Journal of Biogeography, **30**, 1861–1872

Parsimony Analysis of Endemicity (PAE) of Mexican hydrological basins based on helminth parasites of freshwater fishes

Rogelio Aguilar-Aguilar[1]*, Raúl Contreras-Medina[2] and Guillermo Salgado-Maldonado[1]
[1]*Laboratorio de Helmintología, Instituto de Biología, Universidad Nacional Autónoma de México, México and* [2]*Departamento de Biología Evolutiva, Facultad de Ciencias, Universidad Nacional Autónoma de México, México*

Abstract

Aim The distributional patterns of helminthological fauna of freshwater fishes were analysed to postulate a general hypothesis on the relationships of some Mexican hydrological systems.

Location Eight hydrological systems of central and eastern Mexico were studied and compared with records from Nicaragua.

Methods A Parsimony Analysis of Endemicity (PAE) was applied to the presence/absence of ninety-two helminth parasite taxa (Monogeneans, Digeneans, Cestodes, Acanthocephalans and Nematodes) of freshwater fishes, from eight Mexican hydrological systems, using the Hennig86 program.

Results The results represent the first attempt for a biogeographical analysis through application of the PAE method to the distributional patterns of helminth parasites of freshwater fishes in Mexico. A single most parsimonious cladogram was obtained, which grouped all the Neotropical systems in accordance with previous proposals based on other plant and animal taxa.

Main conclusions The most basal systems were Santiago and Lerma basins, which exhibited Nearctic affinities. The remaining areas of the cladogram showed Neotropical affinities. All the southeastern systems were grouped in a clade with the Nicaragua system, providing support for a 'Mesoamerican province' based on helminth parasites of cichlids. The cladogram also suggests that the treatment of the Lerma-Santiago basin as a single biogeographical unit is inaccurate and that they should be treated as separate systems.

Keywords
Biogeography, helminth parasites, freshwater fishes, hydrological basins, Mexico, parsimony.

INTRODUCTION

Recent research on the helminth parasites of freshwater fishes in the hydrological basins of Mexico has greatly increased the knowledge of the helminth fauna of these areas. In an effort to propose a general hypothesis on the relationships between several Mexican hydrological basins, data set contained in these studies was used to create a data base for use in a Parsimony Analysis of Endemicity (PAE).

At least 375 freshwater fish species occur in Mexico, and this increases to over 500 species when those living in estuaries and coastal lagoons are included (Miller, 1982; Espinosa-Pérez *et al.*, 1998). Physical, climatic and ecological barriers of Mexico have affected the geographical distribution of its fish fauna (Álvarez & Lachica, 1974). Mexico also holds a unique place in the biogeography of the Americas because it straddles the transition between

---

*Correspondence: Rogelio Aguilar-Aguilar, Laboratorio de Helmintología, Instituto de Biología, Universidad Nacional Autónoma de México, Apartado Postal 70-153, C.P. 04510, D.F., México.
E-mail: raguilar@mail.ibiologia.unam.mx

© 2003 Blackwell Publishing Ltd

the Nearctic and Neotropical biogeographical regions. The Nearctic region includes almost all of North America, including the Mexican Highlands province, and its southern boundary lies along the Mexican Transvolcanic Belt (Halffter, 1976). The Neotropical region includes southern Mexico, Central and South America. Some authors place its northern limit in the Papaloapan basin, in the coastal plains of the state of Veracruz (Vidal-Martínez & Kennedy, 2000). Each region can be divided into subregions or provinces based on the congruence of the distribution patterns of the taxa inhabiting them (Morrone *et al.*, 1999). Using distributional data of different taxa, mainly vascular plants, arthropods and vertebrates, a revised regionalization of the Nearctic and Neotropic provinces in Mexico has been proposed (Morrone *et al.*, 1999; Morrone, 2001).

Of the wild animals used in biogeographical studies, helminth parasites have scarcely been used. The work by Vidal-Martínez & Kennedy (2000) on the helminth fauna of cichlid fishes is the unique previous study addresing some areas of Mexico. Based on helminth data, these authors claim a close similarity between Central America and southern Mexico, suggesting this area be regarded as a 'Mesoamerican province' of the Neotropics.

Recent surveys of the helminth parasites of freshwater fishes in several Mexican hydrological basins (Salgado-Maldonado *et al.*, 2001a,b, 2003a,b,c), indicate that the composition of helminth communities in different host species includes species with wide geographical distributions, and other species with more restricted distributions. This is especially the case in the Mexican Highland Plateau, where the Lerma-Santiago river basin is considered a centre of endemism (Salgado-Maldonado *et al.*, 2001b). Also, there are helminth species that exhibit a close ecological association to certain freshwater fish families throughout their distributional range, such as tropical cichlid and characid fishes (Salgado-Maldonado *et al.*, 2003a). This host specifity is determinant in helminth community composition in some tropical fishes, and can explain the distributional patterns of some helminth species.

Given these characteristics, the helminth parasites of freshwater fishes in Mexican hydrological basins offer an excellent opportunity to study distributional patterns, and to compare these patterns with those previously identified for other biological groups. However, the lack of cladistic analyses of the helminthological fauna of freshwater fishes, prevents any formal cladistic biogeographical analysis using comparison of taxon–area cladograms.

Although PAE is not considered an historical method (Humphries & Parenti, 1999), some authors (e.g. Morrone, 1994; Luna *et al.*, 1999; Morrone *et al.*, 1999; Cavieres *et al.*, 2002) propose its use for forwarding a preliminary hypothesis of relationships between analysed areas. This hypothesis can then be tested under a formal cladistic biogeographical protocol. Currently, this method has been applied to vascular plants, insects and vertebrates in different regions of the world, principally in Latin America (e.g. Luna *et al.*, 1999; Morrone *et al.*, 1999; Cavieres *et al.*, 2002). The objective of the present study is to propose a general hypothesis on the relationships of Mexican hydrological systems, using a PAE based on the distributional patterns of their helminth parasites of freshwater fishes. The resulting relationships can then be used to test the concordance of these distributions with previously proposed biogeographical generalizations.

MATERIALS AND METHODS

Using published faunal surveys (Kritsky *et al.*, 1994; Moravec *et al.*, 1995, 2002a,b,c; Scholz *et al.*, 1995a,b, 1996, 2001; Moravec, 1998; Caspeta-Mandujano *et al.*, 1999, 2000, 2002; Mendoza-Franco *et al.*, 1999; Caspeta-Mandujano & Moravec, 2000; Choudhury & Pérez, 2001; Mendoza-Franco & Vidal-Martínez, 2001; Pérez, 2001; Salgado-Maldonado *et al.*, 2001a,b, 2004a,b,c; Scholz & Salgado-Maldonado, 2001; Moravec & Salgado-Maldonado, 2002, 2003; Aguilar-Aguilar *et al.*, 2003), a data matrix of the presence/absence was assembled containing data for ninety-two helminth parasites taxa (including monogeneans, digeneans, cestodes, acanthocephalans and nematodes) in freshwater fishes from Mexican hydrological basins and bodies of water in the state of Tabasco and the Yucatán Peninsula. We recognize that the bodies of water sampled in Tabasco (Salgado-Maldonado *et al.*, 2003c) do not conform a single basin, but rather correspond to the lower reaches of several large main drainages, mainly the Grijalva and Usumacinta river systems. Also, despite the lack of surface watercourses on the Yucatán Peninsula, and that the sinkholes and other water sources do not form a single drainage basin, they were grouped as a single basin in this analysis for the sake of clarity and data manageability. Additional data from authors' research recorded for helminths from the Papaloapan river basin were also included in the data base. All surveys used to build the data base were taxonomically validated to detect and updating synonyms.

The units of analysis were eight Mexican river basins (Fig. 1). For comparative purposes, helminthological records from Nicaragua (middle Central America) (Watson, 1976; Vidal-Martínez & Kennedy, 2000; Aguirre-Macedo *et al.*, 2001a,b; Vidal-Martínez *et al.*, 2001b) were also included in the analysis. Study units were delimited based on the Mexican hydrological basins map produced by the Comisión Nacional para el Conocimiento y uso de la Biodiversidad (CONABIO) (see de Alba & Reyes, 1998). To test the naturalness of Lerma-Santiago river basin as a single biogeographical unit, we treated the two drainages as two separate basins in this study. This was done because some studies about the fish or helminth fauna of fishes (Miller, 1986; Salgado-Maldonado *et al.*, 2001b), treated the Lerma-Santiago river basin as a unit, while other studies were carried out only in one of these basins (Díaz-Pardo *et al.*, 1993; Soto-Galera *et al.*, 1998).

The PAE, originally proposed by Rosen (1988), groups areas (analogous to taxa) by their shared taxa (analogous to characters) according to the most parsimonious cladogram. PAE data consist of an area-by-taxa matrices and the resulting cladograms represent nested sets of areas

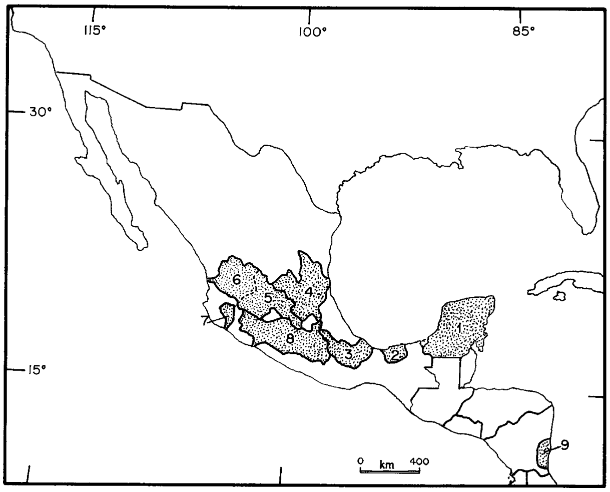

Figure 1 Mexican hydrological systems considered in the analysis. The areas displayed belong to the main basin. Main river inside each area are not shown. 1 = Yucatán hydrological system, 2 = Tabasco hydrological system, 3 = Papaloapan river basin, 4 = Pánuco river basin, 5 = Lerma river basin, 6 = Santiago river basin, 7 = Ayuquila river basin, 8 = Balsas river basin, 9 = Nicaragua hydrological system.

(Morrone, 1994; Morrone & Crisci, 1995). The matrix for this study was prepared by coding taxa for the absence (0) or presence (1) in each area (Appendix 1). Taxa found in a single area (equivalent to autapomorphies) are not useful in assessing biogeographical relationships, and so were excluded from the matrix. *Posthodiplostomum minimum* (MacCallum, 1921) and *Contracaecum* sp. were also excluded from the analysis, because they were shared by all analysed hydrological basins.

Biogeographical analysis was carried out with the Hennig86 program (Farris, 1989) applying the ie* option, which calculates all possible most parsimonious trees. The cladogram was rooted using a hypothetical area coded with all zeros.

RESULTS

The PAE yielded a single most parsimonious area cladogram, with 153 steps, consistency index of 0.60, and retention index of 0.64 (Fig. 2; species diagnosing the nodes in the cladogram are detailed in Tables 1 and 2). Seven nested monophyletic groups were distinguished within the cladogram. The most basal areas, indicating Nearctic affinities, were occupied by the Lerma and Santiago river basins. The remaining areas showed Neotropical affinities. The Neotropical clade includes Ayuquila, Balsas, Pánuco, Papaloapan, Tabasco, Yucatán, and Nicaragua hydrological basins. The Tabasco, Yucatán, Papaloapan and Nicaragua basins formed a clade. There were a total of 120 helminth taxa restricted to a single analysed hydrological basins, which represent autapomorphies (see Appendix 2), and that were thus excluded from the matrix.

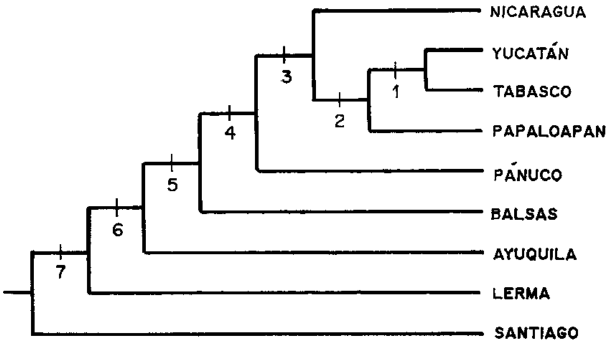

Figure 2 Area cladogram obtained by Parsimony Analysis of Endemicity. Species diagnostic for each node are given in Table 1.

DISCUSSION

The most parsimonious tree obtained represents a hypothesis of relationships between different hydrological basins in Mexico. In the cladogram, resultant clades group areas involving different biogeographical provinces and regions.

Relationships on the area cladogram are based on a data base from all available published records. At present there is a reasonable data set for helminth parasites of cichlids in southeastern Mexico (Salgado-Maldonado *et al.*, 1997; Vidal-Martínez & Kennedy, 2000; Vidal-Martínez *et al.*, 2001a); however, the data base for the helminths of other freshwater fishes is incomplete because each hydrological system has only been partially explored. Consequently, no information exists on the occurrence of helminth parasites in a large number of fish species, meaning that these results can be modified or supported by new data in the future; also, there may be a considerable number of helminth species not detected in one area because sampling effort was not sufficient, then some of the zero values in the presence/absence matrix may not be true absences. Despite these limitations, to date the data base used in this study is the most complete reference of helminthological records in each Mexican hydrological basin.

Anthropogenic movement of fish species has lead to the introduction of exotic helminth species including *Actinocleidus fergusoni*, *Bothriocephalus acheilognathi*, *Centrocestrus formosanus* and *Pseudocapillaria tomentosa* among others (see Scholz & Salgado-Maldonado, 2000; Moravec *et al.*, 2001; Aguilar-Aguilar *et al.*, 2003; Salgado-Maldonado & Pineda-López, 2003), into the hydrological basins included in the data base. None of the clades were supported by these introduced species, and thus it was concluded that these helminths have no influence on the relationships proposed in the cladogram.

The Lerma and Santiago river systems located in the Mexican Plateau biogeographical province, have traditionally been treated as a single hydrological system, namely the Lerma-Santiago basin (see Miller, 1986; de Alba & Reyes, 1998). This proposal has been used in some helminthological studies carried out in this area (Salgado-Maldonado *et al.*,

Table 1 Data matrix of helminth taxa. Consecutive numbers refer to Appendix 1

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Root	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nicaragua	0	0	0	0	1	0	1	0	0	0	1	0	0	0	1	0	1	0	1	0	1	1	1
Yucatán	0	0	0	0	0	0	1	0	0	1	1	1	0	0	0	0	1	1	0	1	1	1	1
Tabasco	0	0	0	1	0	0	1	1	1	1	1	0	0	0	0	1	1	0	1	1	1	0	1
Santiago	0	1	0	0	0	0	0	1	1	1	0	0	1	0	0	0	0	0	1	0	0	0	0
Pánuco	0	0	0	0	0	0	1	1	1	1	1	0	0	1	1	0	1	0	1	0	1	1	0
Balsas	1	0	0	0	0	0	1	0	1	1	0	0	1	1	1	0	1	0	1	1	1	1	1
Ayuquila	1	0	1	0	0	0	1	1	1	1	0	0	0	1	1	0	1	0	0	0	1	1	0
Lerma	0	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	0	0	0	0	0
Papaloapan	0	0	0	0	0	1	1	0	1	0	0	0	1	0	1	1	1	1	1	0	1	1	1
	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46
Root	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nicaragua	1	0	0	0	0	1	0	0	1	0	0	0	1	0	0	0	0	1	1	0	1	1	0
Yucatán	1	0	0	0	0	1	0	1	1	0	1	0	1	0	0	0	1	1	1	0	1	1	1
Tabasco	1	0	0	0	0	1	0	0	1	0	1	0	1	0	1	1	1	1	1	0	1	1	1
Santiago	0	0	1	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Pánuco	1	1	0	1	1	1	1	0	1	1	0	0	1	0	0	1	0	1	1	1	1	0	0
Balsas	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ayuquila	1	0	0	1	0	1	1	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0
Lerma	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Papaloapan	1	1	0	0	0	1	1	0	1	0	0	1	1	1	0	0	1	1	1	1	1	0	0
	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69
Root	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nicaragua	1	0	0	1	0	1	0	1	0	0	0	0	0	0	0	1	0	1	1	0	1	0	1
Yucatán	1	1	1	1	1	1	1	1	1	0	1	1	1	0	1	1	1	0	1	1	1	1	1
Tabasco	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Santiago	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pánuco	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Balsas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ayuquila	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lerma	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Papaloapan	1	0	1	1	0	0	0	1	0	1	1	0	0	1	0	1	0	0	1	0	1	1	1
	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92
Root	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nicaragua	0	0	0	0	0	1	1	1	0	0	0	0	0	1	0	0	0	1	1	1	0	0	1
Yucatán	1	1	1	1	0	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	0
Tabasco	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	1
Santiago	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pánuco	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0
Balsas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ayuquila	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lerma	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Papaloapan	1	1	0	0	1	1	0	0	0	0	0	0	1	1	1	1	0	1	1	0	1	1	0

2001b). The present analysis results contrast with this hypothesis, because both Lerma and Santiago river basins are located in different positions in the cladogram, suggesting that their faunas actually represent different assemblages. Different fish species composition records from these two basins support this separation. However, the Lerma basin has been more extensively studied for its helminths than the Santiago basin, which could produce significant bias in these results.

The helminthological fauna of Lerma and Santiago basins, apparently exhibit greater affinities with the Nearctic region, as about 90% of the taxa from both basins are also present in freshwater fishes of North America (see Hoffman, 1999). These Nearctic affinities are also supported by the distribution of freshwater fishes (Álvarez & Lachica, 1974; Miller & Smith, 1986).

The analysis demonstrated the presence of a Neotropical clade, with a close relationship between Yucatán and Tabasco. Both Tabasco and Papaloapan, however, belong to the Mexican Gulf biogeographical province, while Yucatán is considered an independent province of the Neotropical region (Morrone, 2001). Nicaragua occupied the most basal position of this clade. In their analysis of the helminth fauna of the cichlid fishes in southeastern Mexico, Central America and South America, Vidal-Martínez & Kennedy (2000) suggested a close relationship between the helminth fauna of

Table 2 Detail of the taxa defining the nodes in the cladogram. Asterisks indicate species which support only partially the groups

Node	Taxa
1	*Ascocotyle chandleri*, *Ascocotyle leighi*, *Ascocotyle macrostoma*, *Ascocotyle nunezae*, *Cichlasotrema ujati*, *Cichlidogyrus dossoui*, *Dendrouterina papillifera*, *Glossocercus caribaensis*, *Goezia* sp., *Haplorchis pumilio*, *Homalometron pallidum*, *Pelaezia loossi*, *Riberoia ondatrae*, *Sciadicleithrum splendidae*, *Tabascotrema verai*, *Valipora mutabilis**
2	*Ameloblastella chavarriai*, *Aphanoblastella travassosi*, *Ascocotyle mcintoshi**, *Ascocotyle megalocephala**, *Crocodilicola pseudostoma*, *Drepanocephalus* sp.*, *Echinochasmus leopoldinae*, *Genarchella isabellae*, *Guavinella tropica**, *Mexiconema cichlasomae*, *Neophilometroides caudata**, *Octospiniferoides chandleri*, *Paracapillaria texeirafreitasi*, *Urocleidoides* sp.
3	*Ascocotyle diminuta*, *Ascocotyle nana*, *Atrophecaecum astorquii**, *Cladocystis trifolium*, *Falcaustra* sp., *Genarchella tropica*, *Oligogonotylus manteri*, *Perezitrema bychowskyi**, *Procamallanus rebecae*, *Tylodelphis* sp., *Serpinema trispinosum*, *Sciadicleithrum meekii**, *Sciadicleithrum mexicanum**, *Stunkardiella minima*
4	Apharyngostrigea gen. sp., *Crassicutis cichlasomae*, *Genarchella astyanactis**, *Procamallanus neocaballeroi*, *Sciadicleithrum bravohollisae*
5	*Diplostomum compactum**, *Neoechinorhynchus golvani**
6	*Ascocotyle tenuicollis**, *Magnivitellinum simplex**, *Rhabdochona kidderi*, *Saccocoelioides sogandaresi*, *Uvulifer amblopites*
7	*Clinostomum complanatum*, *Spiroxys* sp.

the Atlantic coastal drainages of Nicaragua and southeastern Mexico. Based on this, they proposed a Mesoamerican region within the Neotropics based on affinities between Central America and southeastern Mexico. The present analysis results support the findings of Vidal-Martínez & Kennedy (2000). The Neotropical clade produced by PAE in this study is consistent with the scheme of Morrone *et al.* (1999) for the biogeographical provinces of the Neotropical region.

The Pánuco, Balsas and Ayuquila river basins are located in Central Mexico. These three basins are included in the Neotropical region by Morrone (2001), although they belong to different biogeographical provinces. The Pánuco basin is located in the Mexican Gulf province, the Ayuquila basin in the Mexican Pacific Coast province, and the Balsas basin is it own province within the Neotropical region (see Morrone, 2001). Of these three basins, the Pánuco highlights a problem with the province assignment of basins in this area. The Mexican Gulf province includes the Pánuco, Papaloapan and Tabasco hydrological systems, but the present results indicate that these regions do not form a monophyletic group, suggesting that the Mexican Gulf province may not represent an accurate biogeographical unit. However, the helminth fauna of fish species from the Pánuco and Papaloapan basins show similarities, and significant similarities in the fish fauna of the Pánuco and some tropical regions have also been suggested (Miller & Smith, 1986). The position of the Pánuco basin in the cladogram can be explained by the low number of fish species examined from this basin compared with those for Papaloapan, Tabasco and Yucatán. For example, monogeneans represent a significant group supporting the relationships between Tabasco, Yucatán and Papaloapan, but there are no monogenean records from the Pánuco. Evidently, more taxonomic studies will be needed in the Pánuco to test its relationship with the other southeastern hydrological systems of Mexico.

The present study clearly demonstrates the utility of the helminth parasites of freshwater fish species in Mexico in contributing to general biogeographical theory aimed at detecting distributional patterns of Mexican biota. The data base assembled here is especially useful in proposing a general hypothesis of the relationships between several Mexican hydrological basins. These data formed into the nested sets in the area cladogram, indicating hypothetical relationships between the eight basins included in the study. These should be treated as preliminary results because they are based on a relatively small number of helminth taxa. A more accurate biogeographical analysis should be undertaken in the future by considering a larger data set, and incorporating more freshwater taxa, and other hydrological systems. The hypothetical relationships between Mexican basins proposed here can be tested through comparison of taxon–area cladograms of their taxa through an analysis of cladistic biogeography.

ACKNOWLEDGMENTS

We thank R. Griselda Moreno-Navarrete, Sandra Córdoba, Guillermina Cabañas-Carranza, Rafael Báez-Valé, Eduardo Soto-Galera, Raúl Pineda-López, Carlos Mendoza-Palmero, Mirza P. Ortega-Olivares, Elizabeth Mayén-Peña, Petra Sánchez-Nava, Juan M. Caspeta-Mandujano and Felipe Villegas Márquez for technical assistance in the field and laboratory. To Norman Mercado-Silva and two anonymous referees for revising the manuscript. RAA and RCM were supported by Research Doctoral Fellowships numbers 138534 and 169858, respectively, from the Consejo Nacional de Ciencia y Tecnología (CONACyT), México. This work was partially supported by Project 27668N from the Consejo Nacional de Ciencia y Tecnología (CONACyT). This paper is dedicated to our newborns Rogelio Aguilar Moreno and Julio César Contreras Córdoba.

REFERENCES

Aguilar-Aguilar, R., Salgado-Maldonado, G., Moreno-Navarrete, R.G. & Cabañas-Carranza G. (2003) Helmintos parásitos de peces dulceacuícolas de la Sierra Madre Oriental, México. *Biodiversidad de la Sierra Madre Oriental: un estudio multidisciplinario* (ed. by I. Luna, J.J. Morrone and D. Espinosa). Universidad Nacional Autónoma de México, México.

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

Aguirre-Macedo, M.L., Scholz, T., González-Solís, D., Vidal-Martínez, V.M., Posel, P. Arjona-Torres, G., Siu-Estrada, E. & Dumailo, S. (2001b) Larval helminths parasitizing freshwater fishes from the Atlantic Coast of Nicaragua. *Comparative Parasitology*, **68**, 42–51.

de Alba, E. & Reyes, M.E. (1998) El contexto físico. *La diversidad biológica de México: Estudio de país, 1998*, (ed. by CONABIO), pp. 4–22. Comisión Nacional para el Conocimiento y uso de la Biodiversidad, México.

Álvarez, T. & Lachica, F. (1974) Zoogeografía de los vertebrados de México. *El escenario geográfico* (ed. by A. Flores-Díaz, T. González-Quintero and F. Lachica), pp. 221–295. Instituto Nacional de Antropología e Historia, México.

Caspeta-Mandujano, J.M. & Moravec, F. (2000) Two new intestinal nematodes of *Profundulus labialis* (Pisces, Cyprinodontidae) from fresh waters in Mexico. *Acta Parasitologica*, **45**, 332–339.

Caspeta-Mandujano, J.M., Moravec, F. & Salgado-Maldonado, G. (1999) Observations on cucullanid nematodes from freshwater fishes in Mexico, including *Dichelyne mexicanus* sp. n. *Folia Parasitologica*, **46**, 289–295.

Caspeta-Mandujano, J.M., Moravec, F. & Aguilar-Aguilar, R. (2000) *Cucullanus mexicanus* sp. n. (Nematoda: Cucullanidae) from the intestine of the freshwater catfish *Rhamdia guatemalensis* (Pimelodidae) in Mexico. *Helminthologia*, **37**, 215–217.

Caspeta-Mandujano, J.M., Aguilar-Aguilar, R. & Salgado-Maldonado, G. (2002) *Rhabdochona guerreroensis* n. sp. (Nematoda: Rhabdochonidae) from the intestine of the gobiid *Sicydium multipunctatum* from fresh waters in Mexico. *Journal of Parasitology*, **88**, 746–749.

Cavieres, L.A., Arroyo, M.T.K., Posadas, P., Marticorena, C., Matthei, O., Rodríguez, R., Squeo, F.A. & Arancio, G. (2002) Identification of priority areas for conservation in an arid zone: application of parsimony analysis of endemicity in vascular flora of the Antofagasta region, northern Chile. *Biodiversity and Conservation*, **11**, 1301–1311.

Choudhury, A. & Pérez, P.G. (2001) *Spinitectus osorioi* n. sp. (Nematoda: Cystidicolidae) from *Chirostoma* spp. (Osteichtyes: Atherinidae) in Lake Pátzcuaro, Michoacán, México. *Journal of Parasitology*, **87**, 648–655.

Díaz-Pardo, E., Godínez-Rodríguez, M.A., López-López, E. & Soto-Galera, E. (1993) Ecología de los peces de la cuenca del río Lerma, México. *Anales de la Escuela Nacional de Ciencias Biológicas, México*, **39**, 103–127.

Espinosa-Pérez, H., Fuentes, P., Gaspar, M.T. & Arenas, V. (1998) Notas acerca de la ictiofauna mexicana. *Diversidad biológica de México* (ed. by T.P. Ramamoorthy, R. Bye, A. Lot and J. Fa), pp. 227–249. Instituto de Biología, UNAM, Mexico, D.F.

Farris, J.S. (1989) Hennig86: a PC-DOS program for phylogenetic analysis. *Cladistics*, **5**, 163.

Halffter, G. (1976) Distribución de los insectos en la Zona de Transición Mexicana: Relaciones con la entomofauna de Norteamérica. *Folia Entomológica Mexicana*, **35**, 1–64.

Hoffman, G.L. (1999) *Parasites of North American freshwater fishes*. Cornell University Press, Ithaca, NY.

Humphries, C.J. & Parenti, L.R. (1999) *Cladistic biogeography*, 2nd edn. Oxford University Press, New York.

Kritsky, D.C., Vidal-Martínez, V.M. & Rodríguez-Canul, R. (1994) Neotropical Monogenoidea 19. Dactylogyridae of cichlids (Perciformes) from the Yucatán Peninsula, with descriptions of three new species of *Sciadicleithrum*. *Journal of the Helminthological Society of Washington*, **61**, 26–33.

Luna, V.I., Alcántara, O., Espinosa, D. & Morrone, J.J. (1999) Historical relationships of the Mexican cloud forests: a preliminary vicariance model applying Parsimony Analysis of Endemicity to vascular plant taxa. *Journal of Biogeography*, **26**, 1299–1305.

Mendoza-Franco, E. & Vidal-Martínez, V.M. (2001) *Salsuginus neotropicalis* n. sp. (Monogenea: Ancyrocephalinae) from the pike killifish *Belonesox belizanus* (Atheriniformes: Poeciliidae) from southeastern Mexico. *Systematic Parasitology*, **48**, 41–45.

Mendoza-Franco, E., Scholz, T., Vivas-Rodríguez, C. & Vargas-Vázquez, J. (1999) Monogeneans of freshwater fishes from cenotes (sinkholes) of the Yucatán Peninsula, Mexico. *Folia Parasitologica*, **46**, 267–273.

Miller, R.R. (1982) Pisces. *Aquatic biota of Mexico, Central America and West Indies* (ed. by S.H. Hurlbert and A. Villalobos), pp. 486–581. San Diego State University, San Diego, CA.

Miller, R.R. (1986) Composition and derivation of the freshwater fish fauna of Mexico. *Anales de la Escuela Nacional de Ciencias Biológicas, México*, **30**, 121–153.

Miller, R.R. & Smith, M.L. (1986) Origin and geography of the fishes of Central Mexico. *Zoogeography of North American freshwater fishes* (ed. by C.H. Hocutt and E.O. Wiley), pp. 487–517. John Wiley and Sons, Inc., New York.

Moravec, F. (1998) *Nematodes of freshwater fishes of the Neotropical region*. Academia, Praha, Czech Republic.

Moravec, F. & Salgado-Maldonado, G. (2002) Redescription of *Perezitrema bychowskyi* (Caballero & Caballero, 1975) (Trematoda: Macroderoididae), with remarks on the systematic status of *Perezitrema* Barus & Moravec, 1996. *Systematic Parasitology*, **53**, 199–206.

Moravec, F. & Salgado-Maldonado, G. (2003) *Cystoopsis atractostei* n. sp. (Nematoda: Cystoopsidae) from the subcutaneous tissue of the tropical gar, *Atractosteus tropicus* (Pisces), in Mexico. *Journal of Parasitology*, **89**, 137–140.

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

Moravec, F., Aguilar-Aguilar, R. & Salgado-Maldonado, G. (2001) Systematic status of *Capillaria patzcuarensis* Osorio-

Sarabia, Pérez-Ponce de León et Salgado-Maldonado, 1986 (Nematoda: Capillariidae) from freshwater fishes in Mexico. *Acta Parasitologica*, **46**, 8–11.

Moravec, F., García-Magaña, L., & Salgado-Maldonado, G. (2002a) *Spinitectus tabascoensis* sp. nov. (Nematoda: Cystidicolidae) from *Ictalurus furcatus* (Pisces) in southeastern Mexico. *Acta Parasitologica*, **47**, 224-227.

Moravec, F., Salgado-Maldonado, G. & Aguilar-Aguilar, R. (2002b) Two new nematodes, *Paraseuratoides ophisterni* gen. et sp. n. (Quimperiidae) and *Philometra ophisterni* sp. n. (Philometridae), from the swamp-eel *Ophisternon aenigmaticum* in Mexico. *Folia Parasitologica*, **49**, 109–117.

Moravec, F., Salgado-Maldonado, G. & Aguilar-Aguilar, R. (2002c) *Neophilometroides* n. gen. (Nematoda: Philometridae) for *Philometroides caudatus* Moravec, Scholz and Vivas-Rodríguez, 1995, with erection of Neophilometroidinae n. subfam. *Journal of Parasitology*, **88**, 774–777.

Morrone, J.J. (1994) On the identification of areas of endemism. *Systematic Biology*, **43**, 438–441.

Morrone, J.J. (2001) *Biogeografía de América Latina y el Caribe*. SEA y M & T Tesis, Zaragoza, España.

Morrone, J.J. & Crisci, J.V. (1995) Historical biogeography: introduction to methods. *Annual Review of Ecology and Systematics*, **26**, 373–401.

Morrone, J.J., Espinosa, D., Aguilar, C. & Llorente, J. (1999) Preliminary classification of the Mexican biogeographic provinces: a parsimony analysis of endemicity based on plant, insect, and bird taxa. *The Southwestern Naturalist*, **44**, 507–514.

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 bravoe* Lamothe, 1970. *Journal of Parasitology*, **87**, 1112–1114.

Rosen, B.R. (1988) From fossils to earth history: applied historical biogeography. *Analytical biogeography* (ed. by A.A. Myers and P.S. Giller), pp. 437–481. Chapman & Hall, London.

Salgado-Maldonado, G., & Pineda-López, R. (2003) *Bothriocephalus acheilognathi* Yamaguti, 1934. *Biological Invasions*, **5**, 261–268.

Salgado-Maldonado, G., Pineda-López, R.F., Vidal-Martínez, V.M. & Kennedy, C.R. (1997) A checklist of the metazoan parasites of native cichlid fishes from Mexico. *Journal of the Helminthological Society of Washington*, **64**, 195–207.

Salgado-Maldonado, G., Cabañas-Carranza, G., Caspeta-Mandujano, J.M., Soto-Galera, E., Mayén-Peña, E., Brailovsky, D. & Báez-Valé, R. (2001a) Helminth parasites of freshwater fishes of the Balsas river drainage basin of Southwestern Mexico. *Comparative Parasitology*, **68**, 196–203.

Salgado-Maldonado, G., Cabañas-Carranza, G., Soto-Galera, E., Caspeta-Mandujano, J.M., Moreno-Navarrete, R.G., Sánchez-Nava, P. & Aguilar-Aguilar, R. (2001b) A checklist of helminth parasites of freshwater fishes from the Lerma-Santiago river Basin, Mexico. *Comparative Parasitology*, **68**, 201–218.

Salgado-Maldonado, G., Cabañas-Carranza, G., Soto-Galera, E., Pineda-López, R., Caspeta-Mandujano, J.M., Aguilar-Castellanos, E. & Mercado-Silva, N. (2004a) Helminth parasites of freshwater fishes of the Pánuco river basin East, Central Mexico. *Comparative Parasitology*, **71** (in press).

Salgado-Maldonado, G., Mercado-Silva, N., Cabañas-Carranza, G., Caspeta-Mandujano, J.M., Aguilar-Aguilar, R. & Iñiguez-Dávalos, L.I. (2004b) Helminth Parasites of freshwater fishes of the Ayuquila river, Sierra de Manantlán Biosphere Reserve, West Central Mexico. *Comparative Parasitology*, **71** (in press).

Salgado-Maldonado, G., Pineda-López, R., García-Magaña, L., López-Jiménez, S., Vidal-Martínez, V.M. & Aguirre-Macedo, L. (2004c) Helmintos parásitos de peces dulceacuícolas. *Biodiversidad del estado de Tabasco, México* (ed. by. J. Bueno-Soria, S. Santiago-Fragoso and F. Álvarez), in press. Instituto de Biología, UNAM, México.

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

Scholz, T. & Salgado-Maldonado, G. (2001) Metacestodes of the family Dilepididae (Cestoda: Cyclophyllidea) parasitizing fishes in Mexico. *Systematic Parasitology*, **49**, 23–40.

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

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

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

Scholz, T., Aguirre-Macedo, M.L. & Salgado-Maldonado, G. (2001) Trematodes of the family Heteropyidae (Digenea) in Mexico: a review of species and new host and geographical records. *Journal of Natural History*, **35**, 1733–1772.

Soto-Galera, E., Díaz-Pardo, E., López-López, E. & Lyons, J. (1998) Fish as indicators of environmental quality in the Río Lerma Basin, México. *Aquatic Ecosystem Health and Management*, **1**, 267–276.

Vidal-Martínez, V.M. & Kennedy, C.R. (2000) Zoogeographical determinants of the composition of the helminth fauna of Neotropical cichlid fish. *Metazoan parasites in the neotropics: a systematic and ecological perspective* (ed. by G., Salgado-Maldonado, A.N. García-Aldrete and V.M. Vidal-Martínez), pp. 227–290. Instituto de Biología, UNAM, Mexico, D.F.

Vidal-Martínez, V.M., Aguirre-Macedo, M.L., Scholz, T., González-Solís, D. & Mendoza-Franco, E. (2001a) *Atlas of the helminth parasites of cichlid fish of Mexico*. Academia, Praha, Czech Republic.

Vidal-Martínez, V.M., Scholz, T. & Aguirre-Macedo, M.L. (2001b) Dactylogyridae of cichlid fishes from Nicaragua, Central America, with descriptions of *Gussevia heterotilapiae* sp. n. and three new species of *Sciadicleithrum* (Monogenea: Ancyrocephalinae). *Comparative Parasitology*, **68**, 76–86.

Watson, D.E. (1976) Digenea of fishes from Lake Nicaragua. *Investigations of the ichthyofauna of Nicaragua lakes* (ed. by T.B. Thorson), pp. 251–260. University of Nebraska, Lincoln, Nebraska.

BIOSKETCHES

Rogelio Aguilar-Aguilar is a PhD candidate at the Instituto de Biología, UNAM, México. He works in helminth parasites of freshwater fishes, especially in their biogeographical features and taxonomy of nematodes. He is professor of Systematics and Biogeography in the Facultad de Ciencias, UNAM.

Raúl Contreras-Medina is a PhD student and professor of Systematics, Biogeography and Plant Biology at the Facultad de Ciencias, UNAM, México. His research focuses on historical biogeography of Mexican biota.

Guillermo Salgado-Maldonado is a researcher at Instituto de Biología, UNAM, México. He is professor of Parasitology and Invertebrate Zoology at the Facultad de Ciencias, UNAM. His research interest focus on helminth parasites of freshwater fishes, taxonomy, surveys, ecology, community assembly, richness, exotic helminth parasite species introduced to Mexico, and biogeography. For further information see http://www.ibiologia.unam.mx

Appendix 1 List of taxa analysed

Number	Taxon
1	*Rhabdochona guerreroensis* Caspeta-Mandujano, Aguilar-Aguilar et Salgado-Maldonado, 2001
2	*Allocreadium mexicanum* Osorio-Sarabia, Pérez et Salgado-Maldonado, 1986
3	*Margotrema bravoe* Lamothe-Argumedo, 1970
4	*Phyllodistomum lacustris* (Loewen, 1929)
5	Cryptogonimidae gen. sp.
6	*Proterodiplostomum* sp.
7	*Clinostomum complanatum* (Rudolphi, 1814)
8	*Diplostomum* sp.
9	*Centrocestus formosanus* (Nishigori, 1924)
10	*Bothriocephalus acheilognathi* Yamaguti, 1934
11	Proteocephalidea gen. sp.
12	*Valipora campylancristota* (Wedl, 1855)
13	*Dichelyne mexicanus* Caspeta-Mandujano, Moravec et Salgado-Maldonado, 1999
14	*Rhabdochona lichtenfelsi* Sánchez-Álvarez, García-Prieto et Pérez, 1998
15	*Eustrongylides* sp.
16	*Gnathostoma* sp.
17	*Spiroxys* sp.
18	*Polymorphus brevis* Van Cleave, 1916
19	*Gyrodactylus* sp.
20	*Urocleidoides costaricencis* (Price et Bussing, 1967)
21	*Saccocoelioides sogandaresi* Lumsden, 1961
22	*Magnivitellinum simplex* Kloss, 1966
23	*Diplostomum compactum* (Lutz, 1928)
24	*Uvulifer ambloplitis*
25	*Glossocercus auritus* (Rudolphi, 1819)
26	*Parvitaenia cochlearii* Coil, 1955
27	*Capillaria cyprinodonticola* Huffman et Bullock, 1973
28	*Rhabdochona canadensis* Moravec et Arai, 1971
29	*Rhabdochona kidderi* Pearse, 1936
30	*Rhabdochona mexicana* Caspeta-Mandujano, Moravec et Salgado-Maldonado, 2000
31	Acuariidae gen. sp.
32	*Neoechinorhynchus golvani* Salgado-Maldonado, 1978
33	*Sciadicleithrum* sp.
34	*Valipora mutabilis* Linton, 1927
35	*Creptotrema agonostomi* Salgado-Maldonado, Cabañas-Carranza et Caspeta-Mandujano, 1998
36	*Ascocotyle tenuicollis* Price, 1935
37	*Spinitectus agonostomi* Moravec et Barus, 1971
38	*Polymorphus* sp.

Appendix 1 *continued*

Number	Taxon
39	Dactylogyridae gen. sp.
40	*Urocleidoides* sp.
41	Apharyngostrigea gen. sp.
42	*Crassicutis cichlasomae* Manter, 1936
43	Tetrabothridae gen. sp.
44	*Procamallanus neocaballeroi* (Caballero-Deloya, 1977)
45	*Perezitrema bychowskyi* (Caballero y Caballero et Caballero-Deloya, 1975)
46	*Cichlasotrema ujati* Pineda-López et Andrade-Salas, 1989
47	*Oligogonotylus manteri* Watson, 1976
48	*Tabascotrema verai* Lamothe-Argumedo et Pineda-López, 1990
49	*Genarchella isabellae* (Lamothe-Argumedo, 1977)
50	*Genarchella tropica* (Manter, 1936)
51	*Homalometron pallidum* Stafford, 1905
52	*Atrophecaecum astorquii* (Watson, 1976)
53	*Pelaezia loossi* (Pérez Vigueras, 1955)
54	*Stunkardiella minima* (Stunkard, 1938)
55	*Ribeiroia ondatrae* (Price, 1931)
56	*Drepanocephalus* sp.
57	*Echinochasmus leopoldinae* Scholz, Ditrich et Vargas Vázquez, 1996
58	*Ascocotyle leighi* Burton, 1936
59	*Ascocotyle chandleri* Lumsden, 1963
60	*Ascocotyle mcintoshi* Price, 1936
61	*Ascocotyle nunezae* Scholz, Vargas-Vázquez, Vidal-Martínez et Aguirre-Macedo, 1997
62	*Ascocotyle diminuta* Stunkard et Haviland, 1924
63	*Ascocotyle macrostoma* (Robinson, 1956)
64	*Ascocotyle mollienisicola* Sogandares-Bernal et Bridgman, 1960
65	*Ascocotyle nana* Ransom, 1920
66	*Haplorchis pumilio* (Looss, 1896)
67	*Cladocystis trifolium* (Braun, 1901)
68	*Crocodilicola pseudostoma* (Willemoes-Suhm, 1870)
69	*Thylodelphis* sp.
70	*Ameloblastella chavarriai* (Price, 1938)
71	*Aphanoblastella travassosi* (Price, 1938)
72	*Cichlidogyrus dossauri* Paperna, 1960
73	*Cichlidogyrus sclerosus* Paperna et Thurston, 1969
74	*Guavinella tropica* Mendoza-Franco, Scholz et Cabañas-Carranza, 2003
75	*Sciadicleithrum bravohollisae* Kritsky, Vidal-Martínez et Rodríguez-Canul, 1994
76	*Sciadicleithrum meekii* Mendoza-Franco, Scholz et Vidal-Martínez, 1997
77	*Sciadicleithrum mexicanum* Kritsky, Vidal-Martínez et Rodríguez-Canul, 1994
78	*Sciadicleithrum splendidae* Kritsky, Vidal-Martínez et Rodríguez-Canul, 1994
79	*Urocleidoides strombicirrus* (Price et Bussing, 1967)
80	*Dendrouterina papillifera* Fuhrmann, 1908
81	*Glossocercus caribaensis* Rysavy et Macko, 1973
82	*Octospiniferoides chandleri* Bullock, 1957
83	*Procamallanus rebecae* Andrade-Salas, Pineda-López et García-Magaña, 1994
84	*Paracapillaria teixeirafreitasi* (Caballero-Rodríguez, 1971)
85	*Mexiconema cichlasomae* Moravec, Vidal-Martínez et Salgado-Maldonado, 1992
86	*Goezia* sp.
87	*Serpinema trispinosum* (Leidy, 1852)
88	*Falcaustra* sp.
89	*Genarchella astyanactis* (Watson, 1976)
90	*Neophilometroides caudata* (Moravec, Scholz et Vivas-Rodríguez, 1995)
91	*Ascocotyle megalocephala* Price, 1932
92	*Prosthenhystera obesa* (Diesing, 1850)

Appendix 2 List of taxa found in a single area

Taxon	Hydrological Basin
Ancyrocephalus sp.	Ayuquila
Dendrorchis sp.	Ayuquila
Microcotylidae gen. sp.	Ayuquila
Procamallanus jalisciensis Moravec, Salgado-Maldonado et Caspeta-Mandujano, 1999	Ayuquila
Atractis bravoe (Osorio-Sarabia, 1984)	Balsas
Goezia nonipapillata Osorio-Sarabia, 1982	Balsas
Hysterothylacium sp.	Balsas
Parvitaenia macropeos (Wedl, 1855)	Balsas
Rhabdochona salgadoi Caspeta-Mandujano et Moravec, 2000	Balsas
Spinitectus humbertoi Caspeta-Mandujano et Moravec, 2000	Balsas
Valipora minuta (Coil, 1950)	Balsas
Caryophyllidea gen. sp.	Lerma
Crepidostomum cooperi Hopkins, 1931	Lerma
Cyclophyllidea gen. sp.	Lerma
Cyclustera ralli (Underwood et Dronen, 1986)	Lerma
Diplostomum (*Tylodelphys*) sp.	Lerma
Gyrodactylus elegans Nordmann, 1832	Lerma
Ligula intestinalis (Linnaeus, 1758)	Lerma
Margotrema guillerminae Pérez, 2001	Lerma
Octomacrum mexicanum Lamothe-Argumedo, 1981	Lerma
Ochetosoma sp.	Lerma
Paradilepis caballeroi Rysavy et Macko, 1973	Lerma
Paradilepis sp.	Lerma
Paradilepis urceus (Wedl, 1855)	Lerma
Philometridae gen. sp.	Lerma
Proteocephalus pusillus Ward, 1910	Lerma
Pseudocapillaria tomentosa (Dujardin, 1843)	Lerma
Spinitectus osorioi Choudhury et Pérez, 2001	Lerma
Acanthostomum gnerii Szidat, 1954	Nicaragua
Allocreadiidae gen. sp.	Nicaragua
Brevimulticaecum sp.	Nicaragua
Clinostomum sp.	Nicaragua
Gussevia heterotilapiae Vidal-Martínez, Scholz et Aguirre-Macedo, 2001	Nicaragua
Neochasmus ackerti Watson, 1976	Nicaragua
Saccocoelioides sp.	Nicaragua
Sciadicleithrum bicuense Vidal-Martínez, Scholz et Aguirre-Macedo, 2001	Nicaragua
Sciadicleithrum maculicaudae Vidal-Martínez, Scholz et Aguirre-Macedo, 2001	Nicaragua
Sciadicleithrum nicaraguense Vidal-Martínez, Scholz et Aguirre-Macedo, 2001	Nicaragua
Actinocleidus fergusoni Mizelle, 1938	Pánuco
Paracreptotrematina aguirrepequenoi (Jiménez-Guzmán, 1973)	Pánuco
Pharingonidae gen. sp.	Pánuco
Rhabdochona xiphophori Caspeta-Mandujano, Moravec et Salgado-Maldonado, 2001	Pánuco
Ascocotyle longa Ransom, 1920	Papaloapan
Cucullanus caballeroi Petter, 1977	Papaloapan
Cucullanus mexicanus Caspeta-Mandujano, Moravec et Aguilar-Aguilar, 2000	Papaloapan
Cyclustera ibisae (Schmidt et Bush, 1972)	Papaloapan
Choanoscolex lamothei García-Prieto, 1990	Papaloapan
Echeneiobothrium sp.	Papaloapan
Gibsonnema ophisterni (Moravec, Salgado-Maldonado et Aguilar-Aguilar, 2002)	Papaloapan
Monticellia ophisterni Scholz, de Chambrier et Salgado-Maldonado, 2001	Papaloapan

Appendix 2 *continued*

Taxon	Hydrological Basin
Philometra ophisterni Moravec, Salgado-Maldonado et Aguilar-Aguilar, 2002	Papaloapan
Proteocephalus brooksi García-Prieto, Rodríguez et Pérez, 1996	Papaloapan
Pseudocapillaria ophisterni Moravec, Salgado-Maldonado et Jiménez-García, 2000	Papaloapan
Pygidiopsis pindoramensis (Travassos, 1929)	Papaloapan
Spinitectus mexicanus Caspeta-Mandujano, Moravec et Salgado-Maldonado, 2000	Papaloapan
Beaninema nayaritense Caspeta-Mandujano, Moravec et Salgado-Maldonado, 2001	Santiago
Amphimerus sp.	Tabasco
Amphoteromorphus sp.	Tabasco
Bucephalopsis sp.	Tabasco
Caballerorhynchus lamothei Salgado-Maldonado, 1977	Tabasco
Cichlidogyrus tilapiae Paperna, 1960	Tabasco
Cotylogaster sp.	Tabasco
Cruzia sp.	Tabasco
Cucullanus sp.	Tabasco
Cystoopsis atractostei Moravec et Salgado-Maldonado, 2003	Tabasco
Diplectanocotyla sp.	Tabasco
Encotyllabe sp.	Tabasco
Enterogyrus niloticus Eid et Negm, 1987	Tabasco
Gyrodactylus niloticus Cone, Arthur et Bondad-Reantaso, 1995	Tabasco
Haplorchoides sp.	Tabasco
Ligictaluridus mirabilis (Mueller, 1937)	Tabasco
Mazocreaeoides sp.	Tabasco
Microcotyle sp.	Tabasco
Neochasmus olmecus Lamothe-Argumedo, Pineda-López et Andrade-Salas, 1989	Tabasco
Neodiplectanum sp.	Tabasco
Olmeca laurae Lamothe-Argumedo et Pineda-López, 1990	Tabasco
Palaeocryptogonimus sp.	Tabasco
Palombitrema heteroancistrium Price et Bussing, 1968	Tabasco
Phyllobothriidae gen. sp.	Tabasco
Phyllodistomum sp.	Tabasco
Polymorphus mutabilis (Rudolphi, 1819)	Tabasco
Procamallanus sp.	Tabasco
Proteocephalus singularis La Rue, 1911	Tabasco
Pseudoacanthostomum sp.	Tabasco
Pseudocaencicola batallae Lamothe, Salgado-Maldonado et Pineda-López, 1991	Tabasco
Pseudohaliotrematoides sp.	Tabasco
Raillietnema kritscheri Moravec, Salgado-Maldonado et Pineda-López, 1993	Tabasco
Salsuginus seculus (Mizelle et Arcadi, 1945)	Tabasco
Scutogyrus longicornis (Paperna et Thurston, 1969)	Tabasco
Spinitectus tabascoensis Moravec, García-Magaña et Salgado-Maldonado, 2002	Tabasco
Thynnascaris sp.	Tabasco
Urocleidoides reticulatus Mizelle et Price, 1964	Tabasco
Anacanthocotyle anacanthocotyle Kritsky et Fritts, 1970	Yucatán
Ascocotyle ampullacea Miller et Harkema	Yucatán
Ascocotyle gemina Font, Overstreet et Heard, 1984	Yucatán
Ascocotyle sp.	Yucatán
Bothriocephalus pearsei Scholz, Vargas-Vázquez et Moravec, 1996	Yucatán
Capillaria cichlasomae Moravec, Scholz et Mendoza-Franco, 1995	Yucatán
Capillostrongyloides sp.	Yucatán
Cyclustera capito (Rudolphi, 1819)	Yucatán
Dendrouterina pilherodiae Mahon, 1956	Yucatán
Dollfusentis chandleri Golvan, 1969	Yucatán

Appendix 2 *continued*

Taxon	Hydrological Basin
Echinochasmus sp.	Yucatán
Echinorhynchidae gen. sp.	Yucatán
Echinostomatinae gen. sp.	Yucatán
Euhaplorchis californiensis	Yucatán
Gyrodactylus neotropicalis Kritsky et Fritts, 1970	Yucatán
Heterophydae gen. sp.	Yucatán
Hysterothylacium cenotae (Pearse, 1936)	Yucatán
Nomimoscolex sp.	Yucatán
Paracapillaria rhamdiae Moravec, González-Solís et Vargas-Vázquez, 1995	Yucatán
Phocitremoides ovale Martin, 1950	Yucatán
Physocephalus sexalatus (Molin, 1860)	Yucatán
Porrocaecum sp.	Yucatán
Pseudocapillaria yucatanensis Moravec, Scholz et Vivas-Rodríguez, 1995	Yucatán
Pseudoterranova sp.	Yucatán
Salsuginus neotropicalis Mendoza-Franco et Vidal-Martínez, 2001	Yucatán
Southwellina hispida (Van Cleave, 1925)	Yucatán
Urocleidoides annops Kritsky et Thatcher, 1974	Yucatán
Urocleidoides heteroancistrium (Price et Bussing, 1968)	Yucatán