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Helminth Parasites of *Chapalichthys encaustus* (Pisces: Goodeidae), an Endemic Freshwater Fish From Lake Chapala, Jalisco, Mexico

Andrés Martínez-Aquino, Guillermo Salgado-Maldonado*, Rogelio Aguilar-Aguilar, Guillermina Cabañas-Carranza, and Mirza P. Ortega-Olivares, Instituto de Biología, Universidad Nacional Autónoma de México, Apartado Postal 70-153, CP 04510 México, D. F., México; *to whom correspondence should be addressed. *e-mail: gsalgado@mail.ibiologia.unam.mx*

ABSTRACT: A total of 6 helminth species were recorded during helminthological examination of 50 *Chapalichthys encaustus* from Lake Chapala, Jalisco, Mexico. Helminth species identified included: *Salsuginus* sp. (an undescribed monogenea); *Posthodiplostomum minimum* (metacercariae); *Cyclustera ralli* (metacestode); *Polymorphus brevis* (cystacanth); *Contracaecum* sp. (nematode larvae); and *Rhabdochona lichtenfelsi* (adult nematode). Of these, 2 (*Salsuginus* sp. and *R. lichtenfelsi*) are specialist species. The observed species richness, individual parasite abundance, and diversity were low. Data suggest that host specificity is an important factor contributing to observed community composition and richness. Host feeding habits and helminth species availability seem to determine the characteristics of these helminth assemblages.

Freshwater fishes of the Goodeidae (Pisces: Cyprinodontiforms) include Empechtrynidae and Goodeinae (Webb et al., 2004). Goodeinae includes 17 genera and 36 species, primarily restricted to the Mexican Highland Plateau (Berra, 2001; Webb et al., 2004). *Chapalichthys encaustus* is endemic to a single locality, Lake Chapala, Jalisco, in the Lerma River basin in Central Mexico. *Chapalichthys encaustus* and other endemic taxa are seriously endangered by Lake Chapala's dramatic pollution levels and decreasing water volume (Guzmán-Arroyo et al., 2002). To date, 9 goodeid species have been examined for helminth parasites (Salgado-Maldonado et al., 2001; Pineda-López et al., 2004), but there are still no data on the helminth parasites of *C. encaustus*. This report provides the first information regarding the helminths of *C. encaustus* from its only known geographic locality, Lake Chapala.

In March 2003, 50 specimens of *C. encaustus* caught by fishermen in Lake Chapala (20°14′95″N, 103°10′19″W) were examined for helminth parasites. The fish were taken live to the laboratory and examined within 24 hr of capture using standard procedures (see Sánchez-Nava et al., 2004). All the external surfaces, gills, eyes, viscera, and musculature of each fish were examined using a stereomicroscope. All helminths encountered in each fish were counted and then fixed with hot 4% formalin. Monogeneans, metacercariae, metacestodes, and acanthocephalan cystacanths were stained with Meyer's paracarmine or Ehrlich's hematoxylin, dehydrated using a graded alcohol series, cleared in methyl salicylate, and whole-mounted. Nematodes were cleared with glycerin for light microscopy and stored in 70% ethanol. Voucher specimens of all taxa are on deposit in the Colección Nacional de Helmintos (CNHE), Instituto de Biología, National Autonomous University of Mexico, Mexico City. Infection parameters used are those proposed by Bush et al. (1997), i.e., prevalence (percent infected) and mean infection intensity (mean number of parasites per infected fish).

A species richness sample effort curve was used to determine whether sample size was sufficient to produce an accurate estimate of the pool of helminths parasitizing *C. encaustus* in Lake Chapala (Aho et al., 1991; Salgado-Maldonado et al., 2004). A cumulative species curve was plotted, and the observed values were fitted to the Clench model to assess an asymptotic trend (Clench, 1979). The nonparametric species richness estimator bootstrap was calculated from the observed data to extrapolate the number of missing species at the component community level (Poulin, 1998). Numerical dominance was determined using the Berger–Parker dominance index (Southwood, 1978).

Lengths of the *C. encaustus* examined in this study ranged from 16 to 83 mm (mean 59 ± 13 SD). Examination of the gonads demonstrated that all the collected host specimens were sexually mature adults. A total of 3,560 helminth individuals were collected from the 50 fishes. Six helminth species were identified. These include *Salsuginus* sp., an undescribed monogenean; metacercariae of *Posthodiplostomum minimum* (MacCallum, 1921); metacestode of *Cyclustera ralli* (Underwood and Dronen, 1986); the adult nematode *Rhabdochona lichtenfelsi* Sánchez-Álvarez, García, and Pérez, 1998; and larvae of *Contracaecum* sp. Cystacanths of the acanthocephalan *Polymorphus brevis* Van Cleave, 1916, were also present. Two of these helminth species, *Salsuginus* sp. and *R. lichtenfelsi*, are considered goodeid specialists, the latter being found only in the intestine. *Posthodiplostomum minimum* was the most numerous helminth recovered, accounting for about 95% of the worms collected, followed by *Contracaecum* sp. larvae, which accounted for 2%, and by *R. lichtenfelsi*, which accounted for 1.5%. The remaining species were very infrequent and at low mean intensities. Infection site, number of infected fish, prevalence, and mean intensity of each helminth species are shown in Table I.

Based on the cumulative species curve and the value obtained from the nonparametric species richness estimator (bootstrap = 6.49), indicating a minimum number of missing species remaining to be found at the component community level, the inventory presented here can be said to be complete.

No difference in helminth infection prevalences or mean intensity was observed between host sexes for any of the recorded helminth species. No significant correlation was observed between host size and total number of helminth species or total number of individual helminths for each species.

All hosts were infected with at least 1 helminth species. The number of helminth species per host ranged from 1 to 4. Twenty-one hosts had only a single helminth species, 21 had 2 helminth species, 7 had 3, and just 1 had a maximum of 4 helminth species. The total number of helminth individuals of all species per host varied from 1 to 776, with a mean number of helminths per host of 71.2 ± 125. The mean number of species per host was 1.8 ± 0.8. The Brillouin index varied from 0.318 to 0.593, with a mean diversity value of 0.144 ± 0.181. The Berger–Parker dominance index values varied from 0.56 to 1, with a mean value of 0.9 ± 0.1. The metacercariae of *P. minimum* were the most abundant parasites in 84% of the hosts. Intestines of most hosts were empty because only 14 of the 50 hosts examined possessed the enteric parasite, *R. lichtenfelsi*.

Most helminth species parasitizing *C. encaustus* were larval stages. All these helminth species have been previously recorded in freshwater goodeids of the Lerma–Santiago River basin, as well as from other freshwater fish species in Mexico (Pérez et al., 2000; Salgado-Maldonado et al., 2001; Aguilar-Aguilar et al., 2003; Pineda-López et al., 2004; Sánchez-Nava et al., 2004). The predominance of allogenic larval stages suggests that *C. encaustus* occupies an intermediate level in the local trophic web.

Concomitant with low richness, a second characteristic of the helminth community of *C. encaustus* is dominance by a single helminth species. The dominant *P. minimum* is a common parasite of freshwater fishes from a number of aquatic systems in Mexico. Indeed, it is 1 of the most widely distributed helminth parasites in the freshwater fish of Mexico (Aguilar-Aguilar et al., 2003).

The pool of available helminth species combined with a broad host diet seem to be important factors determining helminth community composition and richness. Pineda-López et al. (2004) reported a pool of 28 helminth species parasitizing 9 goodeid species in the Lerma River basin. Twenty-five of these species are generalists, widely distributed throughout this drainage basin, and would be thus available to any goodeid in this geographic area. However, the presence of all these 25 helminth species in Chapala is unknown. Local availability versus regional availability of parasites might be an important factor determining this characteristic. The opportunistic diet of fishes has been related to high richness in some tropical species (Salgado-Maldonado and Kennedy, 1997; Salgado-Maldonado et al., 2004). *Chapalichthys encaustus* is a generalist feeder, and observations of the gastrointestinal contents of the studied specimens showed their diet to consist principally of algae, insect larvae, and the eggs of *Chirostoma* sp. Four of 6 helminth species recorded in this report enter the host via its food. Therefore, the

TABLE I. Helminth of *Chapalichthys encaustus* (n = 50) in Lake Chapala, Mexico.

Helminth	Infection site(s)*	Number infected	Prevalence (%)	Mean intensity ± SD	CNHE catalog no.
Monogenea					
Salsuginus sp.	G	8	16	3.13 ± 1.55	Not deposited
Larval Digenea					
Posthodiplostomum minimum	L, M, E, Bc	44	88	77.18 ± 130.3	4824
Metacestodes					
Cyclustera ralli	M	1	2	1	4822
Larval Acanthocephala					
Polymorphus brevis	M	3	6	1	4823
Adult Nematoda					
Rhabdochona lichtenfelsi	I	14	28	3.93 ± 2.92	4825
Larval Nematoda					
Contracaecum sp.	M, Bc	20	40	4.05 ± 4.9	4826

* Bc, body cavity; E, eyes; G, gills; I, intestine; L, liver; M, mesentery.

observed richness might be explained because availability of infective stages of parasites to this host can be related to a wide diet. This report confirms the depauperate and dominated nature of the helminth communities of goodeid fishes inhabiting the Mexican Highland Plateau (see Choudhury and Dick, 2000; Pineda-López et al., 2004) and suggests host specificity as an important factor contributing to observed community composition and richness. It also suggests that helminth species availability, together with a host's broad diet, determines helminth species richness.

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