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Ectoparasites (Crustacea: Branchiura) of *Pseudoplatystoma fasciatum* (surubí) and *P. tigrinum* (chuncuina) in Bolivian white-water floodplains

Ectoparásitos (Crustacea: Branchiura) de *Pseudoplatystoma fasciatum* (surubí) y *P. tigrinum* (chuncuina) en planicies de aguas blancas en Bolivia

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Abstract

The ectoparasites of *Pseudoplatystoma fasciatum* (surubí) and *P. tigrinum* (chuncuina) from Río Ichilo, from oxbow lakes in the Río Ichilo floodplain and from Río Beni were studied. Sampling was carried out between August 1996 and February 1997 and in August and September 1999. Overall, the ectoparasites from the skin, the branchial cavity, the fins and the gills of 163 *P. fasciatum* and of 42 *P. tigrinum* were collected. All fish were found to be infested with ectoparasites. Seven species of Branchiura were recorded, all belonging to the family Argulidae: *Argulus juparanaensis, A. pestifer, A. elongatus, A. nattereri, Dolops discoidalis, D. carvalhoi* and *Dipteropeltis hirundo.* The data of 1996-1997 show that *P. fasciatum* and *P. tigrinum* harbour the same parasite species, *D. hirundo* being the only species that was not recorded on the latter, and the infestation levels on both hosts were similar. In general, *A. juparanaensis, A. pestifer* and *D. carvalhoi* were the most common species on both fish species. There was a marked difference between the parasite community of *P. fasciatum* in the Río Ichilo (dominated by *Argulus* species) and oxbow lakes (dominated by *Dolops carvalhoi*). For this fish species, the similarity between ectoparasite communities from different rivers (Ichilo and Beni) was higher than the similarity between ectoparasite communities from different habitats (river channel and oxbow lakes in the Ichilo basin). The relevance of these results for the ecology of the fish host species is discussed.

keywords: *Argulus*, *dolops*, branchiura, ectoparasites, Bolivia, *Pseudoplatystoma.*

Resumen

Los ectoparásitos de *Pseudoplatystoma fasciatum* (surubí) y *P. tigrinum* (chuncuina) en el Río Ichilo, en lagunas de várzea del Río Ichilo y en el Río Beni fueron estudiados. El muestreo se llevó a cabo entre agosto de 1996 y febrero de 1997 y en los meses de agosto y septiembre de 1999. Las muestras fueron tomadas de la piel, cavidad branquial, agallas y aletas de 163 individuos de *P. fasciatum* y 42 de *P. tigrinum*. Todos los peces se encontraron infestados con ectoparásitos. Se encontraron siete especies de Branchiura (ectoparásitos) que corresponden a la familia Argulidae: *Argulus* *juparanaensis, A. pestifer, A. elongatus, A. nattereri, Dolops discoidalis, D. carvalhoi* y *Dipteropeltis hirundo*. Los datos de 1996-1997 mostraron que *P. fasciatum* y *P. tigrinum* tienen las mismas especies, con excepción de *D. hirundo* la cual no fue encontrada en la última. *A. juparanaensis, A. pestifer* y *D. carvalhoi* fueron las especies más comunes. Sin embargo, hubo una marcada diferencia entre las comunidades de Branchiura de ríos y de lagunas de varzea en *P. fasciatum*. Se observó que la similitud entre comunidades de ectoparásitos originando de diferentes ríos (Ichilo y Beni) fue mayor que la similitud entre comunidades de río y comunidades de laguna de várzea. Se discute el significado de los resultados para la ecología de los huéspedes.

Palabras clave: *Argulus*, *dolops*, branchiura, ectoparásitos, Bolivia, *Pseudoplatystoma.*

Introduction

Pseudoplatystoma fasciatum Linnaeus 1840 (surubí) and *P. tigrinum* Valenciennes 1840 (chuncuina), belonging to the family Pimelodidae (Siluriformes), are widespread fish species in Latin America. They colonized almost all possible habitats in the Amazon: they are common both in the lower and the upper Amazon and reach the headwaters of black and white water rivers (Rodríguez 1992). They can be found in river channels, in inundated forests and in floodplain lakes (Barthem & Goulding 1997). In the Mamoré river basin, they migrate upstream between July and October to spawn in the headwaters of the Ichilo river around January (Muñoz & Van Damme 1998). The growth and migration patterns of these fish species in the Bolivian Amazon was recently studied by Loubens and Panfili (2000).

Pseudoplatystoma species are carnivores that exert a strong pressure on lower food chain links (Barthem & Goulding 1997; Agudelo Córdoba et al. 2000) and probably play a key role in aquatic habitats of the Amazon basin. They undertake complex lateral migrations between rivers, lakes and river floodplains as well as longitudinal movements along river channels (Barthem & Goulding 1997). The latter authors argue that more detailed studies are needed to understand how environmental factors affect the distribution and migration patterns of these pimelodid fish species.

Disease caused by parasite infestation is one of the environmental factors that may affect pimelodid fish biology and regulate fish abundance. According to various authors, ectoparasites have the potential to exert a strong effect on the behaviour and biology of their fish hosts (Scott & Dobson 1989, Dobson 1988). In Bolivia, the most notorious ectoparasites of Amazon fish species belong to the order Branchiura.

Notwithstanding their wide distribution, the branchiuran parasites of fish species in the Bolivian Amazon are poorly known. Most of the previous research was carried out in Brasil and Paraguay by Thatcher (1990). In Bolivia, Hugghins (1970) described the Branchiura of six host species collected in the Mamoré river. Thatcher (1990) reported 8 Branchiuran species on *P. fasciatum* in the Brazilian Amazon and concluded that this is the fish host species with the highest number of recorded Branchiura species so far.

In the present study, we explore the Branchiuran parasite community on two pimelodid fish species (*P. tigrinum* and *P. fasciatum*) from the Bolivian Amazon. Besides the elaboration of a parasite species list, we focus on the distribution patterns of the parasite species in the host populations and on the habitat characteristics that may affect parasite occurrence.

Study area

The Ichilo and Beni rivers form part of the Madeira river basin. The río Ichilo represents the border between the departments of Cochabamba and Santa Cruz, situated in the center of Bolivia. After its confluence with the Río Grande, its name changes to Mamoré (Fig. 1). The Río Beni originates in the department of La Paz and flows in northeast direction before it joins the Río Mamoré in Guayaramerín (Fig. 1).

Both rivers have high discharge rates and have extensive white-water floodplains, characterized by inundated forest and oxbow lakes (Navarro & Maldonado 2003). Both rivers are important for commercial fisheries, with Puerto Villarroel (Río Ichilo) and Rurrenabaque (Río Beni) being the most important fishery ports.

Methods

The results presented in this study were obtained during two fish sampling campaigns. During the first sampling campaign, between August 1996 and February 1997, 82 *P. fasciatum* and 42 *P. tigrinum* were collected in the Río Ichilo basin (in the river channel and oxbow lakes). During the second sampling campaign, in August and September 1999, 75 *P. fasciatum* were collected in the Río Ichilo, in oxbow lakes of the Ichilo basin, and in the Río Beni.

Fishes were captured using gill nets and immediately after capture samples of ectoparasites were taken with pincets from the skin, the gill cavity, the gills and the fins. The

Fig. 1. Study areas in the Bolivian Amazon.

parasites were fixed and conserved in alcohol 85 %. After parasite collection, the total length of the hosts was measured with an ichthyometer. Fish weight was measured with a balance of 50 kg capacity and a sensitivity of ± 0.5 kg.

In the laboratory, the ectoparasites were separated, counted and determined to species level with a binocular. Identification guides from Lemos de Castro (1986) and Thatcher (1990) were used for this purpose.

For each parasite species, the following parameters were calculated (according to Margolis et al. 1981):

Prevalence (%): (Number of fish infestated * 100) / total number of fish
Abundance: Total number of parasites / total number of fish
Intensity: Total number of parasites / total number of infested fish

The Dispersion index (DI) was calculated as variance / abundance (Elliot 1977).

Principal Components Analysis (PCA) was used to represent fish individuals in the plane formed by the two first principal components. Factor loadings were calculated using the program STATISTICA. Subsequently, the correlation between factor scores and fish length was calculated (Pla 1986, Ludwig & Reynolds 1988).

Results

Seven Branchiura species were recorded, four of which belong to the genus *Argulus (A. elongatus* Heller 1857, *A. pestifer* Ringuelet 1948, *A. nattereri* Heller 1857, *A. juparanaensis* Lemos de Castro 1950*)*, two belong to the genus *Dolops* (*D. discoidalis* Bouvier 1899, *D. carvalhoi* Lemos de Castro 1949) and one belongs to the genus *Dipteropeltis (D. hirundo* Calman 1912*)*.

The prevalence, abundance and intensity of infestation of the 7 species of Branchiura recorded from *Pseudoplatystoma fasciatum* and *P. tigrinum* from the Río Ichilo basin in 1996-1997 are presented in Table 1. *Argulus pestifer*, *A. juparanaensis* and *Dolops carvalhoi* were the most abundant parasite species in both hosts. The infection intensities in both species were similar, *Dipteropeltis hirundo* being the only branchiuran species that was not recorded from *P. tigrinum.*

Table 1: Sample size (n), intensity of infestation (i), prevalence (p) and abundance (a) of 7 Branchiuran species on *Pseudoplatystoma fasciatum* and *P. tigrinum* from the Ichilo River basin between August 1996 and February 1997.

Host species	*Pseudoplatystoma fasciatum* (n=82)			*Pseudoplatystoma tigrinum* (n=42)		
Branchiuran species	p	a	i	p	a	i
Argulus juparanaensis	19	0.4	1.9	14	0.2	1.2
Argulus pestifer	35	1.0	3.0	31	1.6	5.2
Argulus elongatus	1	0.01	1	2	0.02	1
Argulus nattereri	5	0.1	2.3	2	0.05	2
Dipteropeltis hirundo	2	0.02	1	-	-	-
Dolops discoidalis	8	0.2	2.4	5	0.07	1.5
Dolops carvalhoi	17	0.7	4.5	10	2.3	3.0

The infestation intensities, prevalences and abundances of parasites on *P. fasciatum* from the Río Ichilo, oxbow lakes in the Ichilo basin and the Río Beni in 1999 are presented in Table 2. In general, fish from oxbow lakes were more heavily infected (18 parasites/fish) than river fish (Río Ichilo: 4.5 parasites / fish; Río Beni: 3.1 parasites / fish). However, there were two Branchiuran species which were never recorded in oxbow lakes: *Argulus juparanaensis* and *A. nattereri*.

In the Ichilo, the most abundant species was *A. juparanaensis*, whereas it was *Dipteropeltis hirundo* in the Beni. In oxbow lakes of the Río Ichilo basin, *D. carvalhoi* (prevalence 79%) was the most common species, followed by *D. discoidales* (prevalence 68 %), two species which were never recorded in rivers.

Figure 2A shows the plane formed by the two first principal components of a PCA analysis of parasites abundances on *P. fasciatum* from the 1999 sampling campaign. There was a remarkable superposition of the fish populations of rivers Ichilo and Beni, whereas the lake fish populations were clearly separated from the riverine populations along the first axis. In figure 2B, the loadings of the Branchiuran species, relative to the two first principal components, are shown. The length of the fish was correlated significantly with the second principal component (Pearson Correlation, $p < 0.05$).

Table 3 and Figure 3 show that the Dispersion Index for most parasite species is generally significantly larger than 1, illustrating the aggregation of the parasites on a few host individuals. Some species (for example *D. hirundo*) have Dispersion Indices close to one and show truncated dispersion patterns.

In Table 4, all the recorded host species for the branchiuran parasites species that were recorded during the present study are listed. It can be seen that three of the *Argulus* species (*A. pestifer, A. elongatus, A. nattereri*) have the highest host specificity, whereas *Dolops* species in general seem to be less specific.

Discussion

Pseudoplatystoma fasciatum and *P. tigrinum* are very similar species that speciated about two million years ago (Coronel et al. 2004). In Table 3, it is shown that the branchiuran parasite communities of these two species have a similar

Table 2: Sample size (n), intensity of infection (i), prevalence (p) and abundance (a) of 7 Branchiuran species on *Pseudoplatystoma fasciatum* from Río Ichilo, oxbow lakes in the Ichilo basin and Río Beni (1999 sampling campaign).

Locality	Río Ichilo (n=41)			Río Beni (n=15)			Oxbow lakes (Río Ichilo) (n=19)		
Species	p	a	i	P	a	i	p	a	i
Argulus juparanaensis	76	2.6	3.4	13	0.3	2.0	0	0	0
Argulus pestifer	42	1.2	2.9	20	0.5	2.3	63	4.6	7.3
Argulus elongatus	5	0.1	1.5	0	0	0.	42	0.7	1.6
Argulus nattereri	5	0.1	1.0	20	0.3	1.3	0	0	0
Dipteropeltis hirundo	32	0.5	1.7	73	2.0	2.7	5	0.1	1.0
Dolops discoidalis	0	0	0	0	0	0	68	2.8	4.1
Dolops carvalhoi	0	0	0	0	0	0	79	9.8	12.5

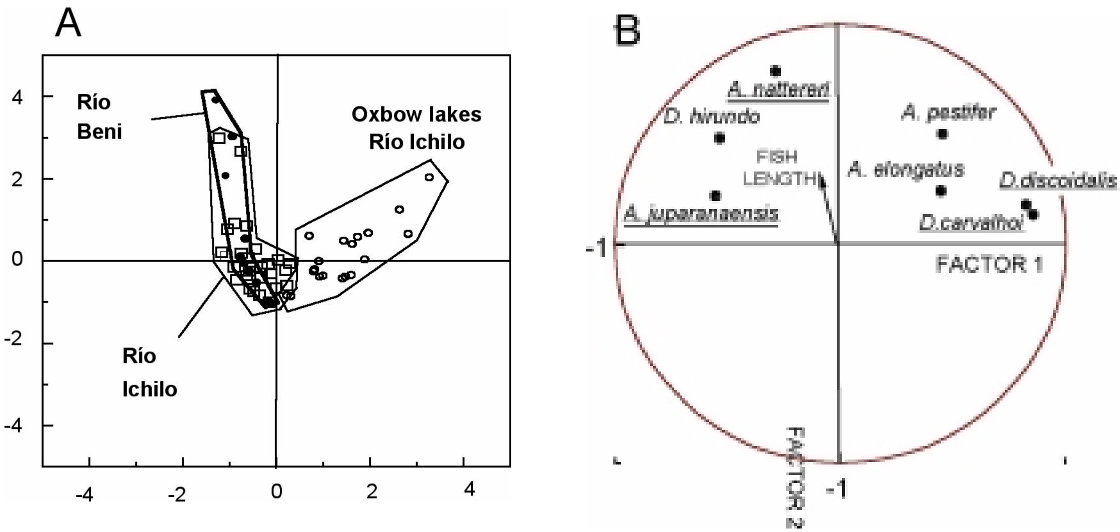

Fig. 2: Branchiuran parasites on *Pseudoplatystoma fasciatum* (1999 sampling campaign): (A) Ordenation diagram of a Principal Components Analysis representing 60 *P. fasciatum* belonging to three different populations (Río Ichilo: _ ; oxbow lakes in the Ichilo basin: _ ; Río Beni: _); (B) Position of the parasite species in the plane formed by the two first principal components.The typical lake species are underlined. The typical river species are underlined twice. The correlation of fish length with the factor scores is indicated by an arrow.

composition, making it highly probable that the speciation within the Branchiura has occurred a lot earlier than within host species. Possibly, speciation within the Branchiura has occurred on the ancestor of *P. tigrinum* and *P. fasciatum*, and these host species inherited the same parasite species. However, we need studies on the phylogeny of branchiuran parasite species to test these hypotheses.

In general, in the case of fish parasites with a relatively high to very high host specificity (such as monogean ectoparasites, for example), related host species have a higher probability to possess a similar parasite fauna than unrelated host species (Boeger & Kritsky 1997, Poulin 2002). However, in the particular case of branchiurans, which are known by their frequent host switching and rather low host specificity (Thatcher 1991), there are other influencing factors: for this group, the similarity of parasite fauna may be more related to (dis)similarity in host behaviour than to genetic similarity. Indeed, if we look at host checklists for branchiuran parasites (Table 4), both genetical and ecological factors may be involved to various degrees.

Pseudoplatystoma fasciatum and *P. tigrinum*, are infestated with a remarkably high number of branchiuran parasites species (see also Malta 1984), whereas other fish species of the same family, such as *Brachyplatystoma sp*., do not have branchiuran parasite species (Table 3) (Thatcher 1990, Van Damme unpublished data). This difference is probably related with the biology of the host species. The presence of a high number of Branchiura on *P. fasciatum* and *P. tigrinum* may be a consequence of their life style, both species displaying a characteristic "sit-and-wait" behavior, staying at any time in close contact with the sediment of rivers or

Table 3. Dispersion Index for branchiuran parasites with a>0.45 on *Pseudoplatystoma tigrinum* and *P. fasciatum* in the Ichilo River basin (1996-1997)

Host Species	Parasite species	Sample number	Dispersion Index
P. fasciatum	*A. pestifer*	82	3.8
	A. juparanaensis	82	1.2
	D. carvalhoi	82	6.6
	D. discoidalis	82	3.6
P. tigrinum	*A. pestifer*	42	7.2
	A. juparanaensis	42	3.9
	D. carvalhoi	42	1.1
	D. discoidalis	42	1.6

oxbow lakes (Barthem & Goulding 1997). As a consequence of this life style, they are probably very vulnerable to infestation with the infective (larval) stages of Branchiuran parasites. This probably also explains why species with a more pelagic life style, such as *Brachyplatystoma spp*. do not harbour branchiuran parasites. The pelagic environment is probably less suitable for Branchiuran species as a result of high current velocities.

Moreover, it is probable that host species that occupy a variety of different habitats are infected with more parasite species. This might be one of the reasons why *Pseudoplatystoma* species, which can be found in all possible habitats of the floodplain (river, inundated forest, oxbow lakes, streams) (Barthem & Goulding 1997), have relatively more parasite species. An alternative explication may be that host species found in different habitats are made up of different populations, which may have favored parasitic speciation, and a consequent increase in parasite species richness.

Apart from the abovementioned factors, host density, which in the case of *Pseudoplatystoma* spp. is thought to be different in lakes and rivers, might also influence the success of parasite transmission. However, there are not enough data to validate this assumption.

Consequently, we suggest that pimelodid fish species that occupy a variety of different habitats and/or that display a sit-and-wait "benthic" behaviour have more parasite species. There seems to be a gradient *Pseudoplatystoma-Phractocephalus-Brachyplatystoma.* However, the same is not necessarily true for characids, where for example a species such as *Salminus maxillosus*, a pelagic species "por excelencia", does have a quite high number of Branchiuran parasite species (Thatcher 1990). Besides the mentioned ecological factors, genetical factores may also play an important role.

The *P. fasciatum* of oxbow lakes of the Río Ichilo River basin had a higher load of Branchiuran parasites than riverine fishes. However, species diversity in the two habitats is equal. *Dolops* species seem to be more common in oxbow lakes (*D. discoidales* and *D. carvalhoi* exclusively occurring in lakes during the 1999 campaign), whereas the genus *Argulus* has both riverine species (*A. juparanensis* and *A. nattereri)* and species with a preference towards lakes (*A. pestifer* and *A. elongatus*). The latter may explain why Malta (1982a) hardly found *A. juparanensis* in Brazilian oxbow lakes.

The observation that parasite community structure on *P. fasciatum* in lakes and rivers is different may suggest that fish host populations

Table 4. Fish host species for Branchiruan parasites according to different authors.

Taxon	Species	*Argulus Juparanaensis*	*Argulus pestifer*	*Argulus elongatus*	*Argulus nattereri*	*Dolops discoidalis*	*Dolops carvalhoi*	*Dipteropeltis hirundo*
SILURIFORMES Pimelodidae	*Pseudoplatystoma fasciatum*	1,2	1,2,5	1	1	1,2,7	1,2,6	1
	Pseudoplatystoma tigrinum	1	1,2,5	1	1	1,2,7	1,2,6	
	Pseudoplatystoma coruscans	4						
	Phractocephalus hemiliopterus					2,4,7	2,6	
	Hemisorubim sp.					2,7		
	Pimelodus pati							2
	Luciopimelodus pati							4
	Leiarius marmoratus					2,7		
ELASMOBRANCHIOMORPHI	*Potamotrygon motoro*	3						
OSTEOGLOSSIFORMES Osteoglossidae	*Arapaima gigas*					2,4,7		
PERCIFORMES Cichlidae	*Astronotus ocellatus*					2,7		
CHARACOIDEI Characidae	*Astyanax bimaculatus*	2,4						
	Tetragonopterus rutilis							4
	Tetragonopterus aureus							4
	Salminus brevidens				2			2
	Salminus maxillosus		2,4			2		2,4
	Rhaphiodon vulpinus						2,4,6	
CHARACOIDEI Erythrinidae	*Hoplerythrinus unitaeniatus*					2,7		
	Hoplias malabaricus					2,4		
PERCIFORMES Sciaenidae	*Pachyurus bonariensis*	2						
	Plagioscion squamosissimus	4						
CHARACOIDEI Serrasalmidae	*Pygocentrus nattereri*	8		8			2,6,8	
	Pygocentrus piraya							2,4
	Piaractus brachypomus						2	
	Colossoma macropomum						2,6	
CLUPEIFORMES Clupeidae	*Pellona castelnaeana*						2,6	

1) present study; 2) Thatcher (1991); 3) Peralta et al. (1998); 4) Lemos de Castro (1986); 5) Malta (1983); 6) Malta & Varella (1983); 7) Malta (1982b); 8) Nobre Carvalho et al. (2003)

are (genetically) different. However, it is known that *P. fasciatum* spawn in the river channels (Barthem & Goulding 1997, Muñoz & Van Damme 1998), and lake fish probably move to the river channel during the spawning season. The previous makes it more plausible that the Branchiuran parasites lose hold when the host moves from one to another habitat, for example because they can not resist high current velocities. If this is so, Branchiura would be bad indicators of the origin or migration patterns of their hosts.

Thatcher (1990) found that *A. pestifer* infesting *Pseudoplatystoma* species in the Brazilian Amazon was found in high numbers during the low water season (november-december), whereas all the other species were more common in June and July, when the water level was higher. Malta (1983) observed similar seasonal patterns for *A. pestifer* in a Brazilian oxbow lake. The abundance of *Dolops carvalhoi* was also related to water levels, maximum peaks of infestation occurring during high water (Malta & Varella 1983). The same seasonal pattern was found for *Dolops discoidales* by Malta (1982b). This type of seasonality may also have affected parasite abundance during the present study.

The species-rich Branchiuran parasite community on *P. fasciatum* offers an excellent opportunity to study host-parasite interactions, parasite isolation effects, and gene fluxes between parasite populations. Moreover, we recommend studying the impact of these

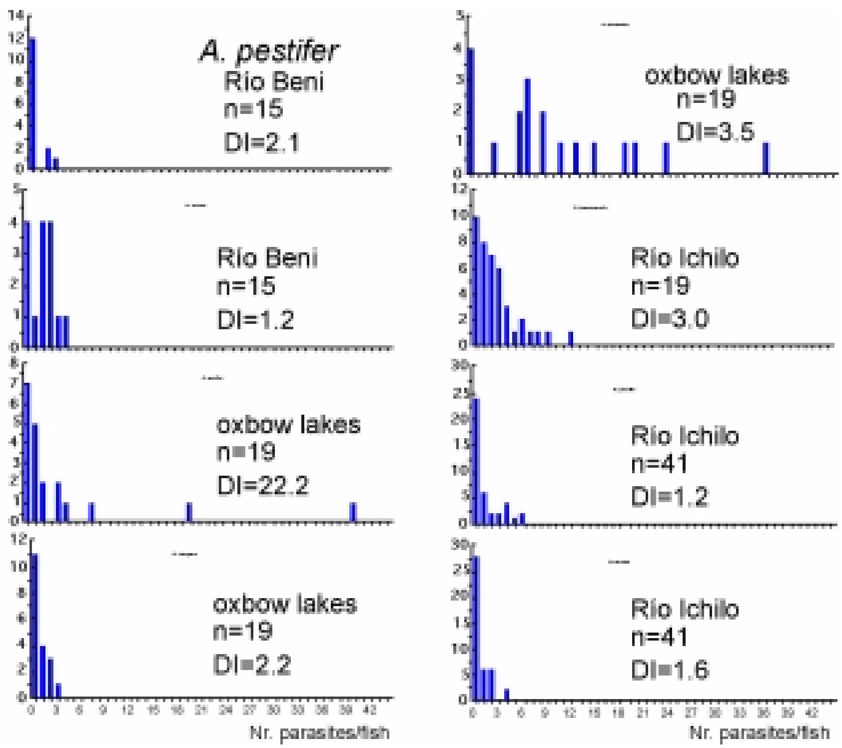

Fig. 3: Frequency distributions of parasites in *P. fasciatum* populations in the Ichilo and Beni basins (1999). Only frequency distribution for parasites with a>0.45 are shown.

abundant parasites on their fish host populations. Branchiuran parasites (as most other parasites) generally show an overdispersed distribution in their host populations (Anderson & Gordon 1982). This phenomenon, confirmed during the present study (Fig. 3; Table 3), suggests that some of these parasites may be controlling host population size. The observation that some parasite species seem to show truncated distributions (*D. hirundo* in Table 3 and Figure 3), suggesting host mortality at high parasite densities, should be investigated in more detail.

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