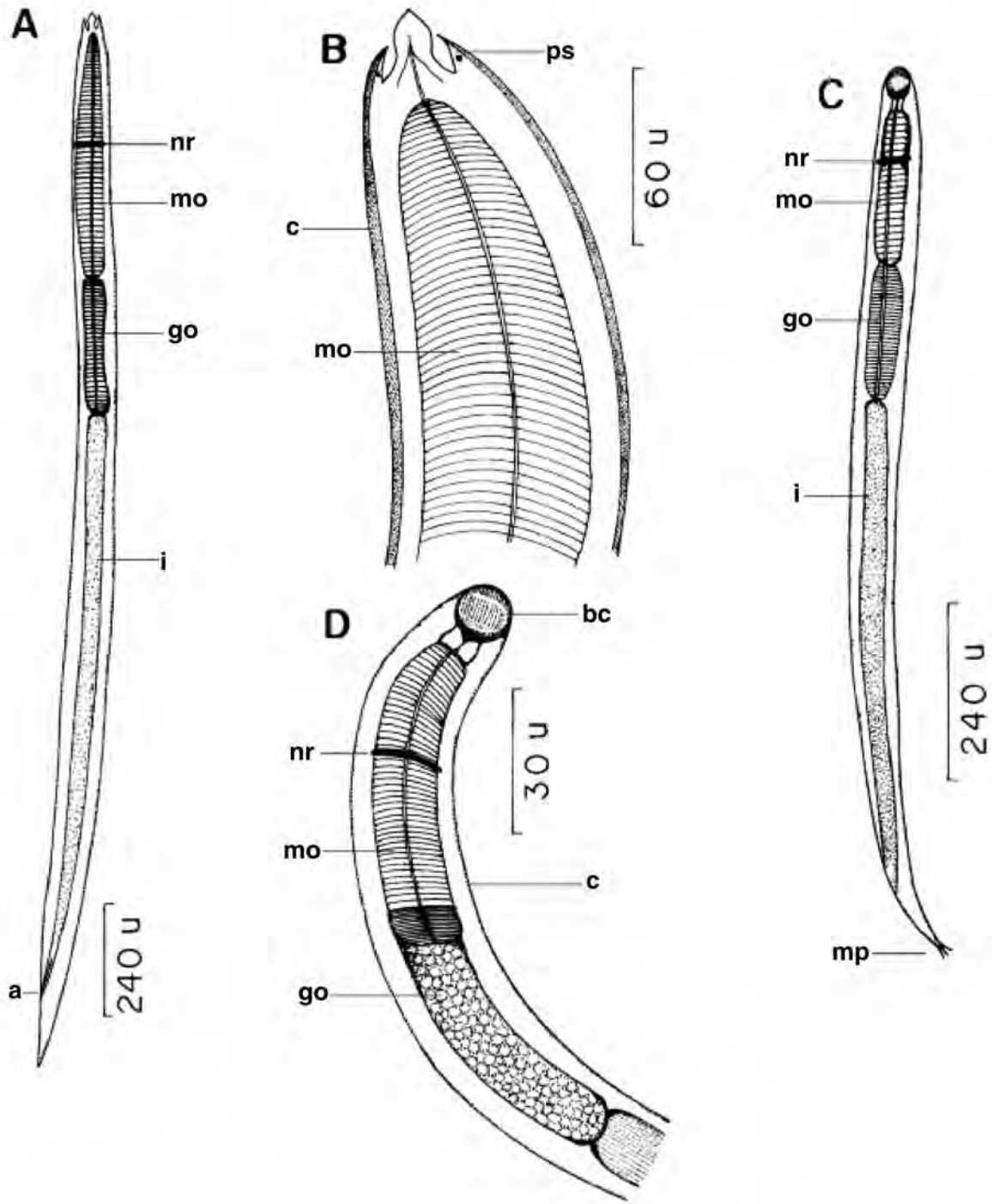


Figure 3. Parasite nematode larvae. A) *Spiroxys* sp from *Dormitator maculatus*. B) *Spiroxys* sp. anterior end, ventral view. C) *Camallanus* sp. D) *Camallanus* sp., anterior end, dorsal view. a = anus, nr = nervous ring, c = cuticle, bc = bucal cavity, go = gland oesophagus, mo =muscle oesophagus, i = intestine, mp = mamilliform processes, ps = pseudolabia.

**Locality:** Mouth of Rio Papaloapan, Alvarado Lagoon, Veracruz, Mexico

**Date of collection:** April–May 1994

**Specimen deposited:** UNAM 3078

**Camallanidae Railliet and Henry, 1915**

***Camallanus* Railliet and Henry, 1915**

***Camallanus* sp. (stage 3 larva)**

(Figures 3C, D)

**Description:** Descriptions based on 9 larval specimens collected from the posterior intestine (near the anus) of *D. maculatus*. Worms very small, stretch easily, move slowly on the mucosa, appear yellow, clear, or pinkish. Anterior part rounded, comprises bucal capsule; divided into dorsal and ventral valves with ornamentations surrounding the interior margins of longitudinal grooves; continues into muscular and glandular portions of esophagus. The posterior end of the worm tapers to a point with 3 processes. No reproductive structures visible/developed.

**Larvae:** Body 0.933–1.075 (1.051) long, 0.050–0.066 (0.058) wide. Bucal capsule 0.054–0.058 (0.056) long, 0.033–0.037 (0.034) wide. Muscular esophagus 0.166–0.200 (0.181) long, 0.037–0.066 (0.044) wide. Glandular esophagus 0.116–0.158 (0.138) long, 0.033–0.058 (0.038) wide. Anus opens a distance of 0.041–0.057 (0.047) from the terminal body end. Terminal processes measure 0.008–0.012 (0.010) long.

**Host:** *Dormitator maculatus*

**Site in host:** posterior intestine

**Locality:** Mouth of Rio Papaloapan, Alvarado Lagoon, Veracruz, Mexico

**Date of collection:** April 1994

**Specimen deposited:** UNAM 3079

**Prevalence and intensity of parasites**

Monthly values of infection parameters for *C. complanatum* and *N. golvani* are shown in Table 3; nematode larvae *Camallanus* sp. and *Spiroxys* sp. were not considered because they were only rarely collected. The prevalence of *D. maculatus* infected with *C. complanatum* was highest in November (90%) and May (94.4%) and lowest in December (60%), while the highest prevalence of hosts infected with the acantocephalan *N. golvani* was in July (100%) and October 1993 (90.9%) and lowest in February (43.7%). The intensity of infection with *C. complanatum* metacercariae was also highest in May (92 worms/infected fish) and least in December (18.7 worms/infected fish). The highest intensity of infection with *N. golvani* was in October 1993 and October 1994 (33.8 and 32.4 worms/infected fish, respectively) and lowest in February (3.1 worms/infected fish). A correlation analysis showed a significant, positive relationship in the intensity of infection between *C. complanatum* and *N. golvani*, although there was a relatively low association between intensity of the 2 parasites (Pearson  $r = 0.36$ ,  $P < 0.05$ ).

**DISCUSSION**

***Clinostomum complanatum***

*Clinostomum* Leidy, 1856 contains a group of species that utilizes freshwater snails as first intermediate host; freshwater fishes, frogs, salamanders, and some snakes as secondary intermediate hosts; and piscivorous birds and occasionally mammals as definitive hosts (Nigrelli 1936, Lo et al. 1981, 1982). Typical avian hosts include herons and egrets (Ardeidae) (Yamaguti 1971). The specimens from *D. maculatus* and *E. caerulea* from Alvarado Lagoon are consistent with *C. complanatum* Rudolphi, 1814 because the ovary is intertesticular, the sucker ratio is correct, the cecal projections are not well pronounced, and the

**TABLE 3**

**Monthly infection variables of *Dormitator maculatus* helminths from the Alvarado Lagoon system. *s* = standard deviation**

| Month           | <i>Clinostomum complanatum</i> |             | <i>Neoechinorhynchus golvani</i> |            |
|-----------------|--------------------------------|-------------|----------------------------------|------------|
|                 | Prevalence                     | Intensity   | Prevalence                       | Intensity  |
| October 93      | 72.7                           | 58.0        | 90.9                             | 33.8       |
| November 93     | 90.9                           | 61.0        | 78.7                             | 22.3       |
| December 93     | 60.0                           | 18.7        | 70.0                             | 12.0       |
| February 94     | 81.2                           | 44.8        | 43.7                             | 3.1        |
| April 94        | 89.4                           | 31.0        | 57.8                             | 18.9       |
| May 94          | 94.4                           | 92.0        | 83.3                             | 14.6       |
| July 94         | 81.8                           | 25.7        | 100.0                            | 12.3       |
| October 94      | 73.5                           | 69.6        | 76.4                             | 32.4       |
| Mean ± <i>s</i> | 80.5 ± 10.7                    | 50.1 ± 23.2 | 75.1 ± 16.8                      | 18.7 ± 9.8 |



genital pore is submedial and lateral to the anterior testis. Even more importantly, the cirrus sac is intertesticular and contains a twisting seminal vesicle in adults. In addition, body size, egg size, lack of metacercarial body spines, and the use of a freshwater or estuarine fish as an intermediate host are all traits of *C. complanatum*. Dimensions for material from the present study is compared to dimensions reported by other authors for metacercaria (Table 1) and adults (Table 2) of *C. complanatum* in Mexico. In all cases, the range of values for morphometric measurements in this study concurs with previous descriptions.

It should be noted that there is some disagreement in the literature regarding the taxonomy of *C. complanatum* and *C. marginatum* Rudolphi, 1819. Dowsett and Lubinsky (1980), after reviewing the works of various authors and available geographic information, considered the 2 species synonymous. Nevertheless, Lo et al. (1982) disregarded this synonymy and considered the position of the genital pore, as well as body length and width, to be a useful and important feature for separating these 2 species. Thus, some North American authors consider metacercariae from North American freshwater fishes to be *C. marginatum* and those from North American frogs and Asian and European fishes to be *C. complanatum*. However, only *C. complanatum* has been reported in Mexico (Lamothe-Argumedo et al. 1996, Salgado-Maldonado et al. 1997, Scholz and Aguirre Macedo 2000), with this identification based on the morphological features defined by Lo et al. (1982). The material we describe from *D. maculatus* is consistent with previous descriptions from Mexican fishes and is thus positively identified as *C. complanatum*. This taxonomic discrepancy may be solved using genetic techniques such as 18S ribosomal RNA gene sequences, which was successfully used to clarify acantocephalan phylogenetic relationships (García-Varela et al. 2000).

Of all the helminths reported from *D. maculatus* in this study, only *C. complanatum* has a worldwide distribution. The definitive hosts for this species (piscivorous birds) have presumably introduced this parasite throughout its cosmopolitan distribution while traveling along migratory pathways. The parasite is able to survive if the proper environmental conditions are present and if the proper intermediate hosts are available (Van Cleave and Mueller 1934, Jiménez 1993).

At least 3 other species of *Clinostomum* have been reported from Mexico. Bravo-Holis (1947) reported *C. heluans* Braun, 1899 from *Ardea herodias* and *C. intermedialis* Lamont, 1920 from *Phallacrocorax penicillatus*, both from Nuevo Leon. More recently, Mejia (1987) reported *C. intermedialis* from *Goodea atripinnis* in Pátzcuaro Lake, Michoacán. *Clinostomum complanatum*

may be differentiated from *C. heluans* by having a much smaller adult body size (3.9–6.5 compared to 20.7–26.1 in length). *Clinostomum complanatum* differs from *C. intermedialis* by being slightly smaller (3.9–6.6 compared to 6.6–11.1 in length) and by having the cirrus sac located slightly more anterior (at the level of the anterior testis rather than at the level of the ovary). Amaya and Duran (1996) reported the third species, which they identified as *C. complanatum* from *D. maculatus*; however, metacercariae they described had body spines like *C. gigantecum* Agarwal, 1959. It is unlikely that the specimens described by Amaya and Duran (1996) are conspecific with *C. gigantecum* owing to the Indian distribution of that species, but it is likely that their specimens belong in a 4th, as of yet unidentified, species of *Clinostomum*. The presence of body spines precludes these specimens from being *C. complanatum*.

Metacercariae of *C. complanatum* have been reported from a great number of second intermediate host fishes. In Asia, including Japan, these hosts include: *Carassius carassius*, *Pseudogobio esocinus*, *Achelilognathus intermedia*, *Misgurnus fossilis anguillicaudatus*, and *Eupomotis gibosus* (see Lo et al. 1982) and *Carassius cuvieri*, *Cyprinus carpio*, *Rhodeos ocellatus*, *Cubitis anguillicaudatus*, *Hypomesus transpacificos*, *Lateolabrax japonicus*, and *Leuciscus hakonensis* (Aohagi et al. 1992a, 1993b, 1995). In Africa, *Serranochromis macrocephalus*, *Oreochromis mortimeri*, and *Tilapia rendalli* have been reported as hosts (Douëllou and Erlwanger 1993), and in North America, over 50 hosts are known. A few of the more common North American hosts include: *Perca flavescens*, *Aphredoderus sayanus*, *Micropterus dolomieu*, *M. salmoides*, *Ambloplites rupestris*, *Lepomis pallidus* (= *L. macrochirus*), *Catostomus commersoni*, and *Pimephales promelas* (Nigrelli 1936). In Mexico alone, *C. complanatum* has been reported from 28 species of freshwater fishes from 11 families including Cichlidae. Within Cichlidae, hosts are known from 10 different states in Mexico, and from Tabasco alone, cichlids host *C. complanatum* in 10 different bodies of water. The most commonly reported cichlid hosts in Mexico are *Cichlasoma cyanoguttatum*, *C. fenestratum*, *C. robertsoni*, *C. istlanum*, *C. passionis*, *C. pearsei*, *C. synspilum*, *C. urophthalmus*, and *Petenia splendida* (Pineda-López 1985, Osorio et al. 1987, García et al. 1993, Galaviz-Silva et al. 1992, Segovia-Salinas et al. 1993, Peresbarbosa 1992, Peresbarbosa et al. 1994, Scholz et al. 1995, Pérez-Ponce de León et al. 1996, Salgado-Maldonado et al. 1997).

Adults of *C. complanatum* have been reported from the mouth and esophagus of piscivorous birds worldwide. In Asia and North America, species in *Ardea*, *Ardeola*,

*Concroma*, *Mycteria*, *Egretta*, *Nycticorax*, *Larus*, *Butorides*, *Phalacrocorax*, *Pelecanus*, *Bubulcus*, *Botaurus*, *Plegadis*, *Gallinula*, *Podiceps*, and *Ixobrychus* serve as hosts, and even humans have been reported as an accidental host (Lo et al. 1982, Aohagi et al. 1993a). In Mexico, Caballero y Caballero (1946) reported *C. complanatum* in *Butorides virescens* from Motozintla, Chiapas. Ramos (1995) reported the same species from *Egretta thula*, *Casmerodius albus*, and *Botaurus* sp. in Oaxaca, and Hernández (1996) reported *C. complanatum* in *Pelecanus erythrorhynchus* and *Rhynchops niger* from Tecolutla, Veracruz. The presence of adults in *E. caerulea*, as reported in this study, represents a new definitive host for *C. complanatum*. However, we cannot assume that the egrets are all infected by *D. maculatus*, as 16 species of frogs, known intermediate hosts of *C. complanatum*, are present in the Alvarado Lagoon area (Altamirano et al. 1996).

Campos (1992) reported a prevalence of 66% and an intensity of 2.3 worms/host in *Gobiomorus dormitor* from Río Tecolutla, Veracruz, whereas the present study found a prevalence of 82.3% and intensity of 49.7 worms/host in *D. maculatus* from Alvarado Lagoon, in the same state as Río Tecolutla. Apparently, *D. maculatus* is a much better host for the parasite. It is possible that this is due to habitat selection by the fish. *Dormitator maculatus* is a sedentary benthic fish that lies semi-buried in mud in the littoral zone and feeds on detritus. In contrast, *G. dormitor* normally lies in wait to ambush prey under cover of vegetation in littoral zones that are thick with aquatic vegetation. Assuming infection by *C. complanatum* is influenced solely by ecological parameters and not by physiological ones, it is likely that these different niches convey different infection rates for fish (Yoshino 1989). The availability of *D. maculatus* as a host for these species is no doubt related to the trophic position of the fish, as discussed by Zander et al. (1993) in European aquatic ecosystems.

The results of this study suggest that *D. maculatus* is often infected by *C. complanatum* in Alvarado Lagoon, and that the sedentary behavior of the fish may increase the time of exposure to infective cercariae, causing greater prevalence of infection and abundance of parasites in this host. The process of infection starts with cercariae actively finding and penetrating the lamellae of the gill arch and then migrating to the heart or liver where they encyst (Chávez et al. 2003). The metacercariae are found in the celomic cavity on intestinal mesenteries (Galaviz-Silva et al. 1992). Although hydrobiid snails, a known host for the cercariae, are found in the diet of *D. maculatus* (Chávez 1998), the cercariae or cysts were never found in the digestive tract, suggesting cercariae infection is active, not passive.

### *Neoechinorhynchus golvani*

The acanthocephalans examined in this study possessed a small proboscis that may appear spherical or almost cylindrical depending on the degree of contraction. The proboscis has 3 lines of hooks, each line having 6 hooks. The body trunk without is devoid of spines and has large hypodermal nuclei, and males have syncytial cement glands associated with the reproductive tract. Together, the presence of these features allows for the identification of this species in *Neoechinorhynchus* Hamann, 1892 (see Petrochenko 1971).

*Neoechinorhynchus* is a diverse genus within Acanthocephala, with nearly 75 described species that live in the intestine of marine and freshwater fishes in Asia, Europe, and North America (Amin 1985). In Mexico, *N. roseum* Salgado-Maldonado 1978 and *N. golvani* Salgado-Maldonado 1978 are morphologically similar. *Neoechinorhynchus golvani* differs from *N. roseum* by having a shorter organ of lemnisci and a smaller and narrower body trunk.

*Neoechinorhynchus golvani* has been reported from 4 different families of freshwater and brackish water fishes in Mexico and is a common acanthocephalan of fishes in Tabasco, Campeche, Yucatan, and Colima. Of these fishes, the cichlids are the most common hosts for *N. golvani*. Eleven species of cichlid, from 5 states (Campeche, Colima, Tabasco, Veracruz, and Yucatan) are known hosts (Salgado-Maldonado 1978, 1985, Osorio et al. 1987, Ramírez 1987, Pérez-Ponce de León et al. 1996, Salgado-Maldonado et al. 1997). In Veracruz, *Cichlasoma fenestratum* is host to *N. golvani* in Catemaco Lake (see Jiménez 1993), and *Centropomus parallelus* and *Dormitator maculatus* host the species in Alvarado Lagoon (Velázquez 1994, Cancela 1995, present study). Specimens examined in this study are slightly smaller than those reported in cichlids from Tabasco by Salgado-Maldonado (1985; Table 4). Nevertheless, the specimens are similar in internal configuration, and despite the slightly smaller measurements, the specimens from both locations are conspecific.

Cancela (1995) reported a prevalence of infection by *N. golvani* of 1.1% in *C. parallelus*, Trujillo (1995) reported 16.7% prevalence in *C. urophthalmus*, Velázquez (1994) reported 53.3% prevalence in *G. dormitor*, and, in our study, 76.1% of *D. maculatus* were infected. The maximum number of acanthocephalans present in a single fish was 114. These differences are probably due to the environmental conditions that may reduce or favor the likelihood of predation on the intermediate host. In the case of *D. maculatus*, the high prevalence and intensity of infection suggest a close association with large numbers of

TABLE 4

Morphometric features of *Neoechinorhynchus golvani* adults. Minimum and maximum values are presented in mm. *n* = number of individuals.

| Morphometric feature   |        | This study                       |                                    | Salgado 1985                    |                                   |
|------------------------|--------|----------------------------------|------------------------------------|---------------------------------|-----------------------------------|
|                        |        | Male ( <i>n</i> = 10)<br>min-max | Female ( <i>n</i> = 10)<br>min-max | Male ( <i>n</i> =23)<br>min-max | Female ( <i>n</i> = 9)<br>min-max |
| Total length           |        | 1.206–2.580                      | 1.870–3.500                        | 0.776–5.812                     | 4.865–7.165                       |
| Trunk                  | Length | 1.125–2.500                      | 1.760–3.410                        | 0.714–5.490                     | 3.300–7.080                       |
|                        | Width  | 0.375–0.625                      | 0.520–1.170                        | 0.316–1.650                     | 0.930–2.370                       |
| Proboscis              | Length | 0.070–0.090                      | 0.060–0.090                        | 0.049–0.083                     | 0.065–0.098                       |
|                        | Width  | 0.040–0.060                      | 0.050–0.070                        | 0.052–0.083                     | 0.070–0.098                       |
| Apical hooks           | Length | 0.040–0.050                      | 0.040–0.057                        | 0.039–0.057                     | 0.039–0.052                       |
|                        | Width  | 0.006–0.008                      | 0.006–0.008                        | 0.005–0.007                     | 0.005–0.007                       |
| Medial hooks           | Length | 0.012–0.014                      | 0.012–0.014                        | 0.013–0.020                     | 0.015–0.026                       |
|                        | Width  | 0.003–0.004                      | 0.003–0.004                        | 0.002–0.005                     | 0.002–0.007                       |
| Basal hooks            | Length | 0.014–0.016                      | 0.014–0.016                        | 0.010–0.015                     | 0.013–0.020                       |
|                        | Width  | 0.003–0.004                      | 0.004                              | 0.002                           | 0.002–0.005                       |
| Proboscis receptacle   | Length | 0.150–0.290                      | 0.150–0.310                        | 0.169–0.390                     | 0.285–0.397                       |
|                        | Width  | 0.050–0.090                      | 0.050–0.100                        | 0.052–0.150                     | 0.065–0.171                       |
| Reproductive apparatus | Length | 0.550–1.550                      | 0.290–0.330                        | 0.387–3.810                     | 0.795–0.897                       |
| Copulatrix bursa       | Length | 0.083–0.125                      | —                                  | —                               | —                                 |
|                        | Width  | 0.075–0.116                      | —                                  | —                               | —                                 |
| Eggs                   | Length | —                                | 0.028–0.031                        | —                               | —                                 |
|                        | Width  | —                                | 0.008                              | —                               | —                                 |

infected intermediate hosts, perhaps related to the productive nature of Alvarado Lagoon.

***Spiroxys* sp.**

The larval nematodes obtained from the muscular stomach wall of *D. maculatus* did not have reproductive structures of any sort; however, the configuration of the digestive tract, the structures on the cephalic region (2 triangular lips surrounded by pseudolabiae), a poorly developed oral cavity, and the type of host make it possible to place the species in *Spiroxys* Schneider, 1866. Measurements from specimens examined here are compared to those of Moravec et al. (1995) and Osorio et al. (1987) in Table 5. While the ranges of the specimens from this study are similar to those described by Osorio et al. (1987), our specimens appear smaller than those of Moravec et al. (1995).

In Mexico, larvae of *Spiroxys* spp. have been reported from many states including Nuevo León, Morelos, Puebla, and Michoacán (Pérez-Ponce de León et al. 1996). In Lake Pátzcuaro, Michoacán, the following fishes are host to the worms: *Algansea lacustris* (Mendoza 1994), *Allophorus robustus* (Peresbarbosa et al. 1994), *Chirostoma attenuatum* (Meléndez and Rosas 1995), *Goodea atripinnis* (Mejía 1987), and *Micropterus salmoides* (Ramírez 1987). In

addition, larval specimens of *Spiroxys* have been reported from Tabasco in *Cichlasoma meeki* and *C. pasioni* from the “El Chiribital” Lagoon by Osorio et al. (1987), and from fishes of the cenotes of Yucatan (*C. meeki*, *C. urophthalmus*, *Poecilia* sp., *Poecilia velifera*, and *Astyanax fasciatus*; Moravec et al. 1995).

Larvae of *Spiroxys* have not been reported from Alvarado Lagoon prior to this study. This represents the first report of the genus from that locality, and it represents a new host record in *D. maculatus*. Trujillo (1995) reported larval nematodes in the stomach and intestinal wall of *C. urophthalmus* from the same lagoonal system but was not able to identify the worms to genus. In all likelihood, they were the same as the worms reported here. The prevalence of infection for *Spiroxys* sp. reported here in *D. maculatus* (21.3%) is comparable to prevalence values reported from other fishes in other localities in southeastern Mexico: 30.0% in cichlids in Tabasco (Osorio et al. 1987) and 12.0–33.3% in various species of fishes in cenotes in Yucatan (Moravec et al. 1995). The definitive hosts for *Spiroxys* sp. are aquatic turtles, and *Trachemis scripta* is a known host for *Spiroxys* sp. in Alvarado Lagoon (Altamirano et al. 1996).

TABLE 5

Morphometric features of *Spiroxys* sp. larval stages. Minimum and maximum values are presented in mm. *n* = number of individuals.

| Morphometric features              | This Study<br>( <i>n</i> = 7)<br>min–max | Moravec et al. 1995<br>( <i>n</i> = 5)<br>min–max | Osorio et al. 1987<br>( <i>n</i> = 9)<br>min–max |
|------------------------------------|--|---|--|
| Body length                        | 0.625–1.770                              | 2.050–2.170                                       | 1.520–1.810                                      |
| Body wide                          | 0.033–0.050                              | 0.060–0.078                                       | 0.050–0.060                                      |
| Buccal cavity length               | 0.016–0.033                              | —   | 0.013–0.019                                      |
| Buccal cavity wide                 | 0.020–0.024                              | —   | 0.014–0.020                                      |
| Oesophagus length                  | 0.133–0.325                              | —   | 0.130–0.188                                      |
| Distance between anus and tail end | 0.053–0.068                              | 0.246–0.264                                       | 0.066–0.085                                      |

### *Camallanus* sp.

The *Camallanus* nematodes collected from the intestinal mucosa of *D. maculatus* had not yet developed reproductive structures and are therefore still larvae. They may be identified as *Camallanus* sp. because the anterior end is rounded and the bucal capsule is divided into 2 rounded sclerotized structures, which are smooth. *Camallanus* sp. is distinguished from other genera and species in Camallanidae by the structure of the sclerotized plates in the bucal cavity. In *Camallanus* sp., the interior margin of the dorsal and ventral plates is smooth, whereas the plates have longitudinal grooves or spiral grooves in other genera (Chabaud 1975).

Species of *Camallanus* are parasitic in the intestine of fishes, frogs, turtles, and snakes as adults. Small aquatic crustaceans like copepods act as first intermediate hosts for larval stages (Moravec et al. 1995b, Moravec and Vargas-Vazquez 1996), and freshwater fishes serve as second intermediate hosts. At least 52 species of freshwater fishes serve as second intermediate hosts for *Camallanus* spp. in North America (Stromberg and Crites 1974), and the family Camallanidae accounts for 8% of the total number of nematode larvae recorded in Mexican fishes (Moravec 2000). Both the guppy *Poecilia reticulata*, and the Mayan cichlid, *Cichlasoma urophthalmus*, are natural paratenic hosts of camallanid nematodes (Moravec et al. 1998), as we have shown for *D. maculatus*.

Larvae of *Camallanus* spp. have been reported from a variety of fishes in a number of states in Mexico. *Astyanax mexicanus* and *Cichlasoma cyanoguttatum* serve as hosts in Nuevo Leon (Pérez-Ponce de León et al. 1996). *Ilyodon whitei* is a host in Morelos (Caspeta 1996). Osorio et al. (1987) reported *Camallanus lacustrus* Zoega, 1776 from *Cichlasoma* sp., *C. meeki*, and *Petenia splendida* in Lake El Chiribital and Lake El Horizonte in Tabasco. The specimens in our study are most similar to that reported by Iruegas (see Pérez-Ponce de León et al. 1996) but differs

slightly by being smaller in body length and width, and in esophagus length. Regardless, they appear to be the same species but perhaps at a different developmental stage.

This study represents a new intermediate host record (*D. maculatus*) and a new locality record (Alvarado Lagoon) for *Camallanus* sp. larvae. Though the species cannot be determined, it is clear that the specimens reported in the present study differ from specimens reported as *Camallanus* sp. in cichlids from Tabasco by Osorio et al. (1987) in Salgado-Maldonado et al. (1997). Worm rank was low in the present study (1–3 worms/host). This may be due to possible exiting of worms through the anus brought about by the stress of host capture, a phenomenon previously reported by Van Cleave and Mueller (1934) when *Camallanus* sp. exited *Perca flavescens* at the time of capture. Caspeta (1996) reported a similar occurrence in *Ilyodon whitei*.

In Mexico, studies involving parasites of estuarine fishes are scarce. In this study, we report new habitat, host and distributions records for 4 parasite species in the Alvarado Lagoon. *Dormitator maculatus* is an intermediate host for larval stages of *C. complanatum*, presumably a paratenic host for *Spiroxys* sp. and *Camallanus* sp. and the definitive host for adult *Neoechinorhynchus golvani*. The prevalence for the 2 most commonly occurring parasites, *C. complanatum* and *N. golvani*, was high throughout the year, and intensity of infection was generally highest at the end of the rainy season (October–November) for both species.

### ACKNOWLEDGMENTS

This manuscript is based on a thesis by the senior author in partial fulfillment of the Masters of Science degree from the Universidad Nacional Autónoma de México in 1998. The authors thank D. Osorio-Sarabia and G. Salgado-Maldonado for assistance in identifying the parasites and J. Cruz-Cruz for collecting the biological

material from Alvarado Lagoon. This manuscript was translated from the Spanish and edited by S.S. Curran (The University of Southern Mississippi). The authors especially thank N.J. Brown-Peterson and M.S. Peterson for their time and assistance with numerous editorial comments and suggestions resulting in a greatly improved manuscript.

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