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Research note

Didymozoid *Monilicaecum* type trematodes in chaetognaths from the Mexican Caribbean Sea

Tremátodos didimozoides tipo *Monilicaecum* en quetognatos del mar caribe mexicano

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Abstract. Analyses of 22,508 holoplanktonic chaetognaths collected at 21 stations were made from four oceanographic campaigns along the coasts of Quintana Roo, Mexico, in 1991 (Caribe I = February; Caribe II = March; Caribe III = May; Caribe IV= August). Unencysted larval didymozoid parasites were identified as belonging to the *Monilicaecum* type because of the arrangement of the chambers of the heavily twisted intestinal caeca, which occupy nearly the entire body. These larvae were found in the coelom of seven individuals of the chaetognath *Flaccisagitta enflata* (prevalence = 0.03, mean intensity = 1) and in two of *Serratosagitta serratodentata* (prevalence = 0.009, mean intensity = 1). The Mexican Caribbean Sea is reported as a new locality for this type of helminth larvae.

Key words: Didymozoidae, *Monilicaecum*, chaetognaths, Mexican Caribbean Sea.

Resumen. Se analizan 22,508 quetognatos holoplánticos capturados en 21 estaciones a lo largo de las costas del estado de Quintana Roo, México durante 1991 (Caribe I= febrero; Caribe II= marzo; Caribe III mayo; Caribe IV= agosto). Las formas no enquistadas de los parásitos didimozoides fueron identificadas como tipo *Monilicaecum* debido al arreglo de las cámaras de los ciegos intestinales fuertemente sinuosas que ocupan casi la totalidad de la cavidad corporal. Las larvas tipo *Monilicaecum* fueron encontradas en el celoma de siete quetognatos de la especie *Flaccisagitta enflata* (prevalencia= 0.03; intensidad promedio de parasitismo = 1) y en dos ejemplares de *Serratosagitta serratodentata* (prevalencia = 0.009, intensidad promedio = 1). El mar caribe mexicano es registrado como una nueva localidad para esta larva de helminto.

Palabras clave: Didymozoide, *Monilicaecum*, quetognatos, mar caribe mexicano.

Didymozoid trematode larvae have been frequently reported from the coelomic cavity of planktonic chaetognaths (Nagasawa, 1991, Øresland and Bray, 2005), from the digestive tract of cephalopod paralarvae (Vidal and Haimovici, 1999), as endoparasites (Tolonen and Karlsbakk, 2003) or externally on the dorsal musculature of fish larvae (Karlsbakk, 2001), or even in the digestive tract of snakes (Fischthal and Kuntz, 1965). Although two didymozoid larval types are presently recognized, *Torticaecum* and *Monilicaecum*, the second is more frequently found in tropical, subtropical and temperate waters (Nagasawa, 1991).

Adult didymozoids have been recorded in the tissues of pelagic bony fishes (Yamaguti, 1970, 1971), particularly in the subfamily Thunninae (Scombridae) (Cribb et al., 2000). Nagasawa and Marumo (1981) suggested that the flatfish *Cleisthenes pinetorum* Jordan et Starks, 1904 is one of the definitive hosts for this kind of helminth. In Todos Los Santos Bay, Ensenada, México, Caballero y Caballero and Caballero-Rodríguez (1971) described *Unitubulotestis maris* as a new adult species of didymozoid from the scombrid fish *Sarda lineolata* (Girard, 1858). In the present

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study didymozoid trematode metacercariae were found in the coelom of the chaetognaths *Flaccisagitta enflata* Grassi 1881 and *Serratosagitta serratodentata* (Krohn,1853) and are reported for the first time for the Mexican Caribbean Sea.

Studies on chaetognath species assemblages were carried out along the Caribbean Sea, in the vicinity of the coasts of Mexico, during February, March, May and August 1991, using a conic net 0.5m mouth diameter, with 330µ mesh (see Gasca et al., 1996 for study area and methods). A total of 22,508 chaetognaths were identified to species, and those containing parasites were sorted out and further analyzed. Hosts and parasites were stained together with acetic carmine, cleared with methyl salicylate and mounted in permanent slides in Canada balsam. Minimum and maximum size measurements of parasites (in mm, mean and SD in parenthesis) were made with a scaled eye piece, and prevalence and mean infection intensity follows Bush et al. (1997). Parasites are deposited at the Colección Parasitológica del Museo de Historia Natural de la Universidad Autónoma de Baja California Sur (CPMHN-UABCS), catalog numbers 233 to 240.

Flaccisagitta enflata and *Serratosagitta serratodentata* are chaetognaths with a wide distribution in all seas of the world (Alvariño, 1965). Both species are common and frequently collected in the Puerto Morelos coral reef lagoon (Ramírez-Ávila and Álvarez-Cadena, 1999), and both have been reported previously as host for other didymozoid metacercariae (*Torticaecum* type) (Gómez del Prado-Rosas et al., 1999a) or other trematodes (Gómez del Prado-Rosas et al., 1999b; 2002, 2005).

Nine *Monilicaecum* type larvae were found in 22,508 chaetognaths, seven in the coelom of *Flaccisagitta enflata* (Caribe I, II and IV) and two in *Serratosagitta serratodentata* (Caribe IV). Prevalence was low (0.03 for the first chaetognath species and 0.009 for the second). Mean intensity in both cases was 1 (Table 1).

The *Monilicaecum* **t**ype metacercariae recorded here present the following features and measurements: Body cylindrical, 0.117 to 0.242 (0.167; SD = 0.040) long and 0.04-to 0.075 (0.056; SD= 0.010) wide. Hindbody wider than forebody. Tegument smooth. Oral sucker slightly elongated, relatively large and muscular, 0.014 to 0.035 (0.019; SD=0.007) long and 0.010 to 0.021 (0.015; SD= 0.004) wide. Acetabulum pre-equatorial, 0.018 to 0.035 (0.026; SD=0.010) in length, and 0.017 to 0.034 (0.026; SD=0.005) wide. Sucker ratio 1:1.3 in average. Pharynx inconspicuous, observed only in four specimens, 0.006 to 0.009 (0.008; SD= 0.004) long and 0.005 to 0.011 (0.008; SD= 0.004) wide. Esophagus not observed, due to contraction of parasites. Stomach dorsal to acetabulum. Parenchymal tissue finely granulated, observed along the entire body. Caeca heavily twisted and occupying nearly all body. Nine intestinal chambers observed running from post-acetabular region to posterior end of body. Caeca wider posteriorly ending blindly and independently. One specimen with two small genital primordia posterior to ventral sucker. Excretory vesicle globular, short, ending in a conspicuous excreting pore near posterior end of body (Fig. 1).

The metacercariae from this study were identified as belonging to the *Monilicaecum* type because of the presence of a stomach and the arrangement of the chambers of the intestinal caeca, in contrast with the absence of the stomach and the tubular caeca of the *Torticaecum* type (Yamaguti, 1970, 1971). The larvae analyzed in this study are similar to those described by Shimazu (1978) in the form and position of the stomach. However, his larvae were different in the number of chambers (4-8) instead of 9 from the larvae of this study. Our larvae are different from those moniliform reported by Nikolaeva (1965) larvae I, as in her specimens the acetabulum is smaller than the oral sucker, presented a preacetabular glandular region and also showed a tubular narrow caeca anterior to the formation of the caecal chambers. Our larvae are different from Nikolaeva´s *Monilicaecum ventricosum* Yamaguti, 1942 for lacking glands external to the stomach. Didymozooids reported by Fischthal and Kuntz (1964) are also different from parasites of this work for lacking stomach (immature didymozoid A and *Torticaecum nipponicum*) and some of them also lack acetabulum (immature didymozoid B).

The parasites reported by Fischthal and Thomas (1968) and Køie and Lester (1985) differ from our material in presenting a compact glandular mass surrounding the stomach and the ceca (didymozoids D, E), or a considerable larger glandular part in the walls of each ceca (didymozoids F, G); also, the acetabulum is smaller than the oral sucker (didymozoids Nikolaeva´s larvae I, D, F.). Didymozoids reported by Koie and Lester (1985) also differ from our material by having numerous gland cells at the posterior half of forebody and anterior third of hindbody (sp. 1, 3, 4), by the presence of a cecal bifurcation at anteriormost acetabular level (sp. 1), by an anterior tubular part of each cecum (sp. 1, 3, 7), by having long tubular ducts connecting the anteriormost cecal chambers (sp.4), by the presence of eyespots (sp.7), and by having cecum of different length (sp. 8). Differences with the didymozoid larvae reported by Karlsbakk (2001) are: glandular regions on the forebody, an anterior non granular zone and a posterior glandular area between the ganglion and the hindbody, stomach absent, presence of non granular cells in the parenchyma of the hindbody, and the larger size of the parasites (23.5 to 41.8 mm). However, his metacercariae have a small pharynx, a similar number of chambers as ours and the caeca are also

Table 1. Hosts, parasite number (n), prevalence (P) and collecting sites of *Monilicaecum* type larvae from chaetognaths of the Mexican Caribbean Sea

Host	*n §*	*P * ‡*	*Date*	*Collecting Station*	*Specimens deposited*
Flaccisagitta enflata	(1)	0.004%	Feb. 1991	CARIBE I (A)	CPMHN-UABCS, 233
	(1)	0.004%	Feb. 1991	CARIBE I (7)	CPMHN-UABCS, 234
	(1)	0.004%	Feb. 1991	CARIBE I (20)	CPMHN-UABCS, 235
	(2)	0.009%	Feb. 1991	CARIBE I (21)	CPMHN-UABCS, 236
	(1)	0.004%	Mar. 1991	CARIBE II (14)	CPMHN-UABCS, 237
	(1)	0.004%	Aug. 1991	CARIBE IV (10)	CPMHN-UABCS, 238
Serratosagitta serratodentata	(1)	0.004%	Aug. 1991	CARIBE IV (7)	CPMHN-UABCS, 239
	(1)	0.004%	Aug. 1991	CARIBE IV (10)	CPMHN-UABCS, 240

§ All parasites recorded in the coelom
All infections were with a single parasite (Intensity = 1)
‡ Overall prevalence 0.037%

moniliform.

For classification of didymozoid larvae, Nikolaeva (1965) considered features as body size, body length-width ratio, the distance between suckers, and the identity of parasitized hosts. However, Fischthal and Kuntz (1964) and Yamaguti (1970) considered those criteria to be doubtful due to the extreme variability associated with age. Kurochkin and Nikolaeva established differences among didymozoid larvae based on the presence-absence of acetabulum, pharynx, stomach, gland cells and the relative position of the cecal bifurcation and acetabulum. Later, Køie and Lester (1985) reported that the stomach always disappears with age, and observed that the younger developmental stages show the presence of a pharynx and an acetabulum. These structures are therefore, of no taxonomic value. They concluded that it is impossible to assign larval didymozoids to genera or higher taxonomic levels, suggesting that the larval didymozoids should not be given Latin names to avoid a double taxonomic system, one for the larvae and one for the adults, a position that we share in this study.

The prevalence and infection intensity of *Monilicaecum* type larvae is low in planktonic animals as it has been reported for chaetognaths by Shimazu (1978), for copepods by Madhavi (1968) and in reef fish larvae by Cribb et al. (2000).

The didymozoid life cycle is complex, and it is accepted that three or four hosts can be required to complete it (Hochberg, 1990). Madhavi (1968) believes that crustaceans are possibly the second intermediate host for hemiuriforms (Hemiuridae and Didymozoidae), because she recorded *Monilicaecum* type larvae in the body cavity of *Paracalanus aculeatus* Giesbrecht in Waltair, Bengala Bay. Cable and Nahhas (1962) suggested that the cirripedian genus *Lepas* acts as a second intermediate host as they found *Monilicaecum* type larvae in these crustaceans and later found both, the crustaceans and helminths, in the stomach of the dolphin fish *Coryphaena hippurus* Linnaeus.

Madhavi (1968) suggested that fish larvae are paratenic hosts, obtaining the infection when consuming parasitized copepods. Cribb et al. (2000) mentioned that although coral reef fishes, as Lethrinidae and Serranidae, with carnivorous feeding habits, can be the third intermediate host, pelagic fishes like tuna (Scombridae), particularly the subfamily Thunninae (tropical Pacific) are the top and final hosts for adults. Lester (1980) found didymozoid larvae in the intestinal wall of several forager species such as *Engraulis australis* Steindachner, 1879, *Pranesus ogilbyi* Whitley, 1930, *Sillago analis* Whitley, 1943, *S. maculata* Quoy et Gaimard, 1824, *Pelates quadrilineatus* Cuvier et Valenciennes, 1829, *Rhinogobius leftwitchi* Ogilby, 1910; *Favonigobius exquisitus* Whitley, 1930 and *Pseudogobius* sp., suggesting that these species may be paratenic hosts, and that infection of the final host would be accomplished when larger pelagic fishes feed on them.

In other words the metacercariae do not show any preference for paratenic hosts and can be found in cartilaginous fishes as Rhinobatidae or several orders of bony fishes such as Clupeiforms (Clupeidae, Engraulidae), Atheriniforms (Atherinidae), Beloniforms (Exocoetidae) Scorpaeniforms (Scorpaenidae) Perciforms (Serranidae, Pomadasydae,Carangidae, Sciaenidae, Labridae, Sparidae, Gerreidae, Gobiidae, Scombridae, Mullidae),

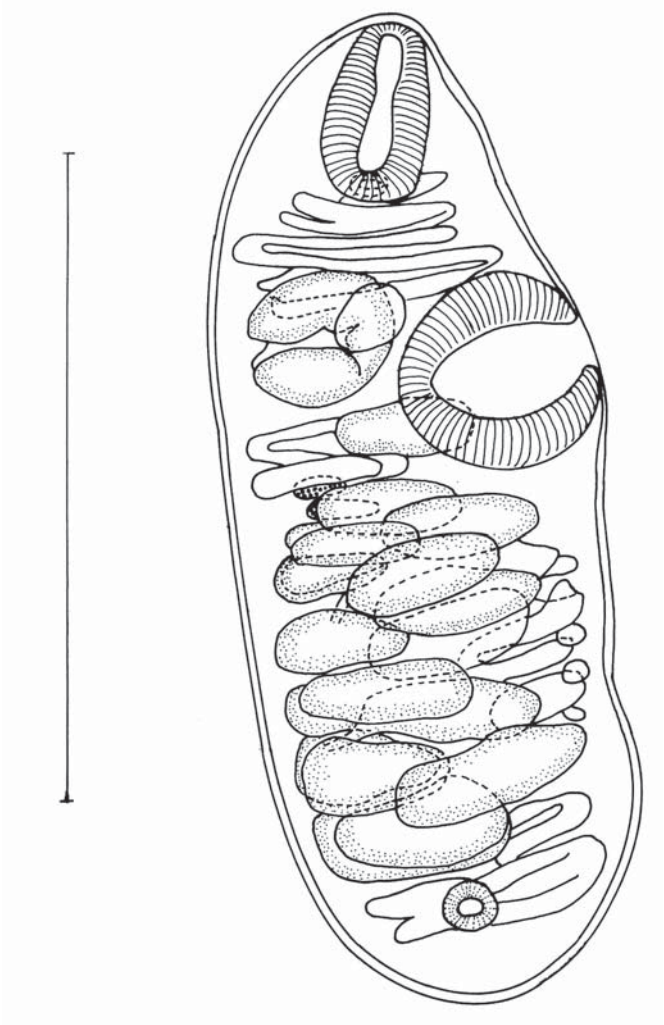

Figure 1. Internal anatomy of the didymozoid larval type *Monilicaecum*. Scale 0.1mm. Lateral view.

Pleuronectiforms (Cynoglossidae, Bothidae) or Tetraodontiforms (Tetraodontidae,) among others.

Nagasawa and Marumo (1981) reported that flatfishes can be final hosts for *Monilicaecum* as is *Cleisthenes pinetorum*. On the other hand, Cribb et al. (2000) suggested that chaetognaths are paratenic hosts for *Monilicaecum*, and Shimazu (1978) believes that chaetognaths, due to its importance in the food web, can be also a link for the third intermediate host or for the final host, i.e. pelagic bony fishes (Yamaguti, 1971). Considering the findings of Madhavi (1968), the infection route for chaetognaths with *Monilicaecum* type larvae is possibly with parasitized microcrustaceans such as copepods. In Puerto Morelos reef lagoon, México, trematode larvae have been observed going through the chaetognath skin (unpublished data). Another possibility is that chaetognaths could be infected in the same way as are squids i.e. chaetognaths ingesting the cercariae directly from the water column (Hochberg, 1990).

For the Mexican Caribbean Sea, there is only one previous report for dydimozoids, identified as *Torticaecum* type (Gómez del Prado-Rosas et al., 1999a), thus, this is the first report for *Monilicaecum* larvae in this area. In both cases the life cycle of these parasites are far from being completely known.

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