



## Helminth parasites of atherinopsid freshwater fishes (Osteichthyes: Atheriniformes) from central Mexico

### Helminthos parásitos de atherinópsidos de agua dulce (Osteichthyes: Atheriniformes) del centro de México

Georgina Lira-Guerrero, Luis García-Prieto\* and Gerardo Pérez-Ponce de León

Laboratorio de Helmintología, Instituto de Biología, Universidad Nacional Autónoma de México. Apartado postal 70-153, 04510, México, D. F., México.

\*Correspondent: gprieto@ibiologia.unam.mx

**Abstract.** Between May 1997 and September 1998, 270 atherinopsids belonging to 7 fish species were analyzed for helminths in 6 lakes located in central Mexico. In addition, a database with all the available previous records of helminth parasites of atherinopsids was built. Based on both information sources, we analyze the composition of the helminth fauna parasitizing atherinopsid freshwater fishes from central Mexico, in order to determine some general species compositional patterns. The helminth fauna parasitizing this fish family in central Mexico is composed by 10 digeneans, 13 cestodes, 1 acanthocephalan, and 8 nematodes (24 of them as larval stage). Individual species richness ranged from 1 to 22 helminth species. Feeding habits of the hosts are identified as the main factor in determining helminth species composition (22 of them are acquired through ingestion). Helminth species composition of almost all host species was dominated by generalist helminth species. Only 2 specialist species were found: *Allocreadium mexicanum* and *Spinitectus osorioi*, representing the core helminth fauna of this group of fishes. These results corroborate the hypothesis that the parasite fauna in freshwater fishes is largely circumscribed by higher levels of monophyletic host taxa.

Key words: helminths, atherinopsids, central Mexico, freshwater fishes.

**Resumen.** Entre mayo de 1997 y septiembre de 1998, se recolectaron 270 atherinópsidos pertenecientes a 7 especies de peces en busca de helmintos, en 6 lagos del centro de México. Basados en esta información y en los registros previos sobre helmintos en este grupo de hospederos, se construyó una base de datos. El objetivo de este estudio es analizar dicha información, para establecer algunos patrones generales acerca de la composición de los helmintos que los parasitan. Treinta y dos especies de helmintos infectan a los peces de esta familia (10 digéneos, 13 cestodos, 1 acantocefalo y 8 nematodos), 24 de ellas en estado larvario. Los hábitos alimenticios de los atherinópsidos determinan la composición de la fauna helmintológica, ya que 22 especies son adquiridas por los peces vía ingestión. La riqueza por especie de pez varió de 1 a 22 especies de helmintos, predominando las generalistas; sólo 2 especies (*Allocreadium mexicanum* y *Spinitectus osorioi*) son específicas para esta familia de hospederos, lo que confirma la hipótesis de que la parasitofauna en peces de agua dulce está circunscrita a niveles superiores de taxa monofiléticos.

Palabras clave: helmintos, atherinópsidos, México, peces de agua dulce.

## Introduction

Atherinopsids represent a group of fishes distributed worldwide, including both marine shoreline and freshwater elements. They were formerly included within the Atherinidae; however, this group of fishes has a complex taxonomic history (Miller et al., 2005). According to Miller et al. (2005), the group includes about 36 species in Mexico, with 10 marine shoreline elements (in the genus *Atherinella*), and 26 freshwater ones (in the genus *Menidia*).

In this paper, we followed the traditional classification and nomenclature of the group; the genus names *Chirostoma* and *Poblana* are used here, even though their validity has not been settled (Miller and Chernoff, 1979; Echelle and Echelle, 1984; Chernoff, 1986).

To date, the helminth fauna of only 3 atherinopsid fish species has been systematically studied: *Chirostoma attenuatum* from Lago de Pátzcuaro and Lago de Zirahuén, Michoacán State, and *Chirostoma estor* and *Chirostoma grandocule* both from Lago de Pátzcuaro (Osorio-Sarabia et al., 1986; Pérez-Ponce de León et al., 1994; Espinosa-Huerta et al., 1996; Pérez-Ponce de León et al., 2000). In addition, numerous isolated records of helminths infecting

some members of this family of fishes have been published so far (Perez-Ponce de León et al., 1996 and references therein; Salgado-Maldonado, 2006 and references therein). The aim of this study is to analyze the composition of the helminth fauna parasitizing atherinopsid freshwater fishes from central Mexico, incorporating new data to previous distributional records in order to determine some general species compositional patterns.

## Materials and methods

Between May 1997 and September 1998, 270 atherinopsids were collected from 6 lakes located in central Mexico. We sampled 30 individuals of each of 7 species of atherinopsids in the following localities: 4 in the State of Michoacán: Lago de Cuitzeo: *Chirostoma jordani*; Lago de Pátzcuaro: *C. attenuatum*, *C. estor*, and *C. grandocule*; Lago de Zacapu: *Chirostoma humboldtianum*; Lago de Zirahuén: *C. attenuatum* and *C. estor*, and 2 in the State of Puebla: Lago Las Minas: *Poblana letholepis* and Lago Quechulac: *Poblana alchichica squamata*. Hosts were collected with a seine net, kept on ice, and examined using a dissecting microscope, within 4 hr after capture. Organs examined included gills, eyes, brain, muscle, mesentery, liver, spleen, heart, gonads, and the gastrointestinal tract. All helminths were counted in situ, recovered from the tissues, and processed according to procedures described in Mendoza-Garfias et al. (1996). Voucher specimens were deposited in the Colección Nacional de Helminths (CNHE), Instituto de Biología, Universidad Nacional Autónoma de México, México City.

In order to analyze the information we obtained in this study in a wider (regional) scope, a database with all the available records of helminth parasites of atherinopsids was assembled, based on all published accounts where at least 1 helminth species was recorded.

## Results

In total, 11 653 specimens of helminths were collected from the 7 species of atherinopsids, representing 14 taxa (6 digeneans, 3 cestodes, 1 acanthocephalan, and 4 nematodes). Ten of the 14 species were represented by larval stages. Body cavity, liver and mesentery were the habitats with the highest species richness with 5 helminth species each one, all as larval stages. Eleven host records are new and the geographic ranges of 9 species are expanded by these records: *Tylodelphis* sp., *Ochetosoma* sp., *Posthodiplostomum minimum*, *Pygidiopsis* sp., *Uvulifer* sp., (digeneans), *Bothriocephalus acheilognathi*, *Ligula*

*intestinalis*, *Paradilepis* sp., (cestodes), and *Eustrongylides* sp. (nematode). The metacercariae of *Pygidiopsis* sp. are recorded for the first time in fishes from water bodies of central Mexico (Tables 1 and 2).

In addition, Tables 1 and 2 include all available information on the composition of the helminth parasite fauna of atherinopsids in central Mexico. To date, 18 species of hosts in 23 localities corresponding to 9 States of the Mexican Republic have been studied.

## Discussion

Previous records as well as the new information provided by the present study indicate that the helminth fauna parasitizing atherinopsid fishes in water bodies in central Mexico is composed by 32 taxa (10 digeneans, 13 cestodes, 1 acanthocephalan, and 8 nematodes). Eight of the 32 species were adult forms: *Allocreadium mexicanum*, *Proteocephalus amploplites*, *B. acheilognathi*, *Atractis bravoae*, *Ornithocapillaria appendiculata*, *P. tomentosa*, *Rhabdochona* sp., and *Spinitectus osorioi*, all of them recovered from the intestine of their hosts; the record of 3 of these species, i. e., *P. ambloplites*, *O. appendiculata*, and *Rhabdochona* sp. is uncommon. On the one hand, *P. ambloplites*, the bass tapeworm, is a common parasite of centrarchid fishes in North America (Hoffman, 1999), so its presence in *C. jordani* from the Río La Laja, Guanajuato State (Salgado-Maldonado, 2006) needs further verification given that no specimens are deposited in a parasite collection. On the other hand, the nematode *O. appendiculata* is an intestinal parasite of cormorants (*Phalacrocorax* sp.) in Brazil (Moravec et al., 2000), and therefore its record in *C. estor* from Lago de Pátzcuaro clearly represents an accidental infection. Finally, *Rhabdochona* sp. was recorded as a larval form by Salgado-Maldonado (2006); this larva was found in the gut, which means that it could be an immature form ( $L_3$ ,  $L_4$ ) that either was unable to develop further or was simply transmitted in the diet. That record may represent the first one of a species of *Rhabdochona* in atherinopsids, since congeneric species commonly occur in goodeids in the same geographic region (Mejia-Madrid et al., 2005); however, there are no specimens available to confirm their identity.

The nematode *P. tomentosa* and the tapeworm *B. acheilognathi* are introduced species; both are intestinal parasites of freshwater fishes with a very low degree of host specificity (Moravec et al., 2001; Salgado-Maldonado and Pineda-López, 2003). Their presence in atherinopsids from central Mexico is due to the introduction of cyprinid fishes for aquaculture.

**Table 1.** Species composition of the helminth fauna of 18 species of atherinopsid freshwater fishes in central Mexico

<i>Helminth species</i>	<i>Atherinella ammophila</i>	<i>Atherinella balsana</i>	<i>Atherinella crystallina</i>	<i>Atherinella lisa</i>	<i>Chirostoma arge</i>	<i>Chirostoma attenuatum</i>	<i>Chirostoma batoni</i>	<i>Chirostoma consocium</i>	<i>Chirostoma estor</i>	<i>Chirostoma grandocule</i>	<i>Chirostoma humboldtianum</i>	<i>Chirostoma jordani</i>	<i>Chirostoma labarcae</i>	<i>Chirostoma riojai</i>	<i>Chirostoma sp.</i>	<i>Poblana alchichicae</i>	<i>Poblana a. squamata</i>	<i>Poblana letholepis</i>	
<b>Trematoda (Adults)</b>																			
<i>Allocreadium mexicanum</i> CNHE 4296-97			x		x	x			x	x	x	x							
<b>Trematoda (larval forms)</b>																			
<i>Diplostomum</i> sp.									x			x							
<i>Centrocestus formosanus</i>	x		x										x						
<i>Clinostomum complanatum</i>												x							
<i>Ochetosoma</i> sp. CNHE 4301															●				
<i>Posthodiplostomum minimum</i> CNHE 4302-04						x			x	x	x	x	x	x		x		●	
<i>Proterodiplostomum</i> sp.											x			x					
<i>Pygidiopsis</i> sp. CNHE 4305											●								
<i>Tylodelphys</i> sp. CNHE 4298-4300						x			x		●	x					●		
<i>Uvulifer</i> sp.									●		●	x							
<b>Cestoda (Adults)</b>																			
<i>Bothriocephalus acheilognathi</i> CNHE 4306-09			x		x	x			x	x	x	x		x	x		●		
<i>Proteocephalus ambloplites</i>												x							
<b>Cestoda (larval forms)</b>																			
Cyclophyllidea gen. sp.						x													
<i>Glossocercus</i> sp.												x							
<i>Ligula intestinalis</i> CNHE 4311						x	x	x				x				x			
<i>Paradilepis caballeroi</i>												x							
<i>Paradilepis</i> cf. <i>urceus</i>												x							
<i>Paradilepis</i> sp. CNHE 4310												x							
<i>Parvitaenia cochlearii</i>			x									x							
Proteocephalidea gen. sp.						x													
<i>Valipora campylancristota</i>											x	x		x					
<i>Valipora minuta</i>												x							
<i>Valipora mutabilis</i>												x							
<b>Acanthocephala (larval forms)</b>																			
<i>Polymorphus brevis</i> CNHE 4312-16						x			x	●	x	x							
<b>Nematoda (Adults)</b>																			
<i>Atractis bravoae</i>		x																	
<i>Ornithocapillaria appendiculata</i>									x										
<i>Pseudocapillaria tomentosa</i> CNHE 4328-29						x			x		x								
<i>Rhabdochona</i> sp. (juvenile)	x																		
<i>Spinitectus osorioi</i> CNHE 4330-31						x			x	x									
<b>Nematoda (larval forms)</b>																			
<i>Contraecum</i> sp. CNHE 4321-23						x						x							
<i>Eustrongylides</i> sp. CNHE 4324-27						x			●			x				x		●	
<i>Spiroxys</i> sp.				x		x			x			x				x			

● New host record; CNHE= accession numbers of helminth species deposited in the Colección Nacional de Helmintos.



**Table 2.** Continues

Localities	Guanajuato			Michoacán										Puebla		Querétaro		Veracruz		
	Estado de México			Hidalgo	Jalisco															
	Presa Guadalupe Victoria																			
	Presa Ignacio Ramírez																			
	Presa Villa Victoria																			
	Presa Ignacio Allende																			
	Presa La Biznaga																			
	Río La Laja																			
	Laguna Metzititán																			
	Lago de Chapala																			
	Embalse Cointzio																			
	Lago de Cuitzeo																			
	Presa El Infiernillo																			
	Lago de Pátzcuaro																			
	Sahuayo																			
	Lago de Zacapu																			
	Lago de Zirahuén																			
	Río Santiago (Aguamilpa)																			
	Lago Alchichica																			
	Lago Las Minas																			
	Lago Quechulac																			
	Presa El Batán																			
	Presa Constitución de 1917																			
	Río san Pedro																			
	Río La Palma																			
<b>Acanthocephala (larval forms)</b>																				
	<i>Polymorphus brevis</i>							x	x	x										
<b>Nematoda (Adults)</b>																				
	<i>Atractis bravoae</i>								x											
	<i>Ornithocapillaria appendiculata</i>									x										
	<i>Pseudocapillaria tomentosa</i>									x	x									
	<i>Rhabdochona</i> sp. (juvenile)																			x
	<i>Spinitectus osorioi</i>									x		x								
<b>Nematoda (larval forms)</b>																				
	<i>Contraecum</i> sp.		x	x	x			x	x											
	<i>Eustrongylides</i> sp.				x			x	x			x	●							
	<i>Spiroxys</i> sp.				x			x	x			x								x

●New locality record.

Twenty four of the 32 helminth taxa (75%) were represented by larval stages inhabiting 9 different sites of the host body. Twenty of them complete their life cycle when fishes are eaten by fish-eating birds; the remaining 4 species complete their development in fishes, amphibians or reptiles (*Ochetosoma* sp., *Proterodiplostomum* sp., *Proteocephalidea* gen. sp., and *Spiroxys* sp.).

*Chirostoma jordani* possesses the highest helminth species richness (22 taxa), followed by *C. attenuatum* with 13, and *C. estor* and *C. humboldtianum* with 12, each. The composition of the helminth fauna of the other fish species ranged from 1 to 5 species. The most widely distributed helminth species among the hosts was the cestode *B. acheilognathi*, recovered from 10 atherinopsid species, as well as the digeneans *P. minimum* and *A. mexicanum* from 9 and 7 host species, respectively. On the other hand, 17

of the 32 helminth species have been recorded parasitizing only 1 host species; this group is composed basically by larval stages of cestodes and digeneans (Table 1).

Helminth faunal composition of almost all species of hosts was dominated by generalist species, which are commonly found in phylogenetically unrelated freshwater fishes and even in amphibians and reptiles. The most frequent association of generalist helminth species is constituted by the digenean *P. minimum*, the tapeworm *B. acheilognathi* and the acanthocephalan *P. brevis*, which co-exist in 5 atherinopsid species; however, most of the generalist species were recovered from only 1 species of host. Helminth species specialized on atherinopsids uncommonly co-occur in the same host species: *A. mexicanum* and *S. osorioi* were found together only in 3 fish species: *C. attenuatum*, *C. estor* and *C. grandocule*, all

of them in Lago de Pátzcuaro, while *A. bravoae* has been exclusively registered as a parasite of *Atherinella balsana* in Presa El Infiernillo.

The most widely distributed helminth species among localities was *B. acheilognathi* which was found in 12 of the 23 localities studied, followed by the metacercariae of *P. minimum* in 10 sites; 12 helminth taxa were found in only 1 locality. The highest number of helminth species was in fishes from Lago de Pátzcuaro (15 species), Río La Laja (15 species), and Lago de Zacapu (10 species), while in 8 localities, the number of helminth species was only 1 (Table 2).

In terms of the factors that determine the helminth species composition of atherinopsids in central Mexico, the feeding habits of the hosts are the most important, given that 22 of the helminth species parasitizing these fishes are acquired through prey. The species transmitted by direct penetration are exclusively larval digeneans (9 species). The life cycle of the nematode *A. bravoae* has not been studied. However, eggs of atractids hatch and larvae develop to third stage in the uteri. Thus, autoinfection seems to be the rule regarding this parasite. Their transmission from host to host is not completely understood (Anderson, 2000).

This is the second study examining species composition of the helminth fauna in specific freshwater fish families along their distributional range in central Mexico, the first one being conducted by Mejía-Madrid et al. (2005) with goodeids. The results we obtained in this study corroborate the hypothesis that the parasite fauna in freshwater fishes is largely circumscribed by higher levels of monophyletic host taxa (Pérez-Ponce de León and Choudhury, 2005). In the case of atherinopsids, the core helminth fauna is represented by the digenean *A. mexicanum*, and the nematode *S. osorioi*. There are sporadic records of *A. mexicanum* in hosts other than atherinopsids (Mejía-Madrid et al., 2005; Salgado-Maldonado, 2006) albeit with very low abundance values that indicate that its presence in these hosts does not represent an established infection. New host and locality records of this digenean have been made in the last few years, so its geographical range has been expanded and it is no longer regarded a species endemic to Lago de Pátzcuaro (Salgado-Maldonado, 2006). Instead, *S. osorioi* has only been found in atherinopsids from Lago de Pátzcuaro and Lago de Zirahuén (Garrido-Olvera et al., 2006).

### Acknowledgements

To Berenit Mendoza, Agustín Jiménez, and Jorge Falcón for their help in field work. To Fernando Bernal-Brooks

for his comments to an early version of the manuscript. This study was funded by projects CONACyT-472233 and PAPIIT-UNAM-IN220605 to GPPL.

### Literature cited

- Anderson, R. C. 2000. Nematode parasites of vertebrates. Their development and Transmission. CABI Publishing, Wallingford, Oxon. 650 p.
- Chernoff, B. 1986. Systematic of American atherinid fishes of the genus *Atherinella*. I. The subgenus *Atherinella*. Proceedings of the Academy of Natural Sciences of Philadelphia 138:86-188.
- Echelle, A. A. and A. F. Echelle. 1984. Evolutionary genetics of a "species flock": Atherinid fishes on the Mesa Central of Mexico. In The evolution of species flocks, A. A. Echelle and I. Kornfield (eds.). University of Maine at Orono Press, Orono, Maine. p. 111-127.
- Espinosa-Huerta, E., L. García-Prieto and G. Pérez-Ponce de León. 1996. Helminth community structure of *Chirostoma attenuatum* (Osteichthyes: Atherinidae) in 2 Mexican lakes. Southwestern Naturalist 41:288-292.
- Garrido-Olvera, L., L. García-Prieto and G. Pérez-Ponce de León. 2006. Checklist of the adult nematode parasites of fishes in freshwater localities from Mexico. Zootaxa 1201:1-45.
- Hoffman, G. L. 1999. Parasites of North American freshwater fishes. Cornell University Press, Ithaca. 539 p.
- Mejía-Madrid, H., O. Domínguez-Domínguez and G. Pérez-Ponce de León. 2005. Adult endohelminth parasites of Goodeinae (Cyprinodontiformes: Goodeidae) from Mexico with biogeographical considerations. Comparative Parasitology 72:200-211.
- Mendoza-Garfias, B., L. García-Prieto and G. Pérez-Ponce de León. 1996. Helminths of the "acúmara" *Algansea lacustris* en el Lago de Pátzcuaro, Michoacán, México. Anales del Instituto de Biología, Universidad Nacional Autónoma de México, Serie Zoología 67:77-88.
- Miller, R. R. and B. Chernoff. 1979. What is *Menidia*?. Annual Meeting of the American Society of Ichthyology and Herpetology 59:1-253.
- Miller, R. R., W. L. Mincley and S. M. Norris. 2005. Freshwater fishes of Mexico. University of Chicago Press, Illinois. 490 p.
- Moravec, F., G. Salgado-Maldonado and D. Osorio-Sarabia. 2000. Records of the bird capillariid nematode *Ornithocapillaria appendiculata* (Freitas, 1933) n. comb. from freshwater fishes in Mexico, with remarks on *Capillaria patzcuarensis* Osorio-Sarabia et al., 1986. Systematic Parasitology 45:53-59.
- Moravec, F., R. Aguilar-Aguilar and G. Salgado-Maldonado. 2001. Systematic status of *Capillaria patzcuarensis* Osorio-Sarabia, Pérez-Ponce de León et Salgado-Maldonado, 1986 (Nematoda: Capillariidae) from freshwater fishes in Mexico. Acta Parasitológica 46:8-11.
- Osorio-Sarabia, D., G. Pérez-Ponce de León and G. Salgado-Maldonado. 1986. Helminths of fishes of the Lago de Pátzcuaro,



- Michoacán I: Helminths of *Chirostoma estor* el “pescado blanco”. Taxonomía. Anales del Instituto de Biología, Universidad Nacional Autónoma de México, Serie Zoología 57:61-92.
- Pérez-Ponce de León, G., B. Mendoza-Garfías and G. Pulido-Flores. 1994. Helminths of the “charal prieto”, *Chirostoma attenuatum* (Osteichthyes: Atherinidae) from Patzcuaro Lake, Michoacán, Mexico. Journal of the Helminthological Society of Washington 61:139-141.
- Pérez-Ponce de León, G., L. García-Prieto, D. Osorio-Sarabia and V. León-Régagnon. 1996. Listados Faunísticos de México VI. Helminths parásitos de peces de aguas continentales de México. Instituto de Biología, Universidad Nacional Autónoma de México, México, D.F. 100 p.
- Pérez-Ponce de León, G., L. García-Prieto, V. León-Régagnon and A. Choudhury. 2000. Helminth communities of native and introduced fishes in Lake Patzcuaro, Michoacán, México. Journal of Fish Biology 57:303-325.
- Pérez-Ponce de León, G. and A. Choudhury. 2005. Biogeography of helminth parasites of freshwater fishes in Mexico: the search for patterns and processes. Journal of Biogeography 32:645-659.
- Salgado-Maldonado, G. and R. Pineda-López. 2003. The Asian fish tapeworm *Bothriocephalus acheilognathi*: a potential threat to native freshwater fish species in Mexico. Biological Invasions 5:261-268.
- Salgado-Maldonado, G. 2006. Checklist of helminth parasites of freshwater fishes from Mexico. Zootaxa 1324:1-357.