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Helminth Parasites of Freshwater Fishes of the Ayuquila River, Sierra de Manantlán Biosphere Reserve, West Central Mexico

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ABSTRACT: This study presents results from the first survey of the helminth parasites of fishes in the Ayuquila River, Sierra de Manantlán Biosphere Reserve, in the states of Jalisco and Colima, west central Mexico. Twenty-eight helminth species were collected from 14 freshwater fish species in July 2000 and February 2001. No helminth species collected is exclusive to the Ayuquila River: 11 are allogenic species, mostly Nearctic in origin, and 17 are autogenics. Three introduced species were recovered. *Saccocoelioides sogandaresi* (Trematoda) was the most prevalent and widespread helminth recovered. The fish helminth fauna of the Ayuquila River is dominated by trematode and nematode species with only a few monogenean and acanthocephalan species. The fauna exhibits considerable overlap with that reported for other freshwater basins in Mexico, and all helminths recovered have been reported previously from Mexico.

KEY WORDS: Sierra de Manantlán Biosphere Reserve, Mexico, Characidae, *Astyanax aeneus*, Goodeidae, *Allodontichthys zonistius*, *Goodea atripinnis*, *Ilyodon furcidens*, *Xenotoca melanosoma*, Poeciliidae, *Poecilia butleri*, *Poeciliopsis baenschi*, *Xiphophorus helleri*, Centrachidae, *Micropterus salmoides*, Cichlidae, *Nandopsis* (*Cichlasoma*) *istlanum*, *Oreochromis aureus*, Mugilidae, *Agonostomus monticola*, Gobiidae, *Sycidium multipunctatum*, *Scartomyzon austrinus*, Monogenea, Ancyrocephalidae, *Ancyrocephalus*, Cichlydogyridae, *Cichlidogyrus sclerosus*, Microcotylidae, Trematoda, Allocreadiidae, *Creptotrema agonostomi*, Gorgoderidae, *Dendrorchis*, Haploporidae, *Saccocoelioides sogandaresi*, Macroderidae, *Margotrema bravoae*, *Magnivitellinum simplex*, Heterophydae, *Centrocestus formosanus*, *Ascocotyle* (*Ascocotyle*) *tenuicollis*, *Ascocotyle* (*Phagicola*) *nana*, Diplostomidae, *Diplostomum*, *Posthodiplostomum minimum*, *Uvulifer*, Clinostomidae, *Clinostomum complanatum*, Cestoda, Bothriocephalidae, *Bothriocephalus acheilognathi*, Dilepididae, metacestode, Nematoda, Capillaridae, *Capillaria cyprinodonticola*, Rhabdochonidae, *Rhabdochona kidderi*, *Rhabdochona mexicana*, *Rhabdochona lichtenfelsi*, *Rhabdochona guerreroensis*, Cystidicolidae, *Spinitectus agonostomi*, Camallanidae, *Procamallanus* (*Spirocamallanus*) *jalisciencis*, Anisakidae, *Contracaecum*, Dioctophymatidae, *Eustrongylides*, Gnathostomidae, *Spiroxys*, Acanthocephala, Polymorphidae, *Polymorphus*.

The Ayuquila River (Río Ayuquila) is the northeastern boundary of the Sierra de Manantlán Biosphere Reserve (SMBR) in the state of Jalisco, in west central Mexico. The SMBR is a protected area considered to be a priority area for biodiversity conservation in North America. The Sierra de Manantlán is a northwestern portion of the Sierra Madre del Sur about 50 km inland from the Pacific Ocean. The Ayuquila River originates 100 km north of the SMBR and flows along the reserve for about 40 km before joining the Tuxcacuesco River to form the Armería River, which flows for approximately 150 km generally east–west through the states of Jalisco and Colima before reaching the Pacific Ocean (total length ~ 240 km). This watershed lies in an area of abrupt biogeographic transition between the Nearctic and Neotropical regions. The Ayuquila River fish fauna includes at least 18 species (5 of them exotic) and 18 genera in 10 families. *Poeciliopsis baenschi* (Poeciliidae) and *Allodontichthys zonistius* (Goodeidae) are endemic. In addition to native fishes, exotic species such as Asian cyprinids (carps) and African cichlids (tilapias) have been introduced (Lyons and Navarro-Pérez, 1990; Santana et al., 1993; Lyons et al., 1998; Martínez et al., 2000). This study is the first survey of helminths parasitizing the fishes of the Ayuquila River.

MATERIALS AND METHODS

As part of an ongoing parasitological investigation of the Mexican freshwater fish helminth fauna, 472 fishes representing 14 species were collected from Río Ayuquila

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Table 1. Sample sizes, sites, and collection dates for 14 fish species collected from the Sierra de Manantlán Biosphere Reserve, Jalisco, Mexico, and examined for helminths from July 2000 to February 2001.

		Sample size (*n*)		
		Río Ayuquila		Arroyo Manantlán
Host family	Host taxon	(Jul 2000)	(Feb 2001)	(Jul 2000)
Characidae	*Astyanax aeneus*	17	37	18
Goodeidae	*Allodontichthys zonistius*	5	16	
	Goodea atripinnis	1		
	Ilyodon furcidens	38	51	21
	Xenotoca melanosoma	1		
Poeciliidae	*Poecilia butleri*	30	78	
	Poeciliopsis baenschi	16		
	Xiphophorus helleri	7	7	
Centrachidae	*Micropterus salmoides*	1		
Cichlidae	*Nandopsis* (*Cichlasoma*) *istlanum*	18	9	
	Oreochromis aureus	6	7	
Mugilidae	*Agonostomus monticola*	31	17	2
Gobiidae	*Sycidium multipunctatum*	5	11	7
	Scartomyzon austrinus	2	13	

and 1 of its tributaries, Arroyo Manantlán, and examined for helminths in July 2000 and February 2001 (Table 1).

Fishes were captured using a DC Backpack Electro fishing device. Habitats across several sites in the main river or tributary were sampled until continuing efforts failed to yield new species or changes in their relative abundance. Captured fishes were taken alive to the laboratory and examined within 24 hr. All external surfaces, viscera, and musculature were examined under a stereomicroscope, and all helminths observed were counted. Digeneans (adults and metacercariae), cestodes, and nematodes were fixed in hot 4% neutral formalin. Acanthocephalans were placed in distilled water, refrigerated overnight (6–12 hr), and then fixed in hot 10% formalin. Digeneans, cestodes, and acanthocephalans were stained with Mayer paracarmine or Ehrlich hematoxylin, dehydrated using a graded alcohol series, cleared in methyl salicylate, and mounted whole. Nematodes were cleared with glycerine for light microscopy and stored in 70% ethanol. Voucher specimens of all taxa have been deposited in the National Helminth Collection (Colección Nacional de Helmintos [CNHE]), Institute of Biology, Universidad Nacional Autónoma de México, Mexico City, Mexico, as follows: *Ancyrocephalus* sp., CNHE 4793; *Ascocotyle* (*Ascocotyle*) *tenuicollis*, CNHE 4780, CNHE 4783; *Ascocotyle* (*Phagicola*) *nana*, CNHE 4781, CNHE 4782; *Bothriocephalus acheilognathi*, CNHE 4791, CNHE 4792, CNHE 4809; *Centrocestus formosanus*, CNHE 4785; *Cichlidogyrus sclerosus*, CNHE 4794; *Clinostomum complanatum*, CNHE 4806; *Contracaecum* sp., CNHE 4804; *Creptotrema agonostomi*, CNHE 4796; *Dendrorchis* sp., CNHE 4786; *Eustrongylides* sp., CNHE 4801; *Magnivitellinum simplex*, CNHE 4787; *Margotrema bravoae*, CNHE 4808; Microcotylidae gen. sp., CNHE 4795; *Posthodiplostomum minimum*, CNHE 4788, CNHE 4789; *Procamallanus* (*Spirocamallanus*) *jalisciencis*, CNHE 4798; *Rhabdochona guerreroensis*, CNHE 44494, CNHE 4495; *Rhabdochona kidderi*, CNHE 4805; *Rhabdochona mexicana*, CNHE 4799; *Saccocoelioides* cf. *sogandaresi*, CNHE 4790, CNHE 4797, CNHE 4807; *Spinitectus agonostomi*, CNHE 4800; *Spiroxys* sp., CNHE 4802, CNHE 4803. Infection parameters are consistent with those of Margolis et al. (1982).

RESULTS

Twenty-eight helminth species of 20 families were found. Table 2 summarizes parasite species collected and their host associations, prevalence, and mean intensity. No helminth was collected from a specimen of *Goodea atripinnis*, *Micropterus salmoides*, *Scartomyzon austrinus*, or *Xenotoca melanosoma*.

Twelve trematode taxa (5 adults and 7 metacercariae), 10 nematode taxa (7 adults and 3 larvae), 3 monogenean taxa, 2 cestode taxa (1 adult and 1 metacestode), and 1 acanthocephalan were collected. Adults of the trematode *Saccocoelioides sogandaresi* were the most widely distributed (8 fish species), most prevalent, and most intense taxon in the study. *Creptotrema agonostomi* (Trematoda) and *Procamallanus* (*Spirocamallanus*) *jalisciencis* Moravec (Nematoda), both parasites of *Agonostomus monticola*, were also prevalent and intense. Larvae of *Spiroxys* sp. were widely distributed across 5 host taxa. Three parasite–host associations were unique to Arroyo Manantlán (Table 2) and did not occur in Río Ayuquila.

Among host taxa, *Ilyodon furcidens* and *A. monticola* displayed the highest parasite richness (9 and 8 helminth taxan, respectively). The regional endemic species *A. zonistius* and *P. baenschi* hosted 6 and 4 helminth taxa, respectively. Communities of helminths in host populations were composed of widely distributed generalist species. *Agonostomus monticola* harbored the most distinctive community,

Table 2. Host association, prevalence (P), and mean intensity (MI) of helminth parasites collected from 14 fish species* from the Sierra de Manantlán Biosphere Reserve, Jalisco, Mexico.

Helminth	Host	*N*	P (%)	MI
Monogenea				
Ancyrocephalidae				
Ancyrocephalus sp.	*Agonostomus monticola*†	17	35	14 ± 17
Cichlydogyridae				
Cichlidogyrus sclerosus	*Oreochromis aureus*†	7	14	4
Microcotylidae				
Microcotylidae gen. sp.	*Agonostomus monticola*†	17	6	1
Trematoda				
Allocreadiidae				
Creptotrema agonostomi	*Agonostomus monticola*‡	17	77	7 ± 10
Gorgoderidae				
Dendrorchis sp.	*Ilyodon furcidens*‡	51	2	1
Haploporidae				
Saccocoelioides sogandaresi	*Allodontichthys zonistius*‡	16	56	69 ± 68
	Astyanax aeneus‡	37	8	1 ± 0.6
	Ilyodon furcidens‡	51	10	10 ± 1
	Xiphophorus helleri‡	7	14	2
	Nandopsis (*Cichlasoma*) *istlanum*‡	9	33	7 ± 7
	Oreochromis aureus‡	7	14	16
	Sycidium multipunctatum‡	11	100	43 ± 23
	Agonostomus monticola‡	17	6	11
Macroderidae				
Margotrema bravoae	*Allodontichthys zonistius*‡	16	6	3
Magnivitellinum simplex	*Astyanax aeneus*‡	37	11	2 ± 1
	Ilyodon furcidens‡	51	2	1
Heterophydae				
Centrocestus formosanus§	*Astyanax aeneus*†	37	13	3 ± 4
	Ilyodon furcidens†	51	14	7 ± 7
	Poecilia butleri†	30	13	3 ± 1
	Poeciliopsis baenschi†	16	19	4 ± 3
	Xiphophorus helleri†	7	29	11 ± 13
	Sycidium multipunctatum†	5	20	31
Ascocotyle (*Ascocotyle*) *tenuicollis*§	*Allodontichthys zonistius*‖	16	13	1
	Agonostomus monticola‖	17	24	2 ± 1
	Poecilia butleri†‖	78	13	5 ± 8
Ascocotyle (*Phagicola*) *nana*§	*Xiphophorus helleri*¶	7	57	5 ± 4
Diplostomidae				
Diplostomum sp.§	*Astyanax aeneus*#	37	11	2 ± 0.5
Posthodiplostomum minimum§	*Allodontichthys zonistius*¶	16	13	1
	Ilyodon furcidens¶	51	33	2 ± 2
	Poecilia butleri¶	78	14	1 ± 0.4
	Xiphophorus helleri¶	7	14	1
	Nandopsis (*Cichlasoma*) *istlanum*¶	18	6	1
Uvulifer sp.§	*Poecilia butleri***	78	10	2 ± 1
	*Poeciliopsis baenschi***	16	19	2 ± 1
	*Xiphophorus helleri***	7	14	3
	Nandopsis (*Cichlasoma*) *istlanum***	18	11	2 ± 1
	*Sycidium multipunctatum***††	7	29	1
Clinostomidae				
Clinostomum complanatum§	*Allodontichthys zonistius*‡‡	5	20	1
	Ilyodon furcidens‡‡	51	6	1
Cestoda				
Bothriocephalidae				
Bothriocephalus acheilognathi	*Poecilia butleri*‡	78	22	2 ± 1
	Poeciliopsis baenschi‡	16	25	1
	Nandopsis (*Cichlasoma*) *istlanum*‡	18	6	1

Table 2. Continued.

Helminth	Host	*N*	P (%)	MI
Dilepididae				
Metacestode gen. sp.§	*Astyanax aeneus*¶	37	3	1
	Allodontichthys zonistius¶	16	6	1
	Ilyodon furcidens¶	51	4	2 ± 1
Nematoda				
Capillaridae				
Capillaria cyprinodonticola	*Ilyodon furcidens*‡††	21	5	1
Rhabdochonidae				
Rhabdochona kidderi	*Nandopsis* (*Cichlasoma*) *istlanum*‡	9	22	2 ± 1
Rhabdochona mexicana	*Astyanax aeneus*‡	37	22	1 ± 0.7
Rhabdochona lichtenfelsi	*Ilyodon furcidens*‡	51	2	1
Rhabdochona guerreroensis	*Sycidium multipunctatum*‡††	7	86	6 ± 9
Cystidicolidae				
Spinitectus agonostomi	*Agonostomus monticola*‡	17	12	5 ± 1
Camallanidae				
Procamallanus (*Spirocamallanus*) *jalisciencis*	*Agonostomus monticola*‡	31	55	4 ± 4
Anisakidae				
Contracaecum sp.§	*Poeciliopsis baenschi*‡‡	16	6	1
	Nandopsis (*Cichlasoma*) *istlanum*‡‡	9	11	1
Dioctophymatidae				
Eustrongylides sp.§	*Poecilia butleri*¶‡‡	78	33	2 ± 0.7
	Xiphophorus helleri¶	7	14	1
Gnathostomidae				
Spiroxys sp.§	*Astyanax aeneus*¶	37	5	3 ± 3
	Poecilia butleri¶	78	8	2 ± 0.5
	Nandopsis (*Cichlasoma*) *istlanum*¶	18	6	1
	Oreochromis aureus¶	7	14	1
	Agonostomus monticola¶	17	6	1
Acanthocephala				
Polymorphidae				
Polymorphus sp.	*Xiphophorus helleri*‡	7	14	1

* *Astyanax aeneus*, *Allodontichthys zonistius*, *Goodea atripinnis*, *Ilyodon furcidens*, *Xenotoca melanosoma*, *Poecilia butleri*, *Poeciliopsis baenschi*, *Xiphophorus helleri*, *Micropterus salmoides*, *Nandopsis* (*Cichlasoma*) *istlanum*, *Oreochromis aureus*, *Agonostomus monticola*, *Sycidium multipunctatum*, and *Scartomyzon austrinus*.

† Helminths collected from host gills.

‡ Helminths collected from host intestine.

§ Only larval forms were recovered.

‖ Helminths collected from host heart.

¶ Helminths collected from host mesenteries.

Helminths collected from host eye.

** Helminths collected from host skin.

†† Host–parasite association observed from the Arroyo Manantlán Tributary but not the Río Ayuquila.

‡‡ Helminths collected from host body cavity.

including *C. agonostomi*, *Spinitectus agonostomi*, *P.* (*S.*) *jalisciencis*, and an undetermined species of *Ancyrocephus* (Table 2). Seventeen of the 28 species recorded are autogenic, maturing in and transported by fishes.

DISCUSSION

We examined 14 of the 18 fish species known to inhabit Río Ayuquila. Additional sampling is needed to examine the helminths of *Ictalurus dugesi* (Ictaluridae) and *Xenotoca eiseni* (Goodeidae), also known to inhabit Río Ayuquila, as well as the introduced cyprinid, *Cyprinus carpio*.

The fish helminth fauna of Río Ayuquila exhibits the same species richness hierarchy reported for other river basins in Mexico and cenotes of the Yucatan Peninsula: species richness is highest among trematodes and nematodes and lowest among monogeneans and cestodes (Salgado-Maldonado et al.,

1992; Moravec, Vivas-Rodríguez, Scholz, Vargas-Vázquez, Mendoza-Franco, and González-Solís, 1995; Moravec, Vivas-Rodríguez, Scholz, Vargas-Vázquez, Mendoza-Franco, Schmitter-Soto, and González-Solís, 1995; Scholz et al., 1995a, b, 1996; Scholz and Vargas-Vázquez, 1998; Choudhury and Dick, 2000; Salgado-Maldonado, Cabañas-Carranza, Caspeta-Mandujano, et al., 2001; Salgado-Maldonado, Cabañas-Carranza, Soto-Galera, et al., 2001). A similar hierarchy has been reported for adult endohelminths parasitizing fishes from Nicaragua (Aguirre-Macedo et al., 2001).

No helminth species limited to Río Ayuquila was collected. *Poeciliopsis baenschi* is regionally endemic, hosting generalist allogenic species and *Bothriocephalus acheilognati*. *Allodontichthys zonistius* is endemic to the basin and also hosts generalist allogenic helminth species and *Margotrema bravoae*, previously reported only from goodeids in the Lerma–Santiago basin (Lamothe-Argumedo, 1971; Pérez, 2001; Salgado-Maldonado, Cabañas-Carranza, Soto-Galera, et al., 2001). The helminth fauna of *A. monticola* is richer and more distinctive than those of other fishes in Río Ayuquila. This host is widely distributed in the Neotropics (in both the West and East coasts of Middle America), and its helminths have a wide geographic distribution. The taxonomic composition of the Río Ayuquila fish helminth fauna is not unique: no unique endemic was collected, and 46% (13 species) of all helminths collected are also reported from the Grijalva–Usumacinta (southeastern Mexico) and the Balsas (central-south Mexico) river systems (Salgado-Maldonado, Cabañas-Carranza, Caspeta-Mandujano, et al., 2001; Salgado-Maldonado et al., 2003).

Fish helminth species richness in Río Ayuquila (28 helminth taxa in 14 host taxa) is higher than that in the Balsas basin (25 helminth taxa in 13 host taxa [Salgado-Maldonado, Cabañas-Carranza, Caspeta-Mandujano, et al., 2001]) but lower than that in the Lerma–Santiago and Grijalva–Usumacinta systems (43 helminth taxa in 33 host taxa [Salgado-Maldonado, Cabañas-Carranza, Soto-Galera, et al., 2001] and 107 helminth taxa in 49 host taxa [Salgado-Maldonado et al., 2003], respectively). The Grijalva–Usumacinta is the largest, oldest, and most diverse of these river basins, suggesting that basin size, host species richness, and geological age are important determinants of helminth species richness.

A characteristic Neotropical component exists in the Río Ayuquila fish helminth fauna and includes *C. agonostomi, Dendrorchis* sp., *Magnivitellinum simplex*, *Rhabdochona mexicana*, *Rhabdochona guerreroensis*, *S. agonostomi*, and *P.* (*S.*) *jalisciencis*. Two species typical of the Mexican Neotropical–Neartic transition zone, *M. bravoae* and *Rhabdochona lichtenfelsi*, previously recorded only from the Mexican Highland Plateau (Salgado-Maldonado, Cabañas-Carranza, Soto-Galera, et al., 2001), are also present in Río Ayuquila. *Posthodiplostomum minimum*, *Clinostomum complanatum*, *Rhabdochona kidderi*, and *Capillaria cyprodonticola* represent species widely distributed throughout the Nearctic. *Cychlidogyrus sclerosus*, *Centrocestus formosanus*, and *B. acheilognathi* are human introductions (Scholz and Salgado-Maldonado, 2000; Salgado-Maldonado and Pineda-López, 2003). This is the first record of *C. sclerosus* in Mexico. The Río Ayuquila fish helminth community is an assemblage including both Neotropical and Nearctic components and is typical of Mexican parasite communities (Darlington, 1957; Rammamoorthy et al., 1995). Most of the helminths observed are autogenic, but the community includes a number of widely distributed, allogenic generalists.

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LITERATURE CITED

Aguirre-Macedo, M. L., T. Scholz, D. Gonzalez-Solís, V. M. Vidal-Martínez, P. Posel, G. Arjona-Torres, S. Dumailo, and E. Siu-Estrada. 2001. Some adult endohelminths parasitizing freshwater fishes from the Atlantic drainages of Nicaragua. Comparative Parasitology 68:190–195.

Choudhury, A., and T. A. Dick. 2000. Richness and diversity of helminth communities in tropical freshwater

fishes: empirical evidence. Journal of Biogeography 27:935–956.

Darlington, P. J. 1957. Zoogeography. Wiley, New York. 675 pp.

Lamothe-Argumedo, R. 1971. Tremátodos de peces VI. *Margotrema bravoae* gen. nov. sp. nov. (Trematoda: Allocreadidae), parásito de *Lermichthys multiradiatus* Meek. Anales del Instituto de Biología, Universidad Nacional Autónoma de México, Serie Zoología 41:87–92.

Lyons, J., G. González-Hernández, E. Soto-Galera, and M. Guzmán-Arroyo. 1998. Decline of freshwater fishes and fisheries in selected drainages of west central Mexico. Fisheries 23:10–18.

Lyons, J., and S. Navarro-Pérez. 1990. Fishes of the Sierra de Manatlán, west central Mexico. The Southwestern Naturalist 35:32–46.

Margolis, L., G. W. Esch, J. C. Holmes, A. M. Kuris, and G. A. Schad. 1982. The use of ecological terms in parasitology (report of an *ad hoc* committee of the American Society of Parasitologists). Journal of Parasitology 68:131–133.

Martínez, R. L. M., A. Carranza, and M. García. 2000. Aquatic ecosystem pollution of the Ayuquila River, Sierra de Manantlán Biosphere Reserve, Mexico. Pages 165–181 *in* M. Munawar, S. G. Lawrence, I. F. Munawar, and D. F. Malley, eds. Aquatic Ecosystems of Mexico: Status and Scope. Backhuys Publishers, Leiden, The Netherlands.

Moravec, F., C. Vivas-Rodríguez, T. Scholz, J. Vargas-Vázquez, E. Mendoza-Franco, and D. González-Solís. 1995. Nematodes parasitic in fishes of cenotes (= sinkholes) of the Peninsula of Yucatan, Mexico. Part 1. Adults. Folia Parasitologica 42:115–129.

Moravec, F., C. Vivas-Rodríguez, T. Scholz, J. Vargas-Vázquez, E. Mendoza-Franco, J. J. Schmitter-Soto, and D. González-Solís. 1995. Nematodes parasitic in fishes of cenotes (= sinkholes) of the Peninsula of Yucatan, Mexico. Part 2. Larvae. Folia Parasitologica 42:199–210.

Pérez, P. G. 2001. *Margotrema guillerminae* n. sp. (Trematoda: Macroderoididae) from two species of freshwater fishes in lake Zacapu, Michoacan state, Mexico, and new records of *Margotrema bravoae* Lamothe, 1970. Journal of Parasitology 87:1112–1114.

Rammamoorthy, T. P., R. Bye, A. Lot, and J. Fa. 1998. Diversidad biológica de México. Orígenes y distribución. Instituto de Biología, Universidad Nacional Autónoma de México, México D. F., Mexico. 792 pp.

Salgado-Maldonado, G., G. Cabañas-Carranza, J. M. Caspeta-Mandujano, E. Soto-Galera, E. Mayén-Peña, D. Brailovsky, and R. Báez-Valé. 2001. Helminth parasites of freshwater fishes of the Balsas River drainage basin of southwestern Mexico. Comparative Parasitology 68:196–203.

Salgado-Maldonado, G., G. Cabañas-Carranza, E. Soto-Galera, J. M. Caspeta-Mandujano, R. G. Moreno-Navarrete, P. Sánchez-Nava, and R. Aguilar-Aguilar. 2001. A checklist of helminth parasites of freshwater fishes from the Lerma-Santiago River basin, Mexico. Comparative Parasitology 68:204–218.

Salgado-Maldonado, G., M. I. Jiménez-García, and V. León-Régagnon. 1992. Presence of *Octospiniferoides chandleri* Bullock, 1957 in *Heterandria bimaculata* from Catemaco, Veracruz and considerations about the acanthocephalans of freshwater fishes of Mexico. Memorias do Instituto Oswaldo Cruz 87:239–240.

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.

Santana, C. E., S. Navarro, L. M. Martínez, A. Aguirre, P. Figueroa, and C. C. Aguilar. 1993. Contaminación, aprovechamiento y conservación de los recursos acuáticos del Río Ayuquila, Reserva de la Biósfera Sierra de Manantlán, Jalisco-Colima. Tiempos de Ciencia 30:29–38.

Scholz, T., and G. Salgado-Maldonado. 2000. The introduction and dispersal of *Centrocestus formosanus* (Nishigori, 1924) (Digenea: Heterophyidae) in Mexico: a review. American Midland Naturalist 143:185–200.

Scholz, T., and J. Vargas-Vázquez. 1998. Trematodes from fishes of the Río Hondo river and freshwater lakes of Quintana Roo, Mexico. Journal of the Helminthological Society of Washington 65:91–95.

Scholz, T., J. Vargas-Vázquez, F. Moravec, C. Vivas-Rodríguez, and E. Mendoza-Franco. 1995a. Cenotes (= sinkholes) of the Yucatan Peninsula, Mexico as a habitat of adult trematodes of fish. Folia Parasitologica 42:37–47.

Scholz, T., J. Vargas-Vázquez, F. Moravec, C. Vivas-Rodríguez, and E. Mendoza-Franco. 1995b. Metacercariae of trematodes of fishes from cenotes (= sinkholes) of the Yucatan Peninsula, Mexico. Folia Parasitologica 42:173–192.

Scholz, T., J. Vargas-Vázquez, F. Moravec, C. Vivas-Rodríguez, and E. Mendoza-Franco. 1996. Cestoda and acanthocephala of fishes from cenotes (= sinkholes) of Yucatan, Mexico. Folia Parasitologica 43:141–152.