Parasitol Res (2005) 96: 69–89
DOI 10.1007/s00436-005-1315-9

ORIGINAL PAPER

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Helminth parasites in freshwater fish from the Papaloapan river basin, Mexico

Received: 8 October 2004 / Accepted: 26 January 2005 / Published online: 6 April 2005

Abstract A checklist based on previously published records and original data is presented for the helminth parasites reported in 35 fish species from nine families from the Río Papaloapan basin, east Mexico. The checklist contains 85 taxa from 39 helminth families. Trematodes and nematodes were the most abundant taxonomic groups. The helminth fauna in the fish of the Papaloapan River basin predominantly consists of Neotropical species that are largely autogenic. The introduced species *Centrocestus formosanus* was the most widely distributed helminth, infecting 16 host species. Ten of the recorded helminth species have only been found in fish from the Papaloapan. This inventory contributes 157 new host records, and reports the presence of 30 helminth species in the Papaloapan for the first time . This inventory shows the richness of helminth parasite species in the fish of the Papaloapan River basin in comparison with the other hydrological basins in Mexico. It also demonstrates that this fauna is typically Neotropical and quite similar to that from the neighboring basins of the Grijalva–Usumacinta system and the Yucatan Peninsula. The data also suggest highly effective transmission between environments within the same basin and that the regional parasite fauna is strongly influenced by fish community composition.

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Introduction

Recent research on the helminth parasites of freshwater fish in Mexico's hydrological basins has increased knowledge of the helminth fauna in these areas. To date, helminth parasite inventories have been published for the freshwater bodies of the Yucatán Península (Moravec et al. 1995a, b; Scholz et al. 1995a, b, 1996b; Salgado-Maldonado et al. 1997; Mendoza-Franco et al. 1999; Kritsky et al. 2000), the Balsas (Salgado-Maldonado et al. 2001a), Lerma and Santiago (Salgado-Maldonado et al. 2001b) and Pánuco river basins (Salgado-Maldonado et al. 2004a), the Ayuquila River in the Sierra de Manantlán, Jalisco (Salgado-Maldonado et al. 2004b), water bodies in the Sierra Madre Oriental (Aguilar-Aguilar et al. 2004), and the lowlands in the state of Tabasco drained by the Grijalva–Usumacinta system (Salgado-Maldonado et al. 2005). Helminth inventories have also been published for some fish families, particularly for the cichlids (Salgado-Maldonado et al. 1997; Vidal-Martínez et al. 2001a), poecilids and goodeids (Pineda-López et al. 2005). Information on the nematodes of freshwater fish in the Neotropics has been addressed by Moravec (1998). Two zoogeographic treatments aid in systematizing the knowledge generated on the distribution, richness and endemic areas of helminths in freshwater fish in Mexico (Vidal-Martínez and Kennedy 2000; Aguilar-Aguilar et al. 2003b). Notwithstanding, the helminth fauna data for fish from the Papaloapan River, one of the largest and most important watercourses in Mexico, are still scattered, mostly in taxonomic publications.

The Papaloapan River basin is the second largest hydrological basin in Mexico and is considered the northern limit of the Neotropical Region. It includes a 46,517 km^2 area in the states of Veracruz, Oaxaca and Puebla (17°N–19°N; 95°W–97°40′W) (Revel-Mouroz 1980). The rivers feeding the Papaloapan generally flow to the east. These tributaries include the Río Cajones,

Río de la Lana, Río Grande–Santo Domingo, Río San Juan, Río Tesechoacán, Río Tonto, Río Valle Nacional and Río Jaltepec. The Papaloapan flows into the Gulf of Mexico at the Laguna de Alvarado in the state of Veracruz. The Papaloapan basin can be divided into two sections: the Upper Papaloapan, which includes waters above 1,000 m asl, and the Lower Papaloapan. Los Tuxtlas area in Veracruz, forms part of the Lower Papaloapan, even though it does have areas higher than 1,000 m asl.

A total of 44 fish species are known in the lotic and lentic waters of the Papaloapan River basin of which ten are endemic to it (Sevilla 1977; Miller 1986; Miller and Smith 1986; Espinosa-Pérez et al. 1998). It is an ichthyologic fauna characteristic of lowland tropical Mexico, and towards the east, it mixes with the ichthyologic fauna of the Usumacinta River.

Studies of the parasites of the fish in the Papaloapan basin began in 1954 and are largely taxonomic treatments concentrating mostly on fish in the Los Tuxtlas area and particularly Catemaco Lake, Veracruz (Caballero and Winter 1954; Lamothe-Argumedo 1974, 1977; Lamothe-Argumedo and Ponciano-Rodríguez 1986; Caballero-Deloya 1977; Salgado-Maldonado 1978; Salgado-Maldonado et al. 1992, 1998; García-Prieto 1990; García-Prieto et al. 1996; Pérez et al. 1992; Jiménez-García 1993; Moravec 1998; Moravec et al. 1998, 2000, 2002a, b; Caspeta-Mandujano et al. 1999, 2000a, b; Scholz and Salgado-Maldonado 2000, 2001; Scholz et al. 2001b; Páez-Rodríguez et al. 2002; Aguilar-Aguilar et al. 2003a; Mendoza-Franco et al. 2003b). More recent studies addressing the role of freshwater fishes as transmitters of the human gnathostomiasis have been done in the Temascal Reservoir, Oaxaca (Almeyda-Artigas 1991; Almeyda-Artigas et al. 1995; Lamothe-Argumedo 1977; Lamothe-Argumedo et al. 1989). No other water bodies in this basin have been studied. In response, the present study brings together previously published information and provides new data derived from our own research to update the knowledge of the helminth parasites of the fish of the Papaloapan River basin.

Materials and methods

A review of the literature dealing with freshwater fish helminth parasites in the Papaloapan River basin was made. In addition, a total of 1,088 fish was collected from 25 sites (Table 1, Fig. 1) in the Papaloapan River basin between March 1999 and July 2002. The following fish species were examined (family and sample size, *n*, follow each taxon parenthetically, taxa marked * are endemic to the Río Papaloapan basin as stated by Miller 1986; Miller and Smith 1986; Espinosa-Pérez et al. 1993): *Agonostomus monticola* (Mugilidae, 17); *Astyanax aeneus* (Characidae, 125); **Bramocharax caballeroi* (Characidae, 10); **Atherinella ammophila* (Atherinidae, 9); **Cichlasoma ellioti* (Cichlidae, 2); **C. fenestratum* (Cichlidae, 67); *C. octofasciatum* (Cichlidae, 4), *C. robertsoni* (Cichlidae, 3); *C. urophthalmus* (Cichlidae, 10); *Cichlasoma* sp. (Cichlidae, 27); *Oreochromis* sp. (Cichlidae, 3); *Petenia splendida* (Cichlidae, 1); *Eleotris* sp. (Eleotridae, 6); *Dormitator maculatus* (Eleotridae, 47); *Gobiomorus dormitor* (Eleotrididae, 50); *Dorosoma anale* (Clupeidae, 2), *D. petenense* (Clupeidae, 16); *Heterandria bimaculata* (Poeciliidae, 70); **Poecilia catemaconis* (Poeciliidae, 25); *P. mexicana* (Poeciliidae, 319); *P. reticulata* (Poeciliidae, 34); **Poeciliopsis catemaco* (Poeciliidae, 24); *Poeciliopsis gracilis* (Poeciliidae, 35); *Poeciliopsis* sp. (Poeciliidae, 13); *Xiphophorus helleri* (Poeciliidae, 68); *Ophisternon aenigmaticum* (Synbranchidae, 42); *Rhamdia guatemalensis* (Pimelodidae, 48); *Sycidium gymnogaster* (Gobiidae, 11). Fish sample size per site are given in Table 2. We sampled localities in the Upper Papaloapan; including irrigation channels, streams and secondary rivers, and localities in the main Río Grande and Río Valle Nacional. Sampling localities of the Lower Papaloapan include streams and large rivers' tributaries to the main Papaloapan course. The principal trend of the Río Papaloapan was sampled near the Tlacotalpan village. Several streams and lakes at Los Tuxtlas region were also sampled (Table 1, Fig. 1).

Fish at each site were captured using a DC Backpack Electrofishing device, using gill nets, or by angling. Captured fish were taken alive to the laboratory and were examined within 24 h using standard procedures. A complete examination for helminth parasites was done of each specimen. External surfaces including scales, skin, and fins were examined for ectoparasites using a stereomicroscope. Gills arches were examined individually. Examination for monogeneans was done immediately after the fish were taken out of water. The buccal cavity, opercula, and eyes were examined separately. The external surfaces of the internal organs (heart, liver, spleen, gall bladder, digestive tract, gonads, swim bladder and kidney, as well as the entire body cavity and mesentery) were inspected for free or encapsulated parasites, and then separated and examined individually. The intestine was opened longitudinally. The liver, spleen, kidney, and heart were compressed between glass plates and were examined for parasites. The body musculature was removed from the vertebral column, the skin removed from the fillets, and the fillets compressed between glass plates and inspected for helminths using a stereomicroscope. All collected helminths were sorted by taxon, cleaned and counted by organ. Trematodes (adult and metacercariae), monogeneans, cestodes (adults and metacestodes), and nematodes were fixed in hot 4% formalin. Acanthocephalans were placed in distilled water, refrigerated overnight (6–12 h) to evert the proboscis, and then fixed in hot 4% formalin. Trematodes, monogeneans, cestodes, and acanthocephalans were stained with Mayer's paracarmine or Ehrlich's haematoxylin, dehydrated using a graded alcohol series, cleared in methyl salicylate, and mounted whole. To study sclerotized parts, several specimens of each species of monogenean were fixed following Malmberg's semipermanent mount method (see Ergens 1969; Vidal-Martínez

Table 1 Codes and features of the localities sampled or reported in the literature from which hosts were collected (codes identify fish collections sites in Fig. 1)

Code (Fig. 1)	Locality name (habitat type)	State (coordinates)
	Upper Papaloapan	
(1)	Ajalpan (irrigation channel)	Puebla (18°24′22″N, 97°16′21″W)
(2)	Calipán (irrigation channel)	Puebla (18°17′31″N, 97°09′45″W)
(3)	Santa María Tecomavaca (stream)	Oaxaca (17°56′47″N, 97°01′42″W)
(4)	Santiago Dominguillo (stream)	Oaxaca (17°41′16″N, 96°56′02″W)
(5)	Río Grande at Guelatao	Oaxaca (17°18′26″N, 96°30′38″W)
(6)	Río Grande at San José del Chilar	Oaxaca (17°46′06″N, 96°57′16″W)
(7)	Puente Valle Nacional	Oaxaca (17°46′15″N, 96°18′33″W)
(8)	San Juan Valle Nacional	Oaxaca (17°46′15″N, 96°18′33″W)
	Lower Papaloapan	
	Arroyo San Juan Evangelista (stream)	Oaxaca (not positioned)
	Arroyo Agrio (stream)	Oaxaca (not positioned)
(9)	Arroyo San Juan Bautista (stream)	Oaxaca (17°43′13″N, 96°18′46″W)
(10)	Presa Temascal (reservoir)	Oaxaca (21°18′N, 96°04′W)
(11)	Mouth of the Río Papaloapan at lagoon Alvarado	Veracruz (18°45′N, 95°49′W)
(12)	Tlacotalpan village	Veracruz (18°36′N, 95°39′W)
(13)	Río Tesechoacán	Veracruz (18°36′N, 95°39′W)
(14)	Río San Juan	Veracruz (18°36′N, 95°39′W)
(15)	El Saltillo – Taller (stream)	Oaxaca (18°33′55″N, 95°25′44″W)
(16)	Cascada El Saltillo (water fall)	Oaxaca (18°31′N, 95°25′W)
	Río Frío	Veracruz (not positioned)
	Los Tuxtlas region	
(17)	Arroyo Balzapote	Veracruz (18°40′N, 95°10′W)
(18)	Río La Palma	Veracruz (18°33′21″N, 95°02′59″W)
(19)	Río Máquinas	Veracruz (18°36′41″N, 95°06′27″W)
(20)	Arroyo La Basura	Veracruz (18°31′27″N, 95°02′54″W)
(21)	Lake La Escondida	Veracruz (18°38′09″N, 95°07′28″W)
(22)	Río San Joaquín (river)	Veracruz (18°26′27″N, 95°09′44″W)
(23)	Lake Catemaco	Veracruz (18°25′N, 95°07′W)

et al. 2001a). Nematodes were cleared with glycerin for light microscopy and were 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, National Autonomous University of Mexico (UNAM), Mexico City. Infection parameters that have been utilized are those proposed by Bush et al. (1997), that is, prevalence (% infected) and mean intensity of infection (number of parasites per infected fish).

Results

A total of 85 taxa from 39 helminth families in 35 fish species from nine families was recorded. Table 2 presents the helminths, their hosts and collection locations as well as prevalence and mean intensity data for each helminth species. This inventory contributes 157 new host records and reports the presence of 30 helminth species in the Papaloapan for the first time .

In terms of the number of taxa recovered from the examined fish, trematodes were the most abundant group with 24 metacercariae and 9 adult species. The species *Stunkardiella minima* and *Oligogonotylus manteri* were recorded as both metacercariae and as adults (Table 2). Nematodes were also numerous and included 17 adults and 8 larvae. Monogenean fauna was well represented with data for 13 taxa. Cestodes and acanthocephalans had eight nominal taxa each, making them the least numerous of the recorded helminths.

Of the 85 recorded species, 58 (68%) are Neotropical, only three could be distinguished as Nearctic, four have broad geographic distribution and one is an introduced species. There was insufficient information to place the remaining taxa into one of these categories. A total of 28 (33%) of the 85 species are allogenic, which implies that they mature in birds and are dispersed by these definitive hosts; 57 (67%) are autogenic, which implies that they mature in fish and its entire life cycle is completed within an aquatic ecosystem (Esch et al. 1988) (Table 2).

The introduced species *Centrocestus formosanus* was the most widely distributed helminth among the examined hosts; metacercariae of this species were found infecting 16 host species. The other frequent helminth species were the metacercariae of *Uvulifer ambloplitis*, found infecting 13 fish species; metacercariae of *Ascocotyle* (*Ascocotyle*) *tenuicollis*, recovered from 12 host species; metacercariae of *Clinostomum complanatum* found in nine host species; and adults of the trematode *Crassicutis cichlasomae*, also found in nine host species. Larvae of the nematode *Spiroxys* sp. were recovered from 14 fish species and those of *Contracaecum* sp. were found in 13 fish species (Table 2).

In some cases very few hosts were examined; however, the data still support the conclusion that the parasite transmission dynamic in this basin is generally

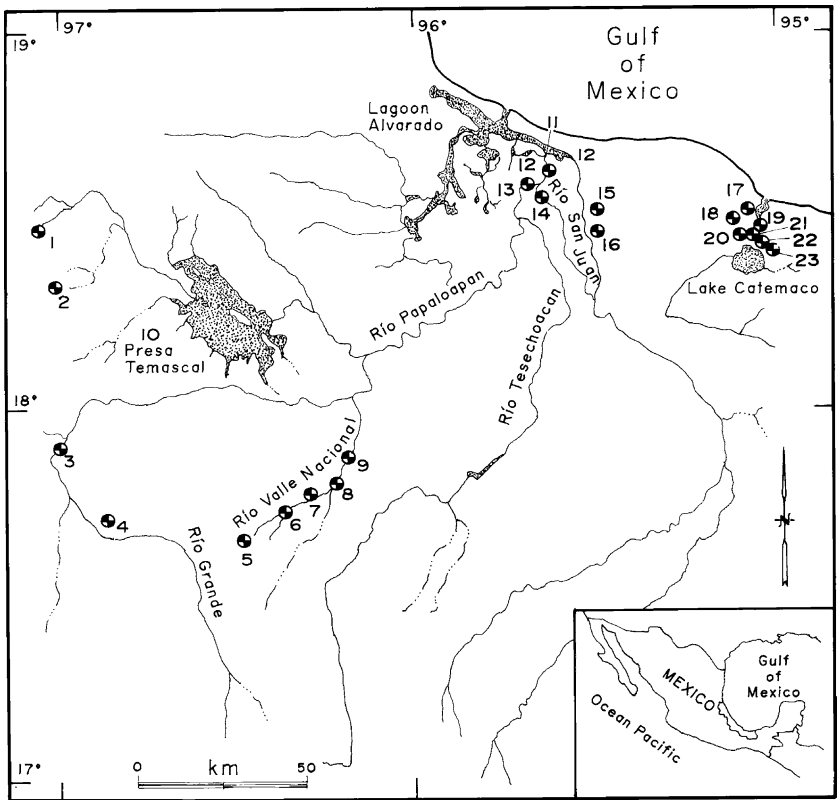

Fig. 1 The Río Papaloapan drainage basin of east Mexico, showing the fish collection sites (codes in Table 1)

intense and effective. This is shown by the high prevalence values for the different (adult and metacercariae) trematode species. For example, the prevalence of adult *Stunkardiella minima* in *Rhamdia guatemalensis* remained above 20%, and that of its metacercariae in different host species is even higher. Another instance is the prevalence of *Creptotrema agonostomi* in *Agonostomus monticola*, which was above 30%. The prevalence of the monogenean species also shows their high frequency in the Papaloapan basin. Though the metacestodes are less frequent, both *Monticellia ophisterni* and *Proteocephalus brooksi* had high prevalences (Table 2). Generally, the nematodes and acanthocephalans had more variable prevalences, though the capillariids and cystidicolids, as well as *Rhabdochona kidderi* and *Neoechinorhynchus golvani*, are very frequent in the fish of this basin.

The host species with the highest number of associated helminths was *Rhamdia guatemalensis* with 25 helminth taxa. It is followed by *Dormitator maculatus* with 22 taxa and *Cichlasoma fenestratum*, *Gobiomorus dormitor* and *Poecilia mexicana*, all with 21 taxa. The helminth communities in the remaining host species had lower richness. Of all the examined fish species, only the gobiid *Sycidium gymnogaster* ($n = 11$) was parasite-free. Species richness per fish in the Upper Papaloapan (locations above 1,000 m) was lower than in the Lower Papaloapan. To date, only ten nominal helminth species in this inventory have been recorded in the fish of the Papaloapan basin: *Saccocoelioides chauhani* and *Anacanthocotyle anacanthocotyle* in *Astyanax fasciatus*; *Caballerorhynchus lamothei* in *Ictalurus meridionalis*; *Spinitectus mexicanus* in *Heterandria bimaculata*; *Cucullanus mexicanus* and *Proteoecephalus brooksi* in *Rhamdia guatemalensis*; and *Monticellia ophisterni*, *Pseudocapillaria* (*Ichthyocapillaria*) *ophisterni*, *Philometra ophisterni*, and *Gibsonnema ophisterni* all in *Ophisternon aenigmaticum*.

Discussion

Data for 35 fish species are included in this inventory, including four species of tilapia (*Oreochromis* spp.) and *Petenia splendida*, which are introduced into the Papaloapan River basin. A total of 31 of the 44 fish species recorded in the Papaloapan were examined, including 7 of its 15 endemic species. It is likely that the number of parasites reported in *Atherinella ammophila*, *Cichlasoma ellioti*, *C. octofasciatum*, *Petenia splendida*, *Eleotris* sp., and *Sycidium gymnogaster* is higher than that reported here, as very few individuals were examined for these host species. Host species from the main fish families in the Papaloapan were examined with the exception of Lepisosteidae, Cyprinidae, Catostomidae and Cyprinodontidae. The endemic species not examined in this study are *Atractosteus spatula*, *Hybopsis moralesi*, *Rivulus robustus*, *R. tenuis*, *Heterandria jonesi*, *Atherinella marvelae*, *A. sallei*, *Priapella bonita*, and *Rhamdia reddelli*. Ten of the 36 examined fish species had not been previously studied for parasites.

Table 2 Host association, number of hosts examined (*N*), prevalence (*P*), and mean intensity (MI) of helminth parasites collected from 35 fish species from Rio Papaloapan basin, Mexico. [a] New host record; [b]New locality record (recorded first time in the Río Papaloapan basin). (Infection sites: *Bc* Body cavity; *Br* Brain; *Ey* eyes; *Fa* Fat; *Fi* Fins; *Ga* inside gill archs; *Gb* Gall bladder; *Gc* Gill cavity; *Gi* Gills; *Go* Gonads; *He* Heart; *In* Intestine (lumen); *Iw* Intestinal wall (serosa); *Ki* Kidney; *Li* Liver; *Me* Mesentery; *Mo* Mouth; *Mu* Muscles; *Sc* Scales of lateral line; *Sk* Skin; *Sp* Spleen; *St* Stomach; *Sw* Stomach wall; *Ub* Urinary bladder). Status: *Na* Nearctic; *Ne* Neotropical; *Al* Allogenic; *Au* Autogenic; *In* Introduced; *WW* world wide distributed

Helminth [Status]	Host	Infection sites	Locality	*N*	*P*(%)/MI	Reference
Adult Trematoda						
Acanthostomidae						
Stunkardiella minima	*Rhamdia guatemalensis*	In	Lago de Catemaco	1	100/9	Lamothe-Argumedo and Ponciano-Rodríguez 1986
(Stunkard 1938)		In	Lago de Catemaco	51	21.5/23.3	Pérez et al. 1992
[Ne, Au]		In	Lago de Catemaco	4	25/8	Present work
		In	San Juan Valle Nacional	3	100/1.3	Present work
		In	Puente Valle Nacional	11	27.3/8.7	Present work
		In	Tlacotalpan	8	25/3	Present work
		In	Río San Juan, Tlacotalpan	5	40/11	Present work
Allocreadiidae						
Creptotrema agonostomi	*Agonostomus monticola*	In	Río La Palma	9	77.8/48	Salgado-Maldonado et al. 1998
Salgado-Maldonado, Cabañas-Carranza and Caspeta-Mandujano 1998		In	Río La Palma	3	33.3/12	Present work
[Ne, Au]		In	Arroyo Balzapote	7	71.4/36.6	Present work
		In	Río Máquinas	15	33.3/1.8	Salgado-Maldonado et al. 1998
Apocreadiidae						
Crassicutis cichlasomae	*Cichlasoma ellioti*[a]	In	Arroyo San Juan Evangelista	2	50/2	Present work
Manter 1936	*Cichlasoma fenestratum*	In	Lago de Catemaco	30	50/11.06	Jiménez-García 1993
[Ne, Au]		In	Lago de Catemaco	18	55.6/26.6	Present work
		In	Río Máquinas	14	78.6/7.9	Present work
		In	Arroyo Balzapote	3	100/19	Present work
		In	Lago La Escondida	12	66.7/4.9	Present work
		In	Río La Palma	2	50/11	Present work
	Cichlasoma octofasciatum[a]	In	Tlacotalpan	1	100/5	Present work
		In	Arroyo San Juan Evangelista	3	100/2	Present work
	Cichlasoma robertsoni[a]	In	Arroyo San Juan Evangelista	3	33.3/2	Present work
	Cichlasoma urophthalmus	In	Tlacotalpan	10	20/6	Present work
	Cichlasoma sp.	In	San Juan Valle Nacional	8	12.5/1	Present work
	Dorosoma petenense[a]	In	Lago de Catemaco	1	100/121	Present work
	Oreochromis sp.	In	Lago de Catemaco	1	50/17	Present work
Cryptogonimidae						
Oligogonotylus manteri	*Cichlasoma octofasciatum*[a]	In	Tlacotalpan	1	100/1	Present work
Watson 1976	*Cichlasoma urophthalmus*	In	Tlacotalpan	10	70/5.3	Present work
[Ne, Au]						
Derogenidae						
Genarchella isabellae	*Rhamdia guatemalensis*	In	Lago de Catemaco	ND	ND	Lamothe-Argumedo 1977
(Lamothe-Argumedo 1977)	*Cichlasoma fenestratum*	St	Lago de Catemaco	30	23/2	Jiménez-García 1993
[Ne, Au]		In		18	11.1/2	Present work
		In	Río La Palma	2	100/6.5	Present work
	Gobiomorus dormitor[a]	In	Tlacotalpan	24	4.2/2	Present work
	Ophisternon aenigmaticum[a]	In	Río Tesechoacán	10	40/2.2	Present work

Table 2 (Contd.)

Helminth [Status]	Host	Infection sites	Locality	*N*	*P*(%)/MI	Reference
Haploporidae						
Saccocoelioides chauhani Lamothe-Argumedo 1974 [Ne, Au]	*Astyanax fasciatus*	In	Lago de Catemaco	ND	ND	Lamothe-Argumedo 1974
Saccocoelioides cf. *sogandaresi*[b] Lumsden 1961 [Ne, Au]	*Astyanax aeneus*[a]	In	Puente Valle Nacional	18	11.1/1	Present work
		In	Río Máquinas	14	7/1	Present work
	Dormitator maculatus[a]	In	Tlacotalpan	36	58.3/8.4	Present work
	Gobiomorus dormitor[a]	In	Tlacotalpan	24	16.7/5.2	Present work
	Poecilia mexicana	In	Lago La Escondida	7	14.3/2	Present work
		In	Cascada El Saltillo	7	42.9/1.7	Present work
		In	El Saltillo - Taller	1	100/2	Present work
		In	Arroyo San Juan Evangelista	7	71.4/4.2	Present work
		In	Arroyo Balzapote	6	100/6	Present work
		In		27	70.3/11.9	Present work
		In	Río La Palma	25	32/1.9	Present work
		In	Río Máquinas	8	50/2.7	Present work
	Poeciliopsis catemaco[a]	In	Lago de Catemaco	24	25/4	Present work
	Xiphophorus helleri[a]	In	Lago La Escondida	7	14.3/3	Present work
		In	Río La Palma	13	38.5/4.2	Present work
		In	Río Máquinas	25	16/1	Present work
		In	Arroyo Balzapote	8	75/6	Present work
Gorgoderidae						
Dendrorchis sp.[b] [Ne, Au]	*Dorosoma petenense*[a]		Río Máquinas	6	33.3/1	Present work
	Eleotris sp.[a]	In	Río Máquinas	6	33.3/1	Present work
	Gobiomorus dormitor[a]	Ub	Arroyo Balzapote	3	33.3/2	Present work
Macroderoididae						
Magnivitellinum simplex[b] Kloss 1966 [Ne, Au]	*Astyanax aeneus*[a]	In	Río La Palma	3	33.3/1	Present work
		In	Río Máquinas	6	16.7/1	Present work
		In	Río Máquinas	5	20/1	Present work
		In	Lago La Escondida	5	20/1	Present work
Larval Trematoda						
Acanthostomidae						
Stunkardiella minima (Stunkard 1938) [Ne, Au]	*Cichlasoma urophthalmus*	Fi	Río Tesechoacán	10	40/8.25	Present work
	Gobiomorus dormitor[a]	Fi	Río Tesechoacán	3	33.3/4	Present work
	Poeciliopsis catemaco[a]	Fi	Lago de Catemaco	24	79.2/7.7	Present work
	Poecilia catemaconis[a]	Fi	Lago de Catemaco	25	64/8.2	Present work
Bucephalidae						
Rhipidocotyle sp.[b] [?, Au]	*Astyanax aeneus*[a]	Fi	Río Máquinas	14	7/3	Present work
	Cichlasoma fenestratum[a]	Fi, Li	Río Máquinas	5	60/1.7	Present work
	Xiphophorus helleri[a]	Fi	Río Máquinas	25	24/7.7	Present work
Clinostomidae						
Clinostomum complanatum (Rudolphi 1814) [WW, Al]	*Bramocharax caballeroi*[a]		Lago de Catemaco	10	10/1	Present work
	Cichlasoma fenestratum		Lago de Catemaco	30	3/1	Jiménez-García 1993
	Cichlasoma gadovii[a]	Fi	Río La Palma	2	50/1	Present work
	Cichlasoma urophthalmus	Bc, Me	Tlacotalpan	10	20/2	Present work
	Dormitator maculatus	Bc	Tlacotalpan	ND	ND	Páez-Rodríguez et al. 2002
		Mo	Mouth of Río Papaloapan	184	82.3/49.7	Montoya-Mendoza et al. 2004
		Bc, Gi, Li, Me, Mu	Tlacotalpan	36	86.1/39.6	Present work

	Gobiomorus dormitor[a]	He, In, Li, Me, St	Tlacotalpan	24	20.8/8	Present work
	Poecilia mexicana[a]	Ey, Bc	Lago La Escondida	7	57.1/5.7	Present work
		Ey	Río La Palma	25	4/1	Present work
	Rhamdia guatemalensis	Gc, Gi, Mu	Lago de Catemaco	51	27.4/24.3	Pérez et al. 1992
		Fi	Lago de Catemaco	4	25/1	Present work
		Fi, Gi, Me, Mo, Mu	Puente Valle Nacional	11	27.3/11	Present work
		Bc, Ey, Gi, Mu	Arroyo San Juan Bautista	6	16.7/25	Present work
		Bc, Me	Tlacotalpan	8	50/6.5	Present work
		Bc	Arroyo San Juan Evangelista	9	11.1/1	Present work
	Xiphophorus helleri[a]	Bc	Arroyo Balzapote	8	12.5/1	Present work
Cryptogonimidae						
Oligogonotylus manteri Watson 1976 [Ne, Au]	*Cichlasoma fenestratum*	In	Lago de Catemaco	ND	ND	Jiménez-García 1993
Remarks: Scholz et al. (1994, 1996) documented these metacercariae previously identified as *Echinochasmus zubedakhaname* by Jiménez-García, 1993 to be *O. manteri*						
Diplostomidae						
Diplostomum compactum	*Cichlasoma urophthalmus*	Ey	Tlacotalpan	10	10/1	Present work
(Lutz 1928)	*Rhamdia guatemalensis*	Ey	Tlacotalpan	8	37.5/2	Present work
[Ne, Al]		Ey	Lago de Catemaco	51	1.9/1	Pérez et al. 1992
	Cichlasoma aureum	Ey	Laguna Pipi, Tlacotalpan	ND	ND	Caballero and Winter 1954
Diplostomum sp.	*Astyanax aeneus*[a]	Gc	Arroyo San Juan Bautista	18	5.6/2	Present work
[?, Al]		Ey	Puente Valle Nacional	18	5.6/1	Present work
	Cichlasoma fenestratum[a]		Lago de Catemaco	6	16.7/9	Present work
	Poecilia mexicana[a]	Ey	Lago La Escondida	7	14.3/1	Present work
	Poecilia catemaconis[a]		Lago de Catemaco	25	8/4.5	Present work
	Rhamdia guatemalensis	Me	Arroyo San Juan Evangelista	9	11.1/1	Present work
Posthodiplostomum minimum	*Cichlasoma fenestratum*	Br, Ey, Fi, Gi, Mu	Lago de Catemaco	30	93/71.3	Jiménez-García 1993
(MacCallum 1921)	*Cichlasoma fenestratum*	Gi, Me	Lago de Catemaco	18	22.2/1.2	Present work
[Na, Al]		Bc, Gi, Li, Me, Mu	Lago La Escondida	12	58.3/2.9	Present work
	Cichlasoma urophthalmus	Gc	Río Tesechoacán	10	10/1	Present work
	Poecilia mexicana	Li, Me	Santiago Dominguillo	63	1.6/3	Present work
		Me	Puente Valle Nacional	18	11.1/26.5	Present work
		Li	Arroyo San Juan Bautista	14	7.1/2	Present work
		Li, Me	Arroyo San Juan Evangelista	7	42.9/2	Present work
		Ey, Li, Mu	Río La Palma	25	20/4.6	Present work
	Poecilia catemaconis[a]		Lago de Catemaco	25	32/2.1	Present work
	Poeciliopsis catemaco[a]		Lago de Catemaco	24	4.2/2	Present work
Tylodelphys sp.[b]	*Cichlasoma fenestratum*[a]	Gi	Lago de Catemaco	18	33.3/22.7	Present work
[?, Al]		Fi, Gc, Gi	Río Máquinas	14	42.9/12.2	Present work
		Gi	Lago La Escondida	12	83.3/27.9	Present work
	Dormitator maculatus[a]	Bc, Fi, Me	Río Tesechoacán	36	2.8/6	Present work
		Ey	Tlacotalpan	36	5.6/3	Present work
	Ophisternon aenigmaticum[a]	Me	Río Tesechoacán	10	20/2.5	Present work
	Poecilia catemaconis[a]		Lago de Catemaco	25	4/1	Present work
Uvulifer ambloplitis[b]	*Agonostomus monticola*[a]	Gi	Arroyo Balzapote	7	14.3/1	Present work
(Hughes 1927)		Fi	Río La Palma	2	50/2	Present work
[Na, Al]	*Astyanax aeneus*[a]	Fi	Río Grande, Guelatao	9	11.1/3	Present work
	Cichlasoma fenestratum[a]	Gi	Lago La Escondida	12	8.3/1	Present work
		Fi	Río La Palma	2	50/2	Present work
		Me	Río Máquinas	5	20/1	Present work

Table 2 (Contd.)

Helminth [Status]	Host	Infection sites	Locality	*N*	*P*(%)/MI	Reference
	Cichlasoma urophthalmus[a]	Fi	Río Tesechoacán	10	60/5	Present work
	Cichlasoma sp.	Fi	Puente Valle Nacional	13	30.7/4.0	Present work
	Cichlasoma sp.	Gi	San Juan Valle Nacional	8	25/1	Present work
	Dormitator maculatus[a]	Fi, Mu, Sk	Tlacotalpan	36	11.1/16.3	Present work
	Gobiomorus dormitor[a]	Fi, Me	Tlacotalpan	6	50/2.7	Present work
		Fi	Arroyo Balzapote	3	33.3/2	Present work
	Petenia splendida[a]	Fi	Tlacotalpan	1	100/10	Present work
	Poecilia mexicana[a]	Fi	Río La Palma	25	4/1	Present work
		Fa, Fi	Arroyo Balzapote	27	7.4/1.5	Present work
	Poeciliopsis gracilis[a]	Fi	Río Grande, San José del Chilar	10	20/24	Present work
	Rhamdia guatemalensis[a]		Tlacotalpan	8	12.5/1	Present work
	Xiphophorus helleri[a]		Río Máquinas	25	4/1	Present work
Echinostomatidae						
Drepanocephalus sp. [Ne, Al]	*Cichlasoma fenestratum*		Lago de Catemaco	30	7/ND	Jiménez-García 1993
Echinochasmus leopoldinae[b] Scholz, Ditrich and Vargas-Vázquez 1996 [Ne, Al]	*Dormitator maculatus*[a]	Gi	Tlacotalpan	11	9.1/2857	Present work
	Dorosoma petenense[a]	Gi	Lago de Catemaco	1	100/2091	Present work
	Petenia splendida[a]		Tlacotalpan	1	100/1	Present work
	Poecilia mexicana[a]	Gi	Arroyo Balzapote	27	14.8/5.7	Present work
Heterophyidae						
Ascocotyle (Ascocotyle) tenuicollis Price 1935 [Ne, Al]	*Astyanax aeneus*[a]	He	Lago La Escondida	5	20/6	Present work
	Bramocharax caballeroi		Lago de Catemaco	ND	ND	Scholz et al. 2001a
	Cichlasoma fenestratum[a]	He	Lago de Catemaco	18	11.1/33.5	Present work
	Dormitator maculatus[a]	He	Tlacotalpan	36	2.8/8	Present work
	Dorosoma petenense[a]	He	Lago de Catemaco	1	100/69	Present work
	Gobiomorus dormitor[a]	He	Tlacotalpan	24	4.2/113	Present work
	Heterandria bimaculata[a]	Gi	Arroyo Balzapote	15	6.7/4	Present work
	Ophisternon aenigmaticum	He	Lago de Catemaco	27	7.4/44.5	Present work
				ND	ND	Scholz et al. 2001a
		He	Tlacotalpan	10	20/19.5	Present work
	Poecilia mexicana[a]	He	El Saltillo - Taller	1	100/6	Present work
		Gi, He	Río La Palma	25	4/3	Present work
		Ga, Gi, He, Me	Arroyo Balzapote	27	44/31.8	Present work
	Poecilia catemaconis		Lago de Catemaco	ND	ND	Scholz et al. 2001a
	Poeciliopsis catemaco		Lago de Catemaco	ND	ND	Scholz et al. 2001a
	Xiphophorus helleri[a]	Fa	Arroyo Balzapote	8	12.5/1	Present work
		Gi	Río Máquinas	25	4/1	Present work
Ascocotyle (*Leighia*) *mcintoshi* Price 1936 [Ne?, Al]	*Poecilia mexicana*	Me	Río Máquinas	ND	ND	Scholz et al. 2001a
		He, Me	Río Máquinas	8	50/28	Present work
	Xiphophorus helleri[a]		Río Máquinas	25	56/24.6	Present work
	*Xiphophorus*sp.	Me	Río Máquinas	ND	ND	Scholz et al. 2001a
Ascocotyle (*Leighia*) *megalocephala* Price 1932 [Ne?, Al]	*Poecilia mexicana*	Iw, Sw	Arroyo Balzapote	ND	ND	Scholz et al. 2001a
				27	11.1/1.7	Present work
Ascocotyle (*Phagicola*) *diminuta*	*Poecilia mexicana*	Gi	Arroyo Balzapote	ND	ND	Scholz et al. 2001a

Stunkard and Haviland 1924 [Ne?, Al]				27	25.9/29.1	Present work
Ascocotyle (*Phagicola*) *longa*[b] Ransom 1920 [WW, Al]	*Dormitator maculatus*[a]	Gi	Tlacotalpan	11	9.1/552	Present work
Ascocotyle (*Phagicola*) *nana* Ransom 1920 [Ne?, Al]	*Cichlasoma fenestratum*	Gi, Li, In, Sp	Lago de Catemaco	18	61.1/1219.7	Present work
		Br, Ey, Gb, Gi, Go, He, In, Li, Ki, Mu, Sp	30	100/1716	10	
	Dorosoma petenense[a]	Iw	Lago de Catemaco	1	100/1125	Present work
	Heterandria bimaculata[a]	In, Me	Arroyo Balzapote	15	33.3/7.2	Present work
	Xiphophorus helleri[a]	Gi	Lago La Escondida	7	14.3/177	Present work
		Iw	Arroyo Balzapote	8	12.5/16	Present work
	Oreochromis sp.[a]		Lago de Catemaco	2	50/1060	Present work
Centrocestus formosanus (Nishigori 1924) [In, Al]	*Agonostomus monticola*	Gi	Arroyo Balzapote	7	71.4/30.2	Present work
		Gi	Río La Palma	6	50/6	Scholz and Salgado-Maldonado 2000
		Gi	Río Máquinas	13	15/3	Scholz and Salgado-Maldonado 2000
	Astyanax aeneus[a]	Gi	Sta. María Tecomavaca	7	42.9/3.7	Present work
		Gi	Calipán	7	85.7/8.2	Present work
		Gi	Arroyo San Juan Bautista	18	72.2/45.7	Present work
		Gi	Cascada El Saltillo	1	100/91	Present work
		Gi	Puente Valle Nacional	18	66.7/46.9	Present work
		Gi	Arroyo San Juan Evangelista	7	14.3/15	Present work
		Gi	Río Máquinas	14	7/2	Present work
	Atherinella ammophila[a]	Gi	Río La Palma	9	55.6/3.4	Present work
	Bramocharax caballeroi	Gi	Río La Palma	7	43/3	Scholz and Salgado-Maldonado 2000
	Cichlasoma fenestratum[a]	Gi	Arroyo Balzapote	3	33.3/38	Present work
		Gi	Río La Palma	14	14/14	Scholz and Salgado-Maldonado 2000
	Cichlasoma urophthalmus	Gi	Tlacotalpan	10	10/1	Present work
	Cichlasoma sp.	Gi	Puente Valle Nacional	13	7.7/3.0	Present work
	Gobiomorus dormitor	Gi	Río Papaloapan	30	70/19	Scholz and Salgado-Maldonado 2000
		Gi	Río La Palma	23	17/71	Scholz and Salgado-Maldonado 2000
		Gi	Arroyo Balzapote	4	100/949	Scholz and Salgado-Maldonado 2000
		Gi	Río Máquinas	7	71/86	Scholz and Salgado-Maldonado 2000
		Gi	Tlacotalpan	6	66.7/6.7	Present work
		Gi	Arroyo Balzapote	3	100/153.7	Present work
	Heterandria bimaculata[a]	Gi	Arroyo San Juan Evangelista	2	50/1	Present work
		Gi	Arroyo Balzapote	15	13.3/15	Present work
		Gi	Río Máquinas	25	64/106	Present work
		Gi	Río La Basura	16	6/1	Present work
	Heterandria sp.	Gi	Río La Palma	4	25/1	Scholz and Salgado-Maldonado 2000
	Poecilia mexicana	Gi	Ajalpan	13	69.2/22.6	Present work
		Gi	Calipán	38	42.1/26.6	Present work
		Gi	Río Grande, San José del Chilar	11	18.2/4.5	Present work
		Gi	Santiago Dominguillo	63	12.7/2.9	Present work
		Gi	Cascada El Saltillo	7	14.3/2	Present work
		Gi	Puente Valle Nacional	18	5.6/1	Present work
		Gi	Arroyo San Juan Bautista	14	35.7/2.8	Present work
		Gi	Río Máquinas	18	5.6/1	Present work
		Gi	Río La Palma	13	46.1/16	Present work
				25	12/2.3	Present work
		Gi	Arroyo Balzapote	6	33.3/5.5	Present work
				27	3.7/2	Present work

Table 2 (Contd.)

Helminth [Status]	Host	Infection sites	Locality	*N*	*P*(%)/MI	Reference
	Poecilia reticulata[a]	Gi	Ajalpan	34	41.2/3.2	Present work
	Poecilia sphenops	Gi	Río La Palma	19	11/20	Scholz and Salgado-Maldonado 2000
	Xiphophorus helleri	Gi	El Saltillo - Taller	5	20/15	Present work
		Gi	Cascada El Saltillo	2	100/141	Present work
		Gi	Río La Palma	13	7.7/1	Present work
		Gi	Arroyo Balzapote	8	37.5/83.7	Present work
		Gi	Río Máquinas	11	36/30	Scholz and Salgado-Maldonado 2000
	Rhamdia guatemalensis[a]	Gi	Arroyo San Juan Evangelista	9	33.3/34	Present work
Haplorchis pumilio[b] (Looss 1896) [WW, Al]	*Poecilia mexicana*[a]	Gi	Arroyo Balzapote	27	3.7/1	Present work
Pygidiopsis pindoramensis (Travassos 1929)	*Poecilia mexicana*	Ga, He	Arroyo Balzapote	ND	ND	Scholz et al. 2001a
		Fa		27	3.7/1	Present work
[Ne?, Al]	*Xiphophorus helleri*	Ga, He	Arroyo Balzapote	ND	ND	Scholz et al. 2001a
	Poecilia catemaconis	Ga, He	Lago de Catemaco	ND	ND	Scholz et al. 2001a
Opisthorchiidae						
Cladocystis trifolium (Braun 1901) [Ne, Al]	*Cichlasoma fenestratum*		Lago de Catemaco	30	83/9.2	Jiménez-García 1993
Proterodiplostomidae						
Crocodilicola pseudostoma (Willemoes-Suhm 1870) [Ne?, Au]	*Rhamdia guatemalensis*	Me	Arroyo San Juan Evangelista	9	11.1/1	Present work
		Bc	Lago de Catemaco	51	23/15.9	Pérez et al. 1992
Strigeidae						
[?, Al]	*Poecilia mexicana*[a]	Me	Río La Palma	25	8/1.5	Present work
Apharyngostrigea sp.[b]	*Dormitator maculatus*[a]	Fi	Tlacotalpan	36	5.6/6	Present work
Cotylurus sp.[b] [?, Al]	*Dormitator maculatus*[a]	Fi, Gi	Tlacotalpan	11	9.1/1	Present work
Monogenea						
Dactylogyridae						
Ameloblastella chavarriai[b] (Price 1938) [Ne, Au]	*Rhamdia guatemalensis*	Gi	Tlacotalpan	8	62.5/76.4	Present work
		Gi	Arroyo San Juan Evangelista	9	33.3/3.7	Present work
		Gi	Lago de Catemaco	4	25/8	Present work
Aphanoblastella travassosi[b] (Price 1938)	*Rhamdia guatemalensis*	Gi	Tlacotalpan	8	62.5/93.2	Present work
			Lago de Catemaco	4	75/11.7	Present work
[Ne, Au] *Guavinella tropica* Mendoza-Franco, Scholz and Cabañas-Carranza 2003 [Ne, Au]	*Gobiomorus dormitor*	Fi, Gi	Arroyo Balzapote	4	50/6	Mendoza-Franco et al. 2003b
			Río Máquinas	1	100/6	Present work
			Arroyo Balzapote	3	33.3/6	Present work
			Tlacotalpan	9	67/28	Mendoza-Franco et al. 2003b
			Arroyo San Juan Bautista	4	50/3	Mendoza-Franco et al. 2003b
		Gi	Tlacotalpan	24	12.5/2	Present work
		Gi	Río La Palma	2	50/11	Present work
		Gi	Río Frío	1	100/4	Present work

Sciadicleithrum bravohollisae[b] Kritsky, Vidal-Martínez and Rodríguez-Canul 1994 [Ne, Au]	*Cichlasoma fenestratum*[a]	Gi	Lago de Catemaco	18	72.2/9.8	Present work
		Gi	Río Máquinas	14	64.3/1.6	Present work
		Gi	Arroyo Balzapote	3	100/7	Present work
		Gi	Lago La Escondida	12	50/2.8	Present work
		Gi	Río La Palma	2	50/4	Present work
	Cichlasoma octofasciatum[a]	Gi	Tlacotalpan	1	100/8	Present work
	Cichlasoma urophthalmus	Gi	Tlacotalpan	10	60/76.8	Present work
	Petenia splendida	Gi	Tlacotalpan	1	100/217	Present work
Urocleidoides costaricensis[b] (Price and Bussing 1967) [Ne, Au]	*Astyanax aeneus*	Gi	Lago La Escondida	5	60/2.3	Present work
Urocleidoides sp. [Ne, Au]	*Astyanax aeneus*	Gi	Sta. María Tecomavaca	7	57.1/2.7	Present work
			Río Grande, San José del Chilar	9	11.1/2	Present work
			Río Grande, Guelatao	9	33.3/3.7	Present work
			Arroyo San Juan Bautista	18	16.7/2	Present work
Urocleidus sp. [?, Au]	*Dormitator maculatus*		Tlacotalpan	36	8.3/1.7	Present work
Ancyrocephalinae gen. sp. [?, Au]	*Heterandria bimaculata*	Gi	Arroyo Balzapote	15	46.7/2.1	Present work
[?, Au]		Gi	Río Frío	4	75/1	Present work
Diplectanidae						
Diplectanidae gen. sp. [?, Au]	*Agonostomus monticola*	Gi	Río La Palma	2	100/5	Present work
Gyrodactylidae						
[b]*Anacanthocotyle anacanthocotyle* Kritsky and Fritts 1970 [Ne, Au]	*Astyanax aeneus*[a]	Fi	Lago La Escondida	5	20/5	Present work
Gyrodactylus sp. [?, Au]	*Astyanax aeneus*	Gi	Río Grande (Guelatao)	9	11.1/2	Present work
	Cichlasoma fenestratum		Río Máquinas	14	42.9/2.8	Present work
	Cichlasoma gadovii	Gi	Río Máquinas	5	20/1	Present work
	Dormitator maculatus	Fi	Tlacotalpan	11	36.4/5.7	Present work
	Gobiomorus dormitor		Tlacotalpan	3	33.3/1	Present work
	Poecilia mexicana	Fi	Calipán	38	10.5/1.5	Present work
		Fi	Santiago Dominguillo	63	55.6/2.9	Present work
		Fi	Río Máquinas	8	12.5/4	Present work
	Poeciliopsis gracilis	Fi	Santiago Dominguillo	20	5/1	Present work
	Rhamdia guatemalensis		Tlacotalpan	8	12.5/1	Present work
Microcotylidae Gen. Sp. [?, Au]	*Agonostomus monticola*	Gi	Río Frío	4	25/1	Present work
Adult Cestoda						
Bothriocephalidae						
Bothriocephalus cuspidatus[b] Cooper 1917 [Ne, Au]	*Gobiomorus dormitor*[a]	In	Arroyo Balzapote	3	66.7/4.5	Present work
Monticelliidae						
Monticellia ophisterni Scholz, de Chambrier and Salgado-Maldonado 2001 [Ne, Au]	*Ophisternon aenigmaticum*	In	Lago de Catemaco	20	70/3.4	Scholz et al. 2001b
		In	Lago de Catemaco	27	63/1.9	Present work
		In	Río Tesechoacán	10	50/2	Present work
Proteocephalidae						
Megathylacoides lamothei (García-Prieto 1990)	*Ictalurus furcatus*	In	Presa Temascal	1	100/4	García-Prieto 1990
		In	Tlacotalpan	ND	ND	Scholz et al. 2003

Table 2 (Contd.)

Helminth [Status]	Host	Infection sites	Locality	*N*	*P*(%)/MI	Reference
[Ne, Au]						
Proteocephalus brooksi	*Rhamdia guatemalensis*	In	Lago de Catemaco	51	23/5.7	García-Prieto et al. 1996, Pérez et al. 1992
García-Prieto, Rodríguez and Pérez 1996		In, Me	Tlacotalpan	8	87.5/16.7	Present work
[Ne, Au]						
Metacestodes						
Dilepididae						
Glossocercus auritus	*Poecilia catemaconis*	Iw, Li, Me	Lago de Catemaco	23	4/1	Scholz and Salgado-Maldonado 2001
(Rudolphi 1819)	*Poecilia mexicana*	Li, Me	Lago La Escondida	2	100/1	Scholz and Salgado-Maldonado 2001
[Ne, Al]		Li, Me	Lago La Escondida	7	28.6/1	Present work
		Me	Puente Valle Nacional	18	5.6/4	Present work
Dilepididae gen. sp.	*Dormitator maculatus*	Ki	Tlacotalpan	36	5.6/1.5	Present work
[?, Al]	*Gobiomorus dormitor*	In, Mu	Tlacotalpan	24	12.5/1	Present work
	Rhamdia guatemalensis		Arroyo San Juan Evangelista	9	11.1/2	Present work
Proteocephalidea gen. sp.	*Astyanax aeneus*		Puente Valle Nacional	18	5.6/1	Present work
[?, ?]	*Ophisternon aenigmaticum*	Li, Me	Río Tesechoacán	10	90/17.9	Present work
Tetraphyllidea gen. sp.	*Dormitator maculatus*	In	Tlacotalpan	36	2.8/1	Present work
[?, Au]	*Gobiomorus dormitor*		Tlacotalpan	6	16.7/1	Present work
Adult Nematoda						
Camallanidae						
Procamallanus (*Spirocamallanus*) sp.	*Dorosoma petenense*		Lago de Catemaco	15	6.7/1	Present work
[Ne, Au]						
Procamallanus (*Spirocamallanus*) *Neocaballeroi*	*Astyanax aeneus*	In	Lago de Catemaco	ND	ND	Caballero-Deloya 1977
(Caballero-Deloya 1977)	*Rhamdia guatemalensis*	Me	Lago de Catemaco	51	13.7/1.7	Pérez et al. 1992
[Ne, Au]		In	Lago de Catemaco	4	25/1	Present work
	Bramocharax caballeroi[a]		Lago de Catemaco	10	30/1.3	Present work
Procamallanus (*Spirocamallanus*) *rebecae*	*Cichlasoma fenestratum*	In	Río de los Pescados	ND	ND	Salgado-Maldonado et al. 1997
Andrade-Salas, Pineda-López and García-Magaña 1994	*Cichlasoma* sp.	In	Puente Valle Nacional	13	30.8/2.2	Present work
[Ne, Au]						
Capillariidae						
Paracapillaria teixeirafreitasi	*Dormitator maculatus*	In	Tlacotalpan	36	2.8/6	Present work
(Caballero-Rodríguez 1971)	*Gobiomorus dormitor*	In	Tlacotalpan	ND	ND	Páez-Rodríguez et al. 2002
[Ne, Au]		In	Tlacotalpan	24	50/2.7	Present work
		In	Río Máquinas	10	30/5.3	Present work
Pseudocapillaria (*Ichthyocapillaria*) *ophisterni*	*Ophisternon aenigmaticum*	In, St	Lago de Catemaco	10	50/7	Moravec et al. 2000b
Moravec, Salgado-Maldonado and Jiménez-García 2000		In		27	7.4/2.5	Present work
[Ne, Au]		In	Río Tesechoacán	10	20/4	Present work
Cucullanidae						
Dichelyne mexicanus Caspeta-Mandujano, Moravec and Salgado-Maldonado 1999	*Agonostomus monticola*		Río Máquinas	9	11/3	Caspeta-Mandujano et al. 1999
[Ne, Au]						

Cucullanus (*Cucullanus*) *caballeroi*	*Gobiomorus dormitor*[a]		Tlacotalpan	6	16.7/11	Present work
Petter 1977		In	Río Máquinas	10	10/1	Present work
[Ne, Au]	*Cichlasoma* sp.	In	Puente Valle Nacional	13	15.3/2.5	Present work
	Dormitator maculatus		Río La Palma	31	3.2/5	Caspeta-Mandujano et al. 1999
			Río Máquinas	9	22/2	Caspeta-Mandujano et al. 1999
			Arroyo Balzapote	4	25/1	Caspeta-Mandujano et al. 1999
	Rhamdia guatemalensis		Tlacotalpan	8	50/6.5	Present work
			Arroyo San Juan Evangelista	9	11.1/1	Present work
Cucullanus mexicanus	*Rhamdia guatemalensis*	In	Valle Nacional	14	14/2	Caspeta-Mandujano et al. 2000a
Caspeta-Mandujano, Moravec and Aguilar-Aguilar 2000a		In	Cascada El Saltillo	1	100/1	Caspeta-Mandujano et al. 2000a
[Ne, Au]		In	Arroyo San Juan Bautista	6	17/2	Caspeta-Mandujano et al. 2000a
		Me	San Juan Valle Nacional	3	33/1	Present work
		In, Me	Puente Valle Nacional	11	9/1	Present work
Cystidicolidae						
Spinitectus mexicanus	*Heterandria bimaculata*	In	Arroyo la Basura	11	73/3	Caspeta-Mandujano et al. 2000b
Caspeta-Mandujano, Moravec and Salgado-Maldonado 2000		Fa, In, Me		16	77/5.5	Present work
[Ne, Au]		In	Río Máquinas	10	70/1	Caspeta-Mandujano et al. 2000b
				10	10/1	Present work
		In	Río La Palma	4	25/1	Caspeta-Mandujano et al. 2000b
		In	Río San Joaquín	21	57.1/2	Present work
		In	Río Frío	4	25/1	Present work
	Poecilia mexicana[a]		Río San Joaquín	1	100/11	Present work
		In	Río Máquinas	18	16.7/1	Present work
Spinitectus agonostomi[b]	*Agonostomus monticola*	In	Arroyo Balzapote	7	100/8.6	Present work
Moravec and Barus 1971		In	Río La Palma	2	100/6.5	Present work
[Ne, Au]		In		3	66.7/1.5	Present work
			Río Máquinas	1	100/5	Present work
		In	Río Frío	4	100/11	Present work
Daniconematidae						
Mexiconema cichlasomae	*Xiphophorus helleri*	Bc	Lago de Catemaco	23	8.7/1.5	Montoya-Mendoza et al. 2004
Moravec, Vidal and Salgado-Maldonado 1992		Bc	Arroyo Agrio	13	92.3/11	Montoya-Mendoza et al. 2004
[Ne, Au]						
Philometridae						
Philometra ophisterni	*Ophisternon aenigmaticum*	Me	Río Tesechoacán	9	55.5/2.6	Moravec et al. 2002a
Moravec, Salgado-Maldonado and Aguilar-Aguilar 2002						
[Ne, Au]						
Neophilometroides caudatus	*Rhamdia guatemalensis*	Gb	Tlacotalpan	4	25/10	Moravec et al. 2002b
(Moravec, Scholz and Vivas-Rodríguez 1995)			Tlacotalpan	5	20/6	Present work
[Ne, Au]						
Quimperiidae						
Gibsonnema ophisterni	*Ophisternon aenigmaticum*	In	Río Tesechoacán	9	11/2	Moravec et al. 2002a
(Moravec, Salgado-Maldonado and Aguilar-Aguilar 2002)						
[Ne, Au]						

Table 2 (Contd.)

Helminth [Status]	Host	Infection sites	Locality	*N*	*P*(%)/MI	Reference
Rhabdochonidae						
Rhabdochona kidderi	*Cichlasoma fenestratum*		Lago de Catemaco	30	13/6.5	Jiménez-García 1993
Pearse 1936		In	Río Máquinas	14	57.1/9.9	Present work
[Ne, Au]		In	Lago La Escondida	12	33.3/1.5	Present work
		In	Río La Palma	2	50/30	Present work
		In	Río Máquinas	5	60/1.7	Present work
	Cichlasoma sp.	In	Puente Valle Nacional	13	69.2/5.2	Present work
	Cichlasoma sp.	In	San Juan Valle Nacional	8	87.5/24.6	Present work
	Dorosoma anale[a]		Río Máquinas	6	100/6.5	Present work
	Gobiomorus dormitor[a]		Tlacotalpan	6	16.7/8	Present work
			Arroyo Balzapote	3	66.6/2	Present work
		In	Río Máquinas	10	80/6.9	Present work
		In	Río La Palma	2	50/1	Present work
	Poecilia mexicana[a]	In	Río Máquinas	18	5.6/2	Present work
		In	Río La Palma	13	15.4/1.5	Present work
	Eleotris sp.[a]	In	Río Máquinas	6	100/6.5	Present work
Rhabdochona mexicana[b]	*Astyanax aeneus*		Río Grande, Guelatao	9	11.1/1	Present work
Caspeta-Mandujano, Moravec and Salgado-Maldonado 2000		In	Santiago Dominguillo	13	15.4/1	Present work
[Ne, Au]		In, Me	Arroyo San Juan Bautista	18	72.2/4.4	Present work
		In, Me	Puente Valle Nacional	18	50/4.6	Present work
			Lago La Escondida	5	20/2	Present work
Larval Nematodes						
Anisakidae						
Contracaecum sp.	*Astyanax aeneus*[a]	Me	Arroyo San Juan Bautista	18	5.6/1	Present work
[WW, Al]		Bc	El Saltillo - Taller	1	100/2	Present work
		In	Puente Valle Nacional	18	11.1/1	Present work
		Me	Arroyo San Juan Evangelista	7	14.3/1	Present work
			Arroyo San Juan Bautista	18	5.6/1	Present work
	Bramocharax caballeroi[a]		Lago de Catemaco	10	20/1	Present work
	Cichlasoma fenestratum[a]	In	Lago de Catemaco	18	5.6/3	Present work
		Bc, Go, Me	Lago La Escondida	12	16.7/2	Present work
	Cichlasoma urophthalmus	Me, St	Tlacotalpan	10	100/1.8	Present work
	Cichlasoma sp.	In	Puente Valle Nacional	13	7.7/3	Present work
	Dormitator maculatus[a]	Me	Tlacotalpan	11	18.2/1	Present work
	Dorosoma anale[a]	Me	Tlacotalpan	2	50/60	Present work
	Gobiomorus dormitor	Me	Tlacotalpan	ND	ND	Páez-Rodríguez et al. 2002
		Me	Tlacotalpan	24	29.2/4.1	Present work
	Heterandria bimaculata[a]	Me	Arroyo San Juan Evangelista	2	50/1	Present work
	Ophisternon aenigmaticum[a]	Me	Lago de Catemaco	27	11.1/1	Present work
			Tlacotalpan	10	80/3.6	Present work
	Poecilia mexicana[a]	In, Me	Río La Palma	25	12/1	Present work
		In		4	25/1	Present work
	Rhamdia guatemalensis	Bc	Lago de Catemaco	51	11.7/3.5	Pérez et al. 1992
		Me	San Juan-Valle Nacional	3	66.7/3	Present work
		Me	Puente Valle Nacional	11	81.8/11.8	Present work
			Arroyo San Juan Bautista	6	33.3/2.5	Present work
		Me	Arroyo San Juan Evangelista	9	44.4/4.2	Present work
			Tlacotalpan	8	37.5/7	Present work

Camallanidae						
Serpinema trispinosum	*Dormitator maculatus*	In	Tlacotalpan	47	2/1	Aguilar-Aguilar et al. 2003a
(Leidy 1852)	Gobiomorus dormitor	In	Mouth of Papaloapan	ND	ND	Montoya-Mendoza et al. 2004
[Ne?, Au]		In, Mu	Tlacotalpan	33	9/3	Aguilar-Aguilar et al. 2003a
	Ophisternon aenigmaticum	In	Tlacotalpan	10	10/1	Aguilar-Aguilar et al. 2003a
	Rhamdia guatemalensis	In	Tlacotalpan	13	8/4	Aguilar-Aguilar et al. 2003a
				8	12.5/2	Present work
Dioctophymatidae						
Eustrongylides sp.[b]	*Dormitator maculatus*[a]	Me	Tlacotalpan	36	2.8/1	Present work
[?, Al]	*Poeciliopsis catemaco*[a]		Lago de Catemaco	24	8.33/1	Present work
Gnathostomidae						
*Gnathostoma*sp.	*Petenia splendida*	Mu	Presa Temascal	73	21.9/1.3	Lamothe-Argumedo et al. 1989
[Ne?, Al]	*Cichlasoma urophthalmus*	Mu	Presa Temascal	80	17.5/1.2	Lamothe-Argumedo et al. 1989
	Cichlasoma fenestratum	Mu	Presa Temascal	36	11.1/2	Lamothe-Argumedo et al. 1989
			Presa Temascal	ND	ND	Lamothe-Argumedo 1997b
	Cichlasoma salvini		Presa Temascal	ND	ND	Lamothe-Argumedo 1997b
	Ictalurus meridionalis		Presa Temascal	ND	ND	Lamothe-Argumedo 1997b
	Oreochromis sp.	Mu	Presa Temascal	194	2/1	Lamothe-Argumedo et al. 1989
Remarks: most of these records relate to *Gnathostoma binucleatum* larvae (Almeyda-Artigas 1991; Almeyda-Artigas et al. 1995)						
Gnathostoma binucleatum	*Oreochromis aureus*	Mu	Presa Temascal	86	1.2/1	Almeyda-Artigas 1991
Almeyda-Artigas 1991	*Oreochromis mossambicus*	Mu	Presa Temascal	117	1.7/1	Almeyda-Artigas 1991
[Ne, Al]	*Oreochromis niloticus*	Mu	Presa Temascal	97	2.1/1	Almeyda-Artigas 1991
	Cichlasoma fenestratum	Mu	Presa Temascal	77	11.1/1.1	Almeyda-Artigas 1991
	Cichlasoma urophtalmus	Mu	Presa Temascal	120	18.3/1.3	Almeyda-Artigas 1991
	Petenia splendida	Mu	Presa Temascal	820	31.5/1.4	Almeyda-Artigas 1991
	Gobiomorus dormitor	Mu	Río Papaloapan	4	50/2.5	Almeyda-Artigas 1991
Spiroxys sp.[b]	*Astyanax aeneus*[a]	In, Me	Puente Valle Nacional	18	16.7/1.3	Present work
[Ne?, Au]		Me	Arroyo San Juan Evangelista	7	14.3/1	Present work
	Atherinella lisa[a]		Río La Palma	9	11.1/1	Present work
	Cichlasoma fenestratum[a]		Lago de Catemaco	18	5.6/1	Present work
		Me	Río Máquinas	14	7.1/2	Present work
		In, Me	Lago La Escondida	12	25/3.7	Present work
	Cichlasoma octofasciatum[a]	Me, Mu	Arroyo San Juan Evangelista	3	33.3/2	Present work
	Cichlasoma urophthalmus	Me, St	Río Tesechoacán	10	20/3	Present work
	Cichlasoma sp.	Me	San Juan Valle Nacional	8	12.5/1	Present work
	Dormitator maculatus[a]	Li, Me, St	Río Tesechoacán	36	33.3/2.2	Present work
	Gobiomorus dormitor[a]	Mu on Int	Mouth of Papaloapan	ND	ND	Montoya-Mendoza et al. 2004
		In, Li, Me, Mu, St	Tlacotalpan	24	41.7/8	Present work
			Arroyo Balzapote	3	33.3/2	Present work
	Ophisternon aenigmaticum[a]	St	Tlacotalpan	10	30/5	Present work
	*Oreochromis*sp.	Me	Arroyo San Juan Evangelista	1	100/1	Present work
	Poecilia mexicana[a]	Me	Arroyo San Juan Evangelista	7	14.3/1	Present work
	Xiphophorus helleri[a]		Arroyo San Juan Evangelista	1	100/1	Present work
	Rhamdia guatemalensis[a]	Me	Tlacotalpan	8	37.5/17.3	Present work
			Arroyo San Juan Evangelista	9	11.1/2	Present work
Kathlaniidae						
Falcaustra sp.[b]	*Dormitator maculatus*[a]	Gi	Tlacotalpan	36	5.6/1.5	Present work
[Ne?, Au]	*Poecilia mexicana*[a]	Me	Río La Palma	25	4/2	Present work
Rhabdochonidae						
Rhabdochona sp.	*Agonostomus monticola*		Río La Palma	3	33.3/1	Present work
[Ne?, Au]	*Atherinella ammophila*	In, St	Río La Palma	9	44.4/2	Present work
	Heterandria bimaculata		Arroyo Balzapote	15	6.7/1	Present work

Table 2 (Contd.)

Helminth [Status]	Host	Infection sites	Locality	*N*	*P*(%)/MI	Reference
Adult Acanthocephala						
Acanthocephala gen. sp.	*Ophisternon aenigmaticum*	In	Río Tesechoacán	10	20/1	Present work
Cavisomidae						
Caballerorhynchus lamothei Salgado-Maldonado 1977 [Ne, Au]	*Rhamdia guatemalensis*[a]	In	Arroyo San Juan Bautista	2	50/1	Present work
Illiosentidae						
Tegorhynchus brevis Van Cleave 1921 [Na?, Au]	*Rhamdia guatemalensis*[a]		Tlacotalpan	5	20/1	Present work
Neoechinorhynchidae						
Floridosentis sp. [Ne?, Au]	*Agonostomus monticola*[a]	In	Río La Palma	3	33.3/17	Present work
Neoechinorhynchus golvani Salgado-Maldonado 1978 [Ne, Au]	*Cichlasoma fenestratum*	In	Lago de Catemaco	ND	ND	Salgado-Maldonado 1978
				120	19.5/1.25	Salgado-Maldonado et al. 1992
				18	33.3/2.2	Present work
Remarks: originally the type host for *N. golvani* was reported as *C. aureum*; however, this species do not inhabit in Lago de Catemaco (Miller and Smith 1998)						
	Cichlasoma ellioti[a]		Arroyo San Juan Evangelista	2	50/1	Present work
		In		30	27/14.5	Jiménez-García 1993
				18	33.3/2.2	Present work
	Cichlasoma octofasciatum[a]		Arroyo San Juan Evangelista	3	33.3/3	Present work
	Cichlasoma urophthalmus		Tlacotalpan	10	10/20	Present work
	Dormitator maculatus		Mouth of Papaloapan	184	76.1/18.7	Montoya-Mendoza et al. 2004
			Tlacotalpan	36	41.7/9.9	Present work
	Gobiomorus dormitor		Tlacotalpan	24	16.7/1.7	Present work
	Rhamdia guatemalensis[a]		Tlacotalpan	8	50/6.5	Present work
Octospiniferoides chandleri Bullock 1957 [Na?, Au]	*Heterandria bimaculata*	In	Lago de Catemaco	10	80/1.5	Salgado-Maldonado 1978
Polymorphidae						
Southwellina hispida (Van Cleave 1925) [Ww, Al]	*Gobiomorus dormitor*	Me	Tlacotalpan	ND	ND	Páez-Rodríguez et al. 2002
Larval Acanthocephala						
Polymorphidae						
Polymorphus sp. [?, Al]	*Rhamdia guatemalensis*	In	Lago de Catemaco	4	25/1	Present work
Polymorphus brevis	*Cichlasoma fenestratum*	Bc, Ey, Me	Lago de Catemaco	ND	ND	Jiménez-García 1993
Van Cleave 1916 [Na, Al]	*Rhamdia guatemalensis*	Me	Lago de Catemaco	51	3.9/2	Páez-Rodríguez et al. 2002

The number of specimens examined for four of the seven endemic species in this inventory was low, between two and ten individuals. However, enough specimens of the other endemic hosts were examined: 24 hosts were examined for *Poeciliopsisis catemaco*, 25 for *Poecilia catemaconis* and 37 for *Cichlasoma fenestratum*. The aterinid *Atherinella ammnophila* and the clupeid *Dorosoma petenense* were the only hosts examined from these families, and the examination of a larger number of specimens from these families could provide additional helminth data that were not recorded in this inventory. The data collected to date shows that the helminths of endemic hosts are mostly generalist species with wide geographic distribution.

Data are provided for the Upper Papaloapan, a geographic area that has not been sampled previously. There are also new records for the Lower Papaloapan, including the previously sampled areas of Los Tuxtlas and Catemaco Lake, Veracruz. This new data helps in creating a more general panorama of the basin's helminth fauna.

The helminth species richness reported here for the fish of the Papaloapan (85 species in 36 host species) is greater than that reported for the Balsas River basin (25 species in 13 host species, Salgado-Maldonado et al. 2001a), the Ayuquila River (28 species in 14 hosts species, Salgado-Maldonado et al. 2004b), and the Lerma and Santiago Rivers (43 species in 33 host species, Salgado-Maldonado et al. 2001b). In contrast, it is comparable to the species richness recorded in the Grijalva–Usumacinta system in the state of Tabasco (107 species in 49 host species, Salgado-Maldonado et al. 2005) and that for the Yucatán Península (93 species in 31 host species, Moravec et al. 1995a, b, c, 2002c; Scholz et al. 1995a, b, 1996a, b, 1997a, b, 2001; Scholz and Salgado-Maldonado 2001; Scholz and Vargas-Vázquez 1998; Mendoza-Franco et al. 1997, 1999, 2000, 2003a, b; Mendoza-Franco and Vidal-Martínez 2001; Kritsky et al. 2000).

The helminth diversity of the Papaloapan basin in terms of taxonomic groups coincides with a well-known pattern for helminth communities in freshwater fish in Mexico, with nematodes and trematodes being more abundant (Salgado-Maldonado and Kennedy 1997; Salgado-Maldonado et al. 2001a, b, 2004a, b, 2005; Aguilar-Aguilar et al. 2003c; Sánchez-Nava et al. 2004). Remarkably, the Papaloapan basin also has an abundant monogenean component compared to the reported abundances in other Mexican hydrological basins. However, previous examinations of freshwater fish for inventories of Mexican freshwater basins (Salgado-Maldonado and Kennedy 1997; Salgado-Maldonado et al. 2001a, b) did not adequately evaluate monogenean presence and diversity because the gills were not examined immediately after the killing of the host. The small size and fragility of the dactyligyrids that predominate in Mexican freshwater fish require that they be collected immediately and that proper fixing and handling procedures be used to avoid their destruction (see Mendoza-Franco et al. 1999, 2000, 2003a; Vidal-Martínez et al. 2001a). The low cestode and acanthocephalan diversity in this inventory also fit previously described patterns for Mexican freshwater fish.

Aguilar-Aguilar et al. (2003b) report a close biogeographic relationship between freshwater helminth faunas from the Papaloapan and those from Tabasco, the Yucatán Península and Nicaragua. The present data support the above and show that the helminth fauna composition in Papaloapan fish is related to that of the freshwater fish from the Grijalva–Usumacinta hydrological system in Tabasco (56% of species shared) (see Salgado-Maldonado et al. 2005) and from the Yucatán Península (42% of species shared) (see Moravec et al. 1995a, b; Scholz et al. 1995a, b, 1996a; Mendoza-Franco et al. 1999, 2000; Kritsky et al. 2000). The Grijalva–Usumacinta system is adjacent the Papaloapan, and, like the Yucatán Península, is located in southeast Mexico. Though knowledge on the helminth fauna of freshwater fish in Nicaragua is still incipient, current records show them sharing 28 helminth species (33%) with the fish of the Papaloapan (see Aguirre-Macedo et al. 2001a, b; Vidal-Martínez et al. 2001b; Mendoza-Franco et al. 2003a). In contrast, only 19% of the helminth species in the Balsas River basin are shared with the fish of the Papaloapan (see Salgado-Maldonado et al. 2001a). The Balsas River basin is adjacent the Papaloapan basin, but drains the western side of the Continental Divide, towards the Pacific Ocean.

The helminth fauna in the fish of the Papaloapan river basin predominantly consists of Neotropical species that are largely autogenic. The latter differs from the other basins in Mexico in which allogenic species are generally more numerous.

Ten of the recorded helminth species (12%) have only been found in fish from the Papaloapan. This means that they can be considered exclusive to this basin, and it provides a distinct character to the basin's helminth fauna. It would be premature, however, to say that these helminths are endemic to the Papaloapan as they were not found associated with endemic fish species. Four of these ten exclusive helminth species parasitize the swamp eel *O. aenigmaticum* and two more in the neotropical catfish *R. guatemalensis*. Both host species are also distributed outside the Papaloapan basin, in Central America. The remaining four exclusive helminth species also parasitize the fish that are distributed outside the Papaloapan. Further examination of these species could show the presence of these helminth species beyond the limits of the Papaloapan River basin.

Host specificity in each parasite species varied from those with strict specificity, such as the monogeneans, to the more frequent generalists found in several host species, like *A.* (*A.*) *tenuicollis*, *C. formosanus*, *P. minimum* and *Contracaecum* sp. It is noteworthy, however, that each host family has a closely associate suite of parasite species. For example, the helminth fauna of *Ophisternon aenigmaticum* is distinguished by the presence of the cestode *Monticellia ophisterni* and the nem-

atodes *Pseudocapillaria ophisterni*, *Philometra ophisterni* and *Gibsonema ophisterni*. Another is the mugilid *Agonostomus monticola*, which has a close relationship with the trematode *Creptotrema agonostomi*, the nematode *Spinitectus agonostomi* and even the acanthocephalan *Floridosentis mugilis*, which is only recorded from estuarine and marine mugilids. Helminth communities in characid fish are different from those of cichlid fish, which are distinguished by their association with the trematodes *Crassicutis cichlasomae*, *Oligogonotylus manteri* and *Genarchella isabellae*, the nematodes *Procamallanus* (*Spirocamallanus*) *rebecae*, and *Rhabdochona kidderi*, and the acanthocephalan *Neoechinorhynchus golvani*. There are cases of parasites, normally considered exclusive to a particular host group, transferring to fish outside this group. For instance, *C. cichlasomae* was found in the clupeid *Dorosoma petenense*, and *R. kidderi* was found in *Poecilia mexicana* and *Dorosoma petenense*. Nonetheless, there are significant quantitative differences in the infection levels between the common hosts and these atypical hosts. This is because, in the latter, these parasites are not as frequent and many do not mature.

This host specificity pattern is a determinant for the helminth fauna composition of the basin. As mentioned previously, there is a complex of helminth species in the Papaloapan that have not been recorded in other hydrological basins in Mexico, including *Saccocoelioides chauhani*, *Caballerorhynchus lamothei*, *Monticellia ophisterni*, *Philometra ophisterni*, *Gibsonema ophisterni*, *Spinitectus mexicanus* and *Cucullanus mexicanus*. The parasite fauna of the host *Ophisternon aenigmaticus* contributes 43% of these seven species and it is likely that these species may be found in other hydrological basins where this host lives.

If a host species is typical of a certain environment, then its parasites are also typical (Chubb 1963). Hence parasite host specificity is so important in determining the characteristics of the parasite fauna of a certain environment. Using this concept, if a group of hosts is abundant in an environment, their specific parasites might disseminate to other hosts, parasitizing hosts where they are not found normally (Dogiel 1961; Wootten 1973). Thus as Wootten (1973) stated, the helminth fauna composition of the Papaloapan basin is more influenced by its ichthyological composition than by limnological factors.

To delimitate host specificity at the host family level can be questionable. However, Vidal-Martínez et al. (2001b) suggest that in Central America and Mexico, these patterns can be related to certain hosts' very dynamic speciation processes. Cichlid speciation, for example, has been so rapid that no morphological or functional differences exist between different species from the same family for their parasite species. This in turn favors host switching between hosts of the same family.

This inventory shows the richness of helminth parasite species in the fish of the Papaloapan River basin in comparison with other hydrological basins in Mexico. It also demonstrates that this fauna is typically Neotropical and quite similar to that from the neighboring basins of the Grijalva–Usumacinta system and the Yucatán Península. The data also suggest highly effective transmission between environments within the same basin and that the regional parasite fauna is strongly influenced by fish community composition.

Acknowledgements This study was supported by project no. 27668N from the Consejo Nacional de Ciencia y Tecnología (CONACyT) Mexico. RAA was supported by Reserach Ph D Fellowship no. 138534 from CONACyT. The authors are indebted to Cristina Cañeda Guzmán, Petra Sánchez Nava, Mirza Patricia Ortega Olivares, Griselda Moreno Navarrete, Juan Manuel Caspeta Mandujano, Rafael Báez Valé and Guadalupe Lara Figueroa, for their assistance in the field and laboratory. We convey our special thanks to two anonymous reviewers and editor for their suggestions in improving the manuscript.

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