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Helminth fauna of two cyprinid fish (*Campostoma ornatum* and *Codoma ornata*) from the upper Piaxtla River, Northwestern Mexico

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Summary

The helminth parasite fauna of 2 species of freshwater fishes from the upper Piaxtla River in northwestern Mexico was studied. A total of 41 cyprinids, corresponding to 20 *Campostoma ornatum* and 21 *Codoma ornata* were analyzed. Six species of platyhelminths were recorded, including 2 species of monogeneans (*Gyrodactylus* sp. and *Dactylogyrus* sp.), 3 species of digeneans (*Posthodiplostomum minimum, Clinostomum complanatum,* and *Margotrema* sp.), and 1 species of tapeworm (*Bothriocephalus acheilognathi*). Helminth parasite infracommunities were depauperate, showed low richness and diversity values, and were dominated by 1 or 2 helminth species. This pattern is consistent with that observed for the helminth parasite communities in other freshwater fishes in central and northern Mexico.

Keywords: Platyhelminthes; Digenea; Monogenea; Cestoda; parasite communities; Cyprinidae; Mexico

Introduction

The freshwater fish species *Campostoma ornatum* Girard, 1856 and *Codoma ornata* Girard 1856 (Cypriniformes: Cyprinidae) have a widespread distribution in northern Mexico (Espinosa-Pérez *et al.*, 1993; Miller *et al*., 2005; Froese & Pauly, 2009). Both species are relatively common among the freshwater fish fauna of the upper Piaxtla River, which flows from the highlands of the Sierra Madre Occidental to the Pacific Ocean in northwestern Mexico. The helminth fauna of these cyprinids along its distributional range is poorly known. The only available records were recently published by Pérez-Ponce de León *et al*. (2009, 2010) from the upper-Mezquital and the Nazas river basins, respectively. The main objectives of this work are to record the helminth parasite fauna of both species of cyprinids in the upper Piaxtla River by presenting the list of species, and to describe the helminth parasite community structure of each host species through the species richness and diversity atributtes. We briefly compare our findings with data reported by Pérez-Ponce de León *et al*. (2009, 2010) for the same fish species in the Nazas and upper-Mezquital river basins.

Materials and methods

In December, 2008, 20 specimens of *Campostoma ornatum* and 21 of *Codoma ornata* were collected by electrofishing in the upper Piaxtla River (24º 21' 59" N, 105º 31' 7.8" W, altitude 2391 m), located at Municipio San Dimas, Durango State, Northern Mexico. Hosts were taken alive to the laboratory. Once there, hosts were pithed, and examined individually for helminths. Gills and fins were separated in Petri dishes with tap water, and then examined under a stereomicroscope. Other organs (intestine, liver, gall, swim and urinary bladders, and spleen) were examined in separate Petri dishes with 0.65% saline. Platyhelminths were fixed with 4% hot (steaming) formalin, stained with Mayer's paracarmine and mounted as permanent slides in Canada balsam. Several individual monogeneans were fixed in glycerin ammonium-picrate (GAP), to study their sclerotized structures. Voucher specimens of all taxa were deposited in the Colección Nacional de Helmintos (CNHE), Instituto de Biología, Universidad Nacional Autónoma de México, Mexico City (see Table 1). Prevalence (% of infected hosts in a sample), and abundance (mean number of parasites of a single species in the sample) follows definitions by Bush *et al.* (1997). To determine if sample size was sufficient to produce an accu-

rate estimate of the pool of parasites using both host species in the sampled locality, an accumulation species curve and the species richness estimators Chao 1 and Chao 2 were used for each component community. Helminth species were classified from an ecological point of view as dominant (high prevalence and abundance) and rare (low prevalence and abundance) after an Olmstead-Tukey corner test of association (Steel and Torrie, 1981). Infracommunities include all the helminth species in an individual host, and were described by using the mean number of parasite species per host, the mean number of individual helminths, and the mean value of the Brillouin diversity index. Infracommunities were compared qualitatively within the locality using the Jaccard similarity index, and quantitatively using the Morisita-Horn index, as calculated in Magurran (1988).

Results

A total of 148 individual helminths belonging to four species were collected from *Campostoma ornatum*. Helminth species recovered include a fins monogenean *Gyrodactylus* sp., the metacercariae of the digeneans *Posthodiplostomum minimum* from the mesentery and *Clinostomum complanatum* from the body cavity, and the adults of an introduced cestode *Bothriocephalus acheilognathi* from the intestine. The Olmstead-Tukey test for this fish species showed that the monogenean *Gyrodactylus* sp and the metacercariae of *P. minimum* were most frequent (prevalence 95 and 85 %, respectively) and abundant (abundance from 3.1 to 3.25 helminths per analyzed host), while *C. complanatum* and *B. acheilognathi* reached low values for these parameters. Infection site, number of infected fish, prevalence, and abundance for each helminth species are shown in Table 1.

In contrast, a total of 3292 individual helminths belonging to five species were collected from *Codoma ornata*. Helminth species recovered include a gills monogenean of the genus *Dactylogyrus* sp., the adult digenean *Margotrema* sp. from the intestine, the metacercariae of *Posthodiplostomum minimum* and *Clinostomum complanatum*, and the cestode *Bothriocephalus acheilognathi*. The Olmstead-Tukey test showed that only the metacercariae of *P. minimum* was most frequent (prevalence 100 %) and abundant (143.29 worms per analyzed host). The monogenean *Dactylogyrus* sp. and the metacercariae of *C. complanatum* exhibited a high prevalence (100 % and 81%, respectively), but they were not abundant, while *Margotrema* sp. and *B. acheilognathi* showed low prevalence and abundance values (Table 1), and were considered as rare. Infection site, number of infected fish, prevalence, and abundance for each helminth species are shown in Table 1.

In *Campostoma ornatum*, most of the parasite infracommunities (85 %) harbored 2 or more helminth species. In terms of abundance, the total number of individual helminths of all species per analyzed host varied from 1 to 15, with a mean number of 7 ± 3.47. Similarly, parasite infracommunities in *Codoma ornata* harbored 2 or more helminth species, however, the presence of gill monogeneans in 5 hosts was not determined because fish died several hours before examination. For this reason, values of prevalence and abundance for those particular helminth taxa were calculated only for 16 individual hosts (Table 1). The number of helminths of all species per analyzed host was much higher, and varied from 3 to 365, with a mean number of 157 ± 92.39.

Even though, individual hosts of both fish species were infected at least with 1 helminth species, the helminth parasite infracommunities in both host species were relatively species-poor. Most of the infracommunities found in *Campostoma ornatum* (55 %), were composed by three species, and only 2 of them reached a maximum of four species. In terms of species richness, the mean number of species per host was 3 ± 0.88. The Brillouin index for the infracommunities varied from 0 to 0.976, with a mean diversity value of 0.537 ± 0.261, while the Berger-Parker dominance index values varied from 0.333 to 1, with a mean of 0.624 ± 0.194. The helminth infracommunities in *C. ornatum* showed a relatively high level of similarity; the corresponding Jaccard index varied from 0 to 1 (mean of 0.59 ± 0.235) while the Morisita-Horn index varied from 0 to 1 (mean of 0.729 ± 0.215).

In the case of *Codoma ornata*, 42.85% of the infracommunities were also composed by 3 species, and only 2 had a maximum of 5 species. The mean number of species per host was 3.09 ± 0.94. The Brillouin index for the infracommunities varied from 0.043 to 0.571, with a mean diversity value of 0.299 ± 0.163, while the Berger-Parker dominance index values varied from 0.667 to 0.991, with a mean of 0.902 ± 0.078. The helminth infracommunities showed a comparatively higher level of similarity; the corresponding Jaccard index varied from 0.2 to 1 (mean of 0.629 ± 0.224) and the Morisita-Horn index varied from 0.43 to 1 (mean of 0.943 ± 0.15).

Discussion

Helminth taxa

The helminth parasite fauna of the cyprinids *Campostoma ornatum* and *Codoma ornata* in the upper Piaxtla River includes 6 helminth species, 2 monogeneans, 3 digeneans and 1 cestode. The taxonomic composition of the helminth parasite fauna of *Campostoma ornatum* comprises 3 generalist species, which are widely distributed among freshwater fishes in several localities in Mexico (Pérez-Ponce de León *et al.*, 2007; Rojas-Sánchez & García-Prieto, 2008). Species of the monogenean *Gyrodactylus* sp., collected from the fins of their hosts, have been recently recorded from diverse freshwater fishes in central and northern Mexico, where apparently a high species richness of this parasite group is found (Mendoza-Palmero, 2007; Mendoza-Palmero *et al*., 2009; Pérez-Ponce de León *et al*., 2010); further studies will allow us to establish the taxonomic identity and potential host specificity of *Gyrodactylus* species occurring in Mexican freshwater fishes. The specimens we collected might be conspecific with an un-

Table 1. Helminth parasites of *Campostoma ornatum* and *Codoma ornata* in the upper Piaxtla River, Durango, Mexico

		Campostoma ornatum (n = 20)				*Codoma ornata* (n = 21)			
Helminth taxa	Infection site	Infected Hosts (n)	Prevalence (%)	Abundance ± SD	CNHE No.	Infected Hosts (n)	Prevalence (%)	Abundance ± SD	CNHE No.
Monogenea									
Gyrodactylus sp.	Fins	19	95	3.1 ± 1.85	7465	-	-	-	-
Dactylogyrus sp. *	Gills	-	-	-	-	16	100	11.2 ± 9.69	7466
Digenea									
Margotrema sp.	Intestine	-	-	-	-	6	28.57	0.33 ± 0.58	7473
Posthodiplostomum minimum	Mesentery	17	85	3.25 ± 2.47	7467	21	100	143.29 ± 85.8	7468
Clinostomum complanatum	Body cavity	8	40	0.45 ± 0.6	7469	17	80.95	4.33 ± 4.49	7470
Cestoda									
Bothriocephalus acheilognathi	Intestine	8	40	0.5 ± 0.76	7471	5	23.81	0.29 ± 0.58	7472

* Values based on16 host

described species, *Gyrodactylus* sp. 4, reported by Pérez-Ponce de León *et al*. (2010) as a parasite of the fins of *Campostoma ornatum* in the Nazas River Basin, however, this species has not yet been described.

Furthermore, the helminth parasite fauna of *Codoma ornata* includes 3 species that were also found in *Campostoma ornatum*; in addition, the adult digenean *Margotrema* sp. and the monogenean *Dactylogyrus* sp. were also found. Currently, 2 species of *Margotrema* spp., an allegedly parasite of goodeid fishes, have been described in freshwater fishes from central Mexico (Pérez-Ponce de León *et al*., 2007). The distinctive morphological character that distinguishes these species is the extent of the ceca. Unfortunately, the specimens we collected from cyprinids in the Piaxtla River had the uteri full of eggs, impeding the observation of the extent of the ceca. Monogeneans of the genus *Dactylogyrus* have also been found parasitizing freshwater fishes in central and northern Mexico (Mendoza-Palmero, 2007; Pérez-Ponce de León *et al*., 2010). In particular, in cyprinids from a nearby river basin (the Nazas River), 6 species of *Dactylogyrus* have been reported (Pérez-Ponce de León *et al*., 2010), 3 of them common parasites of introduced species of cyprinids, and 1 typically found in cichlids. Other 2 species from cyprinids were considered to represent a new species for which no description has been made. As in the case of the fin monogenean, *Gyrodactylus* sp., we may claim conspecificity to some of these undescribed species, however, we preferred to take a conservative position pending proper description of the undescribed species.

Interestingly, the taxonomic composition of the helminth parasite fauna herein reported for both cyprinid species included only platyhelminthes. No nematodes or acanthocephalans were found in present study. This might be due to a relatively small sample size, even though 20 individual hosts are considered a sufficient sample size to detect parasite species richness in a particular locality, and, in addition to that, there are no missing species according with the information provided by the accumulation species curves and the non-parametric species richness estimators Chao 1 and Chao 2. The absence of such parasite groups contrasts with findings we recently made describing the helminth parasite fauna in of freshwater fishes from the Nazas and the upper-Mezquital river basins, including *Campostoma ornatum* (Pérez-Ponce de León *et al*., 2009, 2010). These river basins are located at relatively short distance from the upper Piaxtla River, even though the former runs westwards from high elevation areas of Durango State, through Nayarit State, to the Pacific coast, while the Nazas River represents an endhorreic basin that runs from the Sierra Madre Occidental eastward, through the states of Durango and Coahuila, into the now-dry Laguna del Mayran (Castañeda-Gaytán *et al*., 2005; Návar *et al*., 2006). In the upper-Mezquital River only 4 individuals of *Campostoma ornatum* were sampled, and 2 helminth species were recorded, the cestode *Bothriocephalus acheilognathi*, and the nematode *Rhabdochona canadensis*. We also sampled 23 individuals of *Codoma ornata* and only the tapeworm *B. acheilognathi* was found (see Pérez-Ponce de León *et al*., 2009).

In contrast, in the Nazas River a much larger sample size was analyzed for both cyprinid species (Pérez-Ponce de León *et al*., 2010). Eighty individuals of *Campostoma ornatum* were studied, and the helminth species recorded were: the digeneans *P. minimum* and *Uvulifer* sp., the cestode *B. acheilognathi*, the nematodes *Spiroxys* sp., and *Rhabdochona canadensis* and two species of monogeneans, an undescribed species of *Gyrodactylus* (recorded as *Gyrodactylus* sp. 4) and *Urocleidoides strombicircus*. In 101 analyzed specimens of *Codoma ornata* only 3 helminth species were recorded, the digenean *P. minimum*, the cestode *B. acheilognathi*, and the nematode *R. canadensis* (Pérez-Ponce de León *et al*., 2010). The absence of *R. canadensis* in cyprinids from the Piaxtla River is noteworthy, since this is a common parasite of cyprinids in North America (see Hoffman, 1999). Likewise, the larval digeneans *P. minimum* and *C. complanatum* are commonly found parasitizing freshwater fishes in México (Pérez-Ponce de León *et al*., 2007), while the species of the genus *Margotrema* are allegedly to be members of the helminth parasite core fauna of goodeid fishes in central Mexico (Pérez-Ponce de León & Choudhury, 2005; Mejía-Madrid *et al*., 2005). The adult cestode *B. acheilognathi* is an autogenic and generalist species whose life cycle is completed in the aquatic ecosystem (Hoffman, 1999). This species was introduced into Mexico along with its hosts, grass carps, from Asia. It possesses a large dispersal capability and as a result, it is now found not only in introduced hosts but also in the native freshwater fish fauna (Rojas-Sánchez and García-Prieto, 2008). No carps (*Cyprinus carpio, Ctenopharyngodon idella*), which are commonly used for aquaculture purposes and are disseminated to natural environments on regular basis, were found during our samplings in the Piaxtla River. It could be possible that the endemic cyprinids we studied became infected with the Asian tapeworm through an ecological host extension from other host species, such as poeciliids, but still this needs to be determined with further samplings in the locality.

Helminth communities

Parasite communities of both species of cyprinids are depauperate and are dominated by one helminth species; this, and the fact that a low species richness values at both, the component community and infracommunity levels, were detected, is consistent with the parasite community structure in a diverse array of freshwater fishes inhabiting in epicontinental waters in central and northern Mexico, corresponding with the Nearctic region (Peresbarbosa-Rojas *et al*., 1994; Espinosa-Huerta *et al*., 1996; Rojas *et al*., 1997; Pérez-Ponce de León *et al*., 2000; Martínez-Aquino *et al*., 2004, 2007; Martínez-Aquino & Aguilar-Aguilar, 2008; Romero-Tejeda *et al*., 2008). Helminth parasite communities in the 2 cyprinids we studied herein also show a numerical dominance by a single or a few helminth species. In the case of *Codoma ornata*, dominance is

mainly exerted by the metacercariae of *Posthodiplostomum minimum*, which shows a high abundance. In *Campostoma ornatum*, two helminth species were dominant, the digenean *P. minimum* and the monogenean *Gyrodactylus* sp.

Based on the results of the species accumulation curves and the species richness estimators, we are confident about the accuracy of species richness and community structure patterns herein described. Both methods were used as indicators of species richness as a function of sample size, even though it is well-known that addressing sample size is a common problem when dealing with prevalence data (see Jovani & Tella, 2006); likewise, our analysis corroborated that the number of analyzed hosts represents a sufficient sample size to recover most members of the parasite community. Since the number of hosts we analyzed in this study fall within the category of "medium sample size" as proposed by Jovani and Tella (2006), it is possible that the prevalence of infection for each parasite species might have been affected, but not the species richness. We are certain that, by gathering a larger dataset on different helminth parasite communities in freshwater fishes, we will be able to establish a correlation between the sample size and the parasite fauna. As a comparison, the 80 specimens of *Campostoma ornatum* and 101 of *Codoma ornata* that were studied in the Nazas River basin by Pérez-Ponce de León *et al*. (2010), contained 7 (i.e., *Uvulifer* sp., *Posthodiplostomum minimum*,, *Gyrodactylus* sp. 4, *Urocleidoides strombicircus, Bothriocephalus acheilognathi, Rhabdochona canadensis*, and *Spiroxys* sp.) and 3 helminth species (i.e., *P. minimum, B. acheilognathi* and *R. canadensis*, respectively. The data we provide in the present paper represents an additional piece of information on the parasite species composition, and patterns of community structure of the helminth parasites of freshwater fishes in Mexico, particularly from lotic environments of the northwestern region. Still, more data needs to be gathered on these species of cyprinids along its distributional range, as well as on other freshwater fish species, in order to describe general patterns of host-parasite associations, and to fully understand the processes that shaped the historical biogeography and community structure of the freshwater fish parasite fauna in Mexico.

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