Acta Scientiarum

http://periodicos.uem.br/ojs/acta
ISSN on-line: 1807-863X
Doi: 10.4025/actascibiolsci.v45i1.68282

ZOOLOGY

Parasites of juvenile *Salminus brasiliensis* and *Brycon orbignyanus* (Characiformes, Bryconidae) in the middle Paraná River, Argentina

Exequiel Oscar Furlan[1,2*], Silvina Beatriz Chemes[2] and Pablo Augusto Scarabotti[2,3]

[1]Laboratorio de Ecología de Enfermedades, Instituto de Ciencias Veterinarias del Litoral, Consejo Nacional de Investigaciones Científicas y Técnicas, Universidad Nacional del Litoral, R.P. Kreder 2805, 3080, Esperanza, Santa Fe, Argentina. [2]Departamento de Ciencias Naturales, Facultad de Humanidades y Ciencias, Universidad Nacional del Litoral, Ciudad Universitaria, s/n, 3000, Paraje El Pozo, Santa Fe, Argentina. [3]Instituto Nacional de Limnología, Consejo Nacional de Investigaciones Científicas y Técnicas, Universidad Nacional del Litoral, Paraje El Pozo, Santa Fe, Argentina. *Author for correspondence. E-mail: exequielfurlan@gmail.com

ABSTRACT. Piscivorous *Salminus brasiliensis* and herbivorous/omnivorous *Brycon orbignyanus* often form mixed schools in the same habitats. The aims of this study were: (a) to analyze and compare ecto- and endoparasite communities in juvenile *S. brasiliensis* and *B. orbignyanus* in the Middle Paraná River, Argentina; and (b) to evaluate the possible relationships between degree of parasitic infestation and body condition (Kn) of the fish. Fish necropsy was performed in search of endo- and ectoparasites, which were mounted in permanent or semi-permanent preparations for taxonomic study using helminthological techniques. A total 24 macroparasite taxa were recorded from the two host species. The parasitic infracommunities of both hosts were competitively structured. Ectoparasite communities were more similar than endoparasite communities. The abundance of parasitic species was not correlated with the standard length, weight and Kn of host individuals, except for the abundance of the copepod *E. lacusauratus* in the host *S. brasiliensis*, which was positively related to fish condition. New records of parasites were observed for native hosts, extending the geographic range of several species already known in the Upper Paraná River. The general structure of parasite communities can be determined by several factors, such as parasite-host relationship, host trophic level, and environment. In concordance with the similarity in habitat preferences, and the strong differences in trophic preferences, ectoparasite communities were found to be more similar than endoparasite communities between the two host species.

Keywords: dorado; pirá-pitá; mixed-species shoaling; ichthyoparasites; condition factor.

Received on May 18, 2023.
Accepted on September 5, 2023.

Introduction

The Neotropical region harbors the world's highest fish species richness (Reis, Albert, Mincarone, Petry, & Rocha, 2016). These fish serve as hosts for a great diversity of ichthyoparasites (Carlson, Dallas, Alexander, Phelan, & Phillips, 2020). Parasite community analysis is useful for understanding fish health status and the links among host, pathogen, and environment (Beldomenico & Begon, 2010). However, although many studies have endeavored to link the ecological characteristics of fish to the diversity of their parasites, there is no general consensus (Luque & Poulin, 2008).

Habitat is one of the most important factors in the parasite-stress-host relationship, as it is a source of parasites (Beldomenico et al., 2008). Fish species with similar evolutionary history, geographic range, ecological niche, and feeding behavior tend to have similar parasite communities (Marcogliese, 2016; Oliveira et al., 2018; Deflem et al., 2022). Additionally, top predators are more likely to have a higher parasite load since they may ingest prey that is already parasitized (Pardo, Zumaque, Hernando Noble, & Suarez, 2008).

In the parasite-host relationship, parasites can affect host physiology, morphology, reproduction, or behavior, and have significant impacts on individuals, populations, communities, and even the host ecosystem (Timi & Poulin, 2020). Several authors have used the intensity of parasitism to infer fish health status (Schludermann et al., 2003; Costa, Monteiro, & Brasil-Sato, 2015; Morris, Avenant-Oldewage, Lamberth, & Reed, 2016). The relative body condition factor of fish (Le Cren, 1951) has classically been used to infer the general health of fish, and may be influenced by parasitism. Several authors have found that condition factor generally decreases with high infestations (Neff & Cargnelli, 2004; Lizama, Takemoto, & Pavanelli, 2006; Österlinga & Larsenb, 2013).

The 'dorado' *Salminus brasiliensis* (Cuvier) is a large piscivore which is highly prized by sport fishermen as a trophy fish. Its feeding habits change significantly during ontogeny, but as from the time it attains a length of 21 cm, it becomes piscivorous (Bechara, Alabarcez & Ruiz Díaz, 2005; Graça & Pavanelli, 2007). The 'pirá-pitá' or 'salmón de río' *Brycon orbignyanus* (Valenciennes) is omnivorous (Ruiz Díaz, 2015). Juvenile *S. brasiliensis* can use aggressive mimicry to form mixed schools and prey on individuals of other *Brycon* species (Bessa, Carvalho, Sabino & Tomazzelli, 2011). Co-occurrence of *S. brasiliensis* and *B. orbignyanus* is common in the Paraná River (Scarabotti, López & Poully, 2011; Almiron, Casciotta, Ciotek & Giorgis, 2015) and in the upper reaches of the Paraguay River (Bessa et al., 2011).

Since juvenile *S. brasiliensis* and *B. orbignyanus* generally share the same habitat but differ markedly in feeding preferences, we hypothesize that their ectoparasite communities (available in the same habitat) will be more similar while their endoparasite communities (generally originating from their prey) will be more different. The aim of this study was to compare parasitism in mixed schools of juvenile *S. brasiliensis* and *B. orbignyanus* and evaluate the possible relationships between level of parasite infestation and body condition of fish caught in the Curtiembre River, Rio Paraná, Entre Ríos, Argentina.

Material and methods

Study area and capture of individuals

The Curtiembre Stream is a small, semi-permanent tributary of the Middle Paraná River, located near the town of General San Martín, Entre Ríos, Argentina (31° 27' 44.3'' S, 60° 10' 41.3" W) (Benzaquén, 2013; Dirección de Hidráulica de Entre Ríos, 2018) (Figure 1).

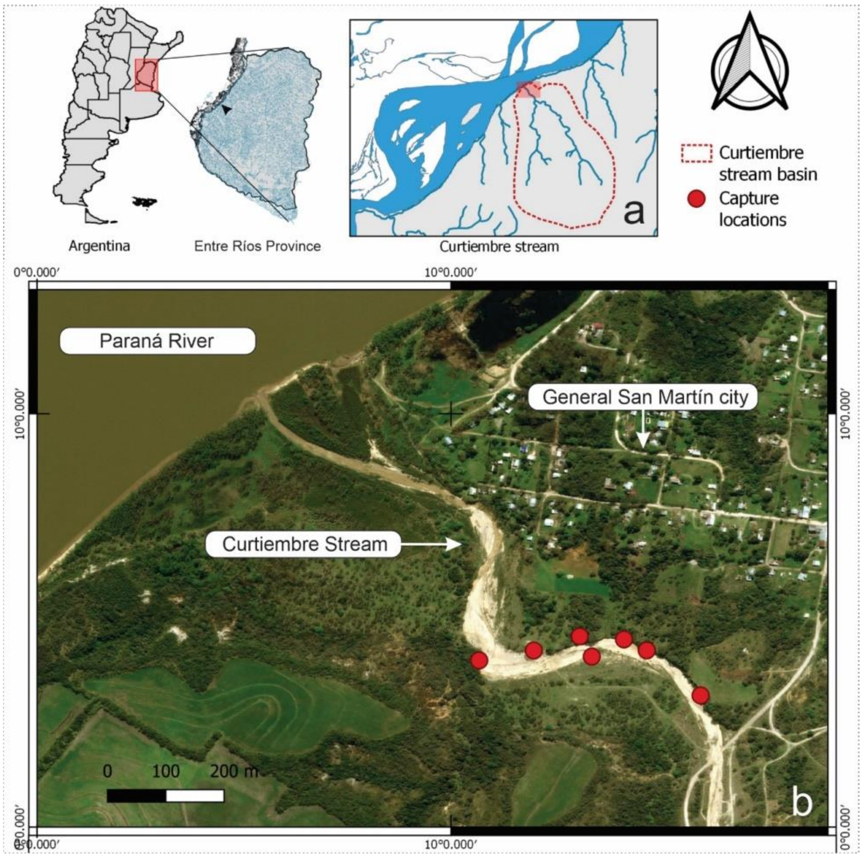

Figure 1. (a) Location of the Curtiembre stream in Entre Ríos Province in Argentina. (b) Satellite image showing the distribution of sampling points along the last reach of the Curtiembre stream and its mouth into the Middle Paraná River.

The final stretch of the Curtiembre Stream is seasonally flooded during high-water periods of the Paraná River. Juvenile *S. brasiliensis* and *B. orbignyanus* were captured in January 2016 (summer) using gillnets (30- and 35-mm mesh opening), arranged in different stretches of the stream. This study was approved by the

Research Ethics and Safety Committee of *Universidad Nacional del Litoral* (Santa Fe, Argentina), and fish collection was authorized by Resolution 1721/14 of the *Dirección General de Recursos Naturales, Ministerio de Producción, Turismo y Desarrollo Económico de la Provincia de Entre Ríos*.

Fish necropsy, fixation and parasite identification

Fish were euthanized by immersion in a solution with a high dose of benzocaine until opercular movement ceased (Neiffer & Stamper, 2009). Standard length (SL, cm) and body weight (W, g) were measured, and specimens were stored at -20°C for subsequent necropsy in the laboratory. The integument, fins, mouth, nostrils and gill apparatus were examined under a stereoscopic microscope (20X, 40X magnification) for ectoparasites (Eiras, Takemoto, & Pavanelli, 2006). The digestive tract was extracted, and the stomach and intestine were examined. The extracted helminths were preserved in 70% alcohol and mounted in permanent or semi-permanent preparations, according to the usual techniques in helminthology. Reference taxonomic keys and original publications were used for taxonomic identification of the parasites. Voucher specimens were deposited in the Invertebrate Collection of the *Museo Provincial de Ciencias Naturales Florentino Ameghino* (MFA-ZI) (Santa Fe, Argentina).

Data analysis

Relative condition factor values were calculated for all individuals as described by Le Cren (1951). The logarithms of standard length (Ls) and total weight (Wt) of each individual host were used to adjust the curve for $Wt\ Ls^{-1}$ ($Wt = a \cdot Lt^{b}$), and the regression coefficients 'a' and 'b' were estimated. The values of 'a' and 'b' were used to estimate the theoretically predicted body weight (We) using the equation: $We = a \cdot Lt^{b}$. Then the relative condition factor (Kn) was calculated, which corresponds to the ratio between the observed weight and the theoretically expected weight for a given length ($Kn = Wt\ We^{-1}$).

Prevalence of parasitic infestation (P) was calculated with confidence intervals obtained using Blaker's method, mean infestation abundance (MA), and mean infestation intensity (MI) with their confidence intervals calculated by bootstrap BCa 95% with 2000 replications (Reiczigel, Marozzi, Fábian & Rózsa, 2019; Klaschka & Reiczigel, 2021). To analyze the level of parasite diversity coverage, a species accumulation curve was generated using sampling rarefaction, estimating species richness as a function of the number of samples (Colwell, Mao, & Chang, 2004). The ecological diversity of the parasite infracommunities of both hosts was assessed by calculating the indices of true diversity of Order 0, 1 and 2 (0D, 1D and 2D, respectively) (Moreno, Barragán, Pineda, & Pavón, 2011) and Simpson's dominance index DS (Moreno, 2001). Ecological similarity between endoparasite and ectoparasite infracommunities of each host was calculated using the Jaccard Similarity and Bray-Curtis dissimilarity indices (Moreno, 2001). To analyze whether parasite communities were structured competitively or randomly, the C-Score index was calculated by evaluating its significance using null models (Gotelli & Entsminger, 2011). To compare the prevalence by parasitic taxon between host species, Fisher's exact test was applied. For the mean abundances and mean intensities, a bootstrap t-test with 1000 replications was performed (Reiczigel et al., 2019). To detect the distribution pattern of the parasite populations, the dispersion indices (ID) and Poulin discrepancy (D) were calculated with their confidence limits estimated by bootstrap BCa with 1000 replications (Reiczigel et al., 2019), only for species with prevalence >10%. To analyze the differences in the degree of parasite infestation, the mean values of abundance of ectoparasites, endoparasites and total parasite abundance were compared using Mann-Whitney U tests. To determine the relationship between host morphometric parameters and parasite infestation, Spearman's correlations between SL, body weight, Kn, and parasite abundance were used. The normality of the data was analyzed by Shapiro-Wilk tests. Paleontological Statistics PAST 4.03 (Hammer, Harper, & Ryan, 2001), EcoSim Version 7.0 (Gotelli & Entsminger, 2011), Quantitative Parasitology web QPweb 3.0 Version 1.0.15 (6 December 2020) (Reiczigel et al., 2019) and R Studio software (RStudio Team, 2020), were used. Significance level was set at 5% ($p < 0.05$).

Results

Eleven *S. brasiliensis* individuals (mean SL ± SD = 142.7 ± 16.3 mm; mean body weight ± SD = 54.2 ± 17.1) and 19 *B. orbignyanus* individuals (mean SL ± SD = 142.7 ± 16.3 mm; mean body weight ± SD = 33.8 ± 15.9) were collected. The relative condition factor was 0.997 ± 0.07 for *S. brasiliensis* and 1.005 ± 0.08 for *B. orbignyanus*.

A total 224 macroparasites belonging to 24 taxonomic entities were recorded (Table 1). Ichthyoparasite prevalence was 100% in *S. brasiliensis* (all individuals were infested by at least one ichthyoparasite), and 68.4%

in *B. orbignyanus*. The most prevalent taxa in *S. brasiliensis* were the ectoparasites Monogenea gen. sp. (81.82%) followed by *Lernaea cyprinacea* (63.64%) and *Anacanthorus daulometrus* (63.64%). The most prevalent taxa in *B. orbignyanus* were *Amplexibranchius bryconis* (26.32%) and *Ergasilus* sp. (21.05%). The accumulation curves of parasite species generated by sample rarefaction approached a plateau, but never became entirely flat (Figure 2). The total parasite community of *S. brasiliensis* consisted of 181 individuals belonging to 20 taxa, with dominance of 0.26 (± 0.128), and Monogenea being the most abundant taxon. The *B. orbignyanus* community was made up of 43 parasites from 14 taxa, with higher dominance of 0.40 (± 0.37), and *A. bryconis* outstanding for its abundance (Table 1).

Table 1. Parasites of *Salminus brasiliensis* and *Brycon orbignyanus* from the floodplain of the Middle Paraná River, Entre Ríos (Argentina).

Parasites	Code	Fish species						Inter-host comparison*		
		S. brasiliensis (n = 11)			*B. orbignyanus* (n = 19)					
		P [CI]	MA [CI]	MI [CI]	P [CI]	MA [CI]	MI [CI]	P p (1)	MA p (2)	MI p (2)
Class Maxillopoda. Order Arguloida. Fam. Argulidae										
Argulus ichesi (Bouvier, 1910)	Cr 589	-	-	-	0.05 [0.01-0.25]	0.05 [0-0.16]	1	-	-	-
Dolops geayi (Bouvier, 1910)	Cr 590	0.09 [0.01-0.40]	0.18 [0-0.54]	2	0.16 [0.04-0.39]	0.26 [0-0.74]	1.67 [1-2.33]	1.00	0.83	-
Dolops cf. *bidentata*		-	-	-	0.05 [0.01-0.25]	0.05 [0-0.16]	1	-	-	-
Dolops cf. *nana*		-	-	-	0.05 [0.01-0.25]	0.05 [0-0.15]	1	-	-	-
Dolops sp. (Audouin, 1857)		0.09 [0.01-0.40]	0.09 [0-0.27]	1	0.16 [0.04-0.39]	0.16 [0-0.32]	1	1.00	0.55	-
Class Hexanauplia. Order Cyclopoida. Fam. Ergasilidae										
Amplexibranchius bryconis (Thatcher y Paredes, 1985)	Cr 591	-	-	-	0.26 [0.12-0.50]	0.68 [0.21-1.53]	2.6 [1.3-38]	-	-	-
Ergasilus cf. *coatiarus*		0.27 [0.08-0.60]	1.18 [0.09-3.36]	4.33 [1-6.67]	0.16 [0.04-0.39]	0.16 [0-0.32]	1	0.64	0.29	0.31
Ergasilus lacusauratus (Mendes, Boeger y Carvalho, 2014)	Cr 588	0.36 [0.14-0.67]	1 [0.27-3.25]	2.75 [1-5.75]	0.105 [0.02-0.32]	0.11 [0-0.26]	1	0.15	0.32	0.35
Ergasilus thatcheri (Enger et al., 2000)	Ct 587	0.46 [0.20-0.74]	0.63 [0.18-1.09]	1.4 [1-1.6]	0.05 [0.01-0.25]	0.05 [0-0.16]	1	0.01*	0.05	-
Ergasilus sp.		0.36 [0.14-0.66]	0.63 [0.18-1.27]	1.75 [1-2.5]	0.21 [0.08-0.45]	0.32 [0.05-0.84]	1.5 [1-2]	0.41	0.38	0.70
Fam. Lernaeidae *Lernaea cyprinacea* (Linnaeus, 1758)	Cr 586	0.64 [0.33-0.87]	0.727 [0.27-1]	1.14 [1-1.43]	0.05 [0.01-0.25]	0.05 [0-0.16]	1	0.01*	0.00*	-
Lernaeidae Gen. sp. 1		0.09 [0.01-0.40]	0.09 [0-0.27]	1	0.11 [0.02-0.32]	0.16 [0-0.47]	1.5 [1-1.5]	1.00	0.61	-
Lernaeidae Gen. sp. 2		0.09 [0.01-0.40]	0.09 [0-0.27]	1	0.05 [0.01-0.25]	0.05 [0-0.16]	1	1.00	0.79	-
Class Secernentea. Order Camallanida. Fam. Camallanidae										
Procamallanus (S.) paraguayensis (Petter, 1990)	Nd 246	0.18 [0.03-0.50]	0.18 [0-0.36]	1	0.16 [0.04-0.39]	0.21 [0-0.47]	1.33 [1-1.67]	1.00	0.87	0.55
Procamallanus (S.) sp.		0.18 [0.03-0.50]	0.36 [0-0.10]	2 [1-2]	-	-	-	-	-	-
Class Eoacanthocephala. Order Gyracanthocephala. Fam. Quadrigyridae										
Quadrigyrus machadoi (Fabio, 1983)	Ac 09	0.27 [0.07-0.59]	0.36 [0-0.81]	1.33 [1-1.67]	-	-	-	-	-	-
Class Monogenea. Order Dactylogyridea. Fam. Ancyrocephalidae										
Anacanthorus contortus Cohen, Kohn y Boeger, 2012	Pl 112	0.36 [0.13-0.66]	1.45 [0.36-3.09]	4 [2-5]	-	-	-	-	-	-
Anacanthorus daulometrus (Cohen et al. 2012)	Pl 109	0.63 [0.33-0.86]	1.18 [0.54-1.91]	1.86 [1.29-2.71]	-	-	-	-	-	-
Anacanthorus douradenses (Cohen et al., 2012)	Pl 110	0.09 [0.01-0.40]	0.27 [0-0.81]	3	-	-	-	-	-	-
Anacanthorus parakruidenieri (Cohen et al., 2012)	Pl 111	0.36 [0.13-0.66]	1.27 [0.18-2.88]	3.5 [1.25-5.5]	-	-	-	-	-	-
Anacanthorus sp.		0.55 [0.23-0.80]	1.27 [0.46-2.09]	2.33 [1.33-3.17]	-	-	-	-	-	-
Jainus iocensins (Cohen et al., 2012)	Pl 108	0.46 [0.20-0.74]	1.36 [0.273-3]	3 [1-4]	-	-	-	-	-	-
Monogenea Gen. sp.		0.82 [0.50-0.97]	3.45 [1.82-5.18]	4.22 [2.44-5.89]	-	-	-	-	-	-
Class Trematoda. Order Plagiorchiida. Fam. Derogenidae										
Genarchella parva (Travassos, Artigas & Pereira, 1928)	Pl 107	0.36 [0.14-0.67]	0.46 [0.09-0.82]	1.25 [1-1.5]	-	-	-	-	-	-

P: prevalence of parasitic infestation, MA: mean infestation abundance, MI: mean infestation intensity, [CI]: confidence interval, * p > 0.05, (1) Fisher's test, (2) Bootstrap 95%

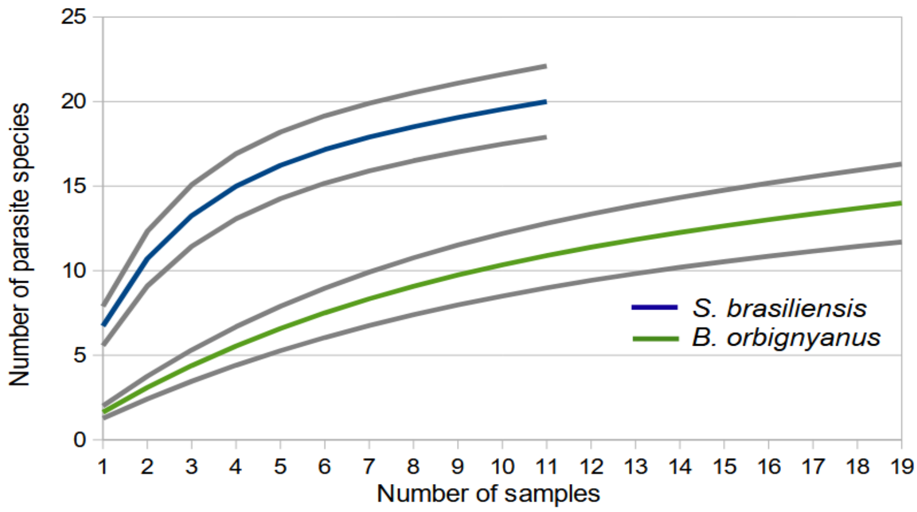

Figure 2. Accumulation curves of parasite species generated by sample rarefaction from juvenile *Salminus brasiliensis* and *Brycon orbignyanus* from the Curtiembre Stream, Middle Paraná River (Argentina). Grey lines represent ± standard error.

Although fewer *S. brasiliensis* than *B. orbignyanus* individuals were analyzed, 0D, 1D and 2 D were higher in *S. brasiliensis* (Table 2). The estimated Chao 2 diversity surpassed the 0D in both hosts (Table 2). The C-Score index showed that the parasitic infracommunities of both hosts were structured competitively (Table 2). Considering the total parasite abundance per host, similarity was greater in terms of species composition (Jaccard index) compared to considering the relative abundances of parasite species (Bray Curtis similarity) (Table 2). Specifically, the Jaccard index showed higher qualitative similarity in the ectoparasite communities than in the endoparasite communities of *S. brasiliensis* and *B. orbignyanus* (Table 2). However, the Bray Curtis similarity was nearly the same for both ectoparasite and endoparasite communities of both host species (Table 2). Comparison of the parasitological descriptors found for the two host populations showed significant differences only between the parasitic prevalence of the ectoparasites *Ergasilus thatcheri* and *Lernaea cyprinacea*, in the latter of which the mean infestation abundances also differed (Table 1). Most of the parasite populations with prevalence greater than 10% had an aggregated distribution (Table 3). The only parasites that presented random and aggregated distribution were *L. cyprinacea*, *Anacanthorus daulometrus* and Monogenea gen. sp.

Table 2. Ecological attributes of the parasitic infracommunities of juvenile *Salminus brasiliensis* and *Brycon orbignyanus* from the Curtiembre Stream, Middle Paraná River (Argentina).

Index of diversity	Hosts	
Index of alpha diversity	*S. brasiliensis*	*B. orbignyanus*
Order 0	20	14
Order 1	13.76	9.71
Order 2	10.63	7.16
Chao 2 (± SD)	25.7 (± 6.9)	22.5 (± 9.7)
Index of beta diversity		
Jaccard similarity total parasites	41%	
Jaccard similarity ectoparasites	45%	
Jaccard similarity endoparasites	25%	
Bray-Curtis dissimilarity total parasites	82.2%	
Bray-Curtis dissimilarity ectoparasites	82.4%	
Bray-Curtis dissimilarity endoparasites	83.4%	
Co-occurrence Score		
Observed index	3.49474	3.32967
Simulated mean of the index (± SD)	5.62134 (± 0.17754)	4.38281(± 0.40277)
p (observed < = expected)	0.00000*	0.01560*
p (observed > = expected)	1.00000	0.98600

*p < 0.05

Table 3. Dispersal index (DI) and Poulin's Discrepancy (D) for the parasitic infracommunities of juvenile *Salminus brasiliensis* and *Brycon orbignyanus* from the Curtiembre Stream, Middle Paraná River (Argentina).

Parasites	*S. brasiliensis*			*B. orbignyanus*		
	DI	D [CI]	TYPE	DI	D [CI]	TYPE
Dolops geayi	-	-	-	2.04	0.84 [0.65-0.90]	AG
Dolops sp.	-	-	-	0.89	0.80 [0.47-0.90]	AG
Amplexibranchius bryconis	-	-	-	2.93	0.77 [0.61-0.89]	AG
Ergasilus cf. *coatiarus*	5.55	0.75 [0.60-0.83]	AG	0.89	0.80 [0.50-0.85]	AG
E. lacusauratus	4.40	0.72 [0.57-0.83]	AG	0.94	0.85 [0.60-0.9]	AG
E. thatcheri	1.03	0.57 [0.34-0.77]	AG	-	-	-
Ergasilus sp.	1.66	0.66 [0.47-0.83]	AG	1.78	0.80 [0.60-0.87]	AG
Lernaea cyprinacea	0.58	0.39 [0.15-0.63]	R-AG	-	-	-
Procamallanus (S.) paraguayensis	0.90	0.75 [0.41-0.83]	AG	-	-	-
Procamallanus (S.) sp.	2.35	0.79 [0.58-0.83]	AG	-	-	-
Quadrigyrus machadoi	1.25	0.70 [0.47-0.83]	AG	-	-	-
Anacanthorus contortus	3.90	0.66 [0.38-0.79]	AG	-	-	-
A. daulometrus	1.32	0.48 [0.29-0.70]	R-AG	-	-	-
A. parakruidenieri	3.79	0.69 [0.47-0.83]	AG	-	-	-
Anacanthorus sp.	1.74	0.54 [0.35-0.75]	AG	-	-	-
Jainus iocensins	4.00	0.66 [0.46-0.81]	AG	-	-	-
Monogenea sp.	2.68	0.42 [0.31-0.65]	R-AG	-	-	-
Genarchella parva	1.04	0.63 [0.33-0.83]	AG	-	-	-

DI: Dispersal Index, D: Poulin's Discrepancy, [CI]: confidence interval, AG: aggregate dispersion, R-AG: random dispersion.

Total parasite abundance (Z = -4.03; p = 5.56E-05), endoparasite abundance (Z = -2.5; p = 0.01) and ectoparasite abundance (Z = -3.71; p = 1.9E-05) differed significantly between the two host species. In most cases, the abundance of parasitic species was not correlated with standard length, weight or *Kn* of individuals (Figures 3 and 4). Only the abundance of *E. lacusauratus* in *S. brasiliensis* juveniles was positively related to the relative body condition factor (Figure 3).

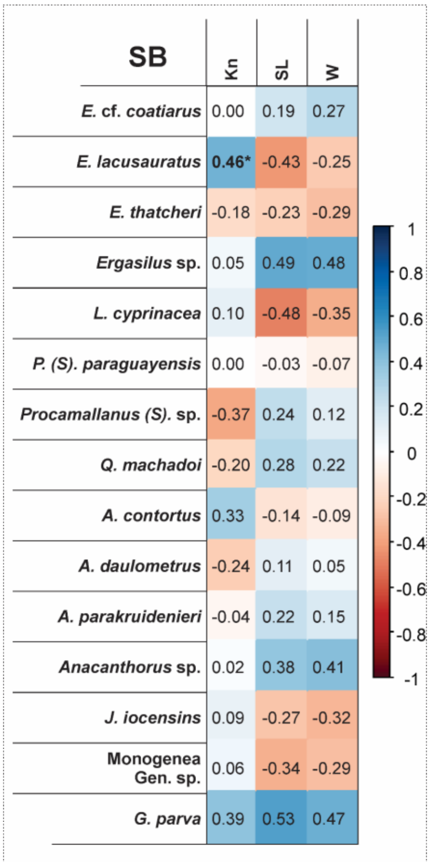

Figure 3. Spearman correlation among relative condition factor (Kn), standard length (SL) and weight (W) of *Salminus brasiliensis* (SB) and its parasites. The color gradient represents the intensity, and the asterisk represents the significance of the correlation.

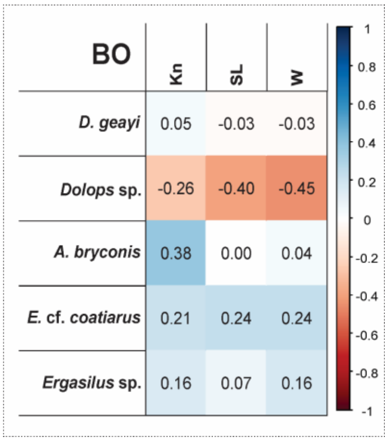

Figure 4. Spearman correlation coefficients among relative condition factor (Kn), standard length (SL) and weight (W) of *Brycon orbignyanus* (BO) and its parasites. The color gradient represents the intensity of the correlation.

Discussion

Previous studies on ichthyoparasites of the Middle Paraná River have mostly focused on endoparasites (Chemes & Takemoto, 2011, 2020; Ostrowski de Núñez, Arredondo, & Gil de Pertierra, 2017; Chemes, Gervasoni, Rossi, & Lizama, 2022; Rossi & Chemes, 2022). The current paper provides information on both endo- and ectoparasites of two Characiform hosts that are ecologically and economically important in the region. It is the first report of parasitic fauna associated with *B. orbignyanus*, a native species valued by sport fishers in the Middle Paraná River. The study reveals the presence of several ectoparasites that were previously recorded in Brazil, but have been found for the first time in Argentina, extending their known geographic range. These ectoparasites include the copepods *Amplexibranchius bryconis*, *Ergasilus lacusauratus* and *E. thatcheri*, and the monogeneans *Anacanthorus contortus*, *A. daulometrus*, *A. douradensis* and *A. parakruidenieri*. Additionally, the fish studied are reported as new hosts for some parasite species. Specifically, *S. brasiliensis* is recorded as a new host for the crustaceans *E. thatcheri* and *Lernaea cyprinacea*, as well as the acanthocephalan *Quadrigyrus machadoi*. *Brycon orbignyanus* is associated for the first time with the branchiurans *Argulus ichesi* and *Dolops geayi*, and the copepods *Amplexibranchius bryconis*, *E. lacusauratus*, *E. thatcheri* and *L. cyprinacea*. This study provides novel information regarding new parasite records and expands the distribution range of several species. However, the species accumulation curve and Chao 2 index indicate the presence of undetected parasite species for these hosts.

Parasite species richness and abundance was higher in *S. brasiliensis* than in *B. orbignyanus*. Both species had more diversity in ectoparasites than endoparasites. In *S. brasiliensis*, monogeneans had higher values of prevalence, mean intensity, and mean abundance of infestation, and were found mainly in the gills. They are of sanitary interest because a high abundance of parasites can cause asphyxia in fish and decrease sanitary conditions, leading to a disease known as 'dactylogyridosis' (Eiras et al., 2006; Pavanelli, Eiras, & Takemoto, 2008). In the Upper Paraná River, Cohen et al. (2012) observed monogeneans in *S. brasiliensis*, though with a lower prevalence than in the current study.

In *B. orbignyanus*, the highest prevalence, abundance and mean intensity of infestation was found for the family Ergasilidae and the species *Amplexibranchius bryconis*, which has also been reported in *B. cephalus* in the Amazon basin (Thatcher & Paredes, 1985). The genus *Brycon* is widely farmed in Brazilian rivers, including the Paraná River basin (Zaniboni Filho, Reynalte-Tataje, & Weingartner, 2006). Fish farming involves moving fish among facilities in different basins, and may account for the dispersal of the parasite *A. bryconis* in the Middle Paraná River. A similar situation occurred with the dispersal throughout Latin America of the copepod *Lernaea cyprinacea*, a parasite originally associated with *Cyprinus carpio*, which has recently been recorded in the region parasitizing another native species (Gervasoni, Chemes, Scaglione, & Cerutti, 2018). In the Upper Paraná River, Lehun et al. (2020) observed monogeneans in *S. brasiliensis*, though with lower parasitic prevalence than in the present study. In Argentina, there is an aquaculture market for *S. brasiliensis*. Proper management in the different fish farm systems in the Paraná River could help prevent the spread of its parasites.

Differences between parasitological descriptors and diversity indices in hosts that use the same habitats could be linked to different interactions among life histories, population dynamics of host fish and parasites, and niche availability (non-infested fish), which do not only involve the environment as a main factor (Luque & Poulin, 2007; Takemoto et al., 2009; Marcogliese & Pietrock, 2011; Alcântara & Tavares Dias, 2015; Soto et al., 2016). Juvenile *S. brasiliensis* had a smaller body size, so they are not strictly piscivorous (> 21 cm) (Bechara et al., 2005). However, *S. brasiliensis* showed greater abundance and diversity of parasites, and less similarity in the species composition of its endoparasite community than that of *B. orbygnianus* ectoparasites. According to Bechara et al. (2005), *S. brasiliensis* juveniles feed mainly on fish, insects and crustaceans, while *B. orbignyanus* juveniles feed primarily on zooplankton, small aquatic insects, and filamentous algae (Tonella, Dias, Vitorino, Fugi, & Agostinho, 2019). The piscivorous feeding of dorado juveniles could foster intake of fish or invertebrates already infested with parasites, which is known as a process of parasitic bioaccumulation through food chains. In *B. orbignyanus*, the present study found a lower diversity of parasites than that reported by Fernandes, Casali, and Takemoto (2019) in a study carried out in the Alto Paraná River, where the authors analyzed 104 fish specimens. This suggests that differences in sample size affect the parasite richness observed. Our results are in concordance with studies that indicate a higher abundance of endoparasites in carnivorous vertebrates than in herbivores or omnivores (Marcogliese, 2002; Lafferty et al., 2008; Pardo et al., 2008). However, these differences are more pronounced in adult fish than in juveniles since, in some hosts, trophic specificity becomes more accentuated with ontogenetic development (Bellay et al., 2015). In agreement with other studies that have analyzed fish body condition, the juveniles of both characiform species had good body condition in the natural environment studied (Lizama et al., 2006; Satake, Mayumi Ishikawa, Hisano, Benites de Pádua, & Tavares-Diaz, 2009). Unlike studies that surveyed more than 150 hosts, finding a directly proportional relationship (Lizama et al., 2006; Österlinga & Larsenb, 2013), the current study found no relationship between the parasite abundance and body condition in either host. One possible explanation is the limited variation in parasite abundance among the collected individuals. It is important to consider that the diversity and abundance of ichthyoparasites are influenced by both host characteristics (such as body size, diet, and biogeographical distribution) and environmental factors (Takemoto, Pavanelli, Lizama, Luque, & Poulin, 2005; Timi et al., 2011).

The only parasite in which abundance was positively associated with the body size of *S. brasiliensis* juveniles was *E. lacusauratus*, with larger fish harboring a greater abundance of this parasite species. In the fish *Leporinus fasciatus*, gill area (gill size) was positively related to the abundance of *Ergasilus* sp. copepods (Oliveira, Prestes, Adriano, & Tavares-Dias, 2022), suggesting that larger fish with larger gill arches could host higher abundances of parasites. This observation should be considered in future research, because the family Ergasilidae includes species with high pathogenic potential, some of which are responsible for high mortality among farmed fish in both freshwater and brackish environments (Piasecki, Goodwin, Eiras, & Nowak, 2004).

The current study provides original information on the parasitic communities of *S. brasiliensis* and *B. orbignyanus* in the Middle Paraná River Argentina. New parasites were recorded for the native hosts, extending the geographic range of several parasite species already known in the Upper Paraná River. The general structure of the parasitic communities was determined by several factors, such as the parasite-host relationship, host trophic level, and the similarity of the environment they share.

Conclusion

During the course of our study, a total of 24 macroparasite taxa were found in *S. brasiliensis* and *B. orbignyanus*. These findings extend the geographic range of several species known in the Upper Paraná River. The parasitic infracommunities were competitively structured. In concordance with the similarity in habitat preferences, and the strong differences in trophic preferences, ectoparasite communities were found to be more similar than endoparasite communities between the two host species. Factors such as parasite-host relationship, host trophic level, and environment play significant roles in shaping parasite communities.

Acknowledgments

This research was funded by the CAI+D Project Res. C.S. UNL 426/17 (UNL, Argentina). We thank F. Rojas, F. Gutierrez and C. Paggi, who kindly helped with the identification of copepod parasites. We thank the fishers K. Silvestre, M. Jamed and S. Borguello. An anonymous reviewer provided helpful comments that improved the quality of the manuscript.

References

Alcântara, N. M., & Tavares-Dias, M. (2015). Structure of the parasites communities in two Erythrinidae fish from Amazon River system (Brazil). *Revista Brasileira de Parasitologia Veterinária*, *24*(2), 183-190. DOI: https://doi.org/10.1590/S1984-29612015039

Almiron, A., Casciotta, J., Ciotek, L., & Giorgis, P. (2015). *Guía de los peces del Parque Nacional Pre-Delta*. Buenos Aires, AR: Administración de Parques Nacionales.

Bechara, J. A., Alabarcez, M. N., & Ruiz Díaz, F. J. (2005). *Elaboración y validación de un modelo de hábitat para el crecimiento del dorado (*Salminus brasiliensis*) en los Esteros del Iberá* (Informe Final Primera Etapa Proy. GEF-PNUD ARFO 2/G35). Corrientes, AR: INICNE- UNNE.

Beldomenico, P., & Begon, M. (2010). Disease spread, susceptibility and infection intensity: vicious circles? *Trends in Ecology & Evolution*, *25*(1), 21-27. DOI: https://doi.org/10.1016/j.tree.2009.06.015

Beldomenico, P., Telfer, S., Gebert, S., Lukomski, L., Bennett, M., & Begon, M. (2008). Poor condition and infection: a vicious circle in natural populations. *Royal Society B: Biological Sciences*, *275*(1644), 1753-1759. DOI: https://doi.org/10.1098/rspb.2008.0147

Bellay, S., Oliveira, E., Almeida-Neto, M., Mello, M., Takemoto, R., & Luque, J. (2015). Ectoparasites and endoparasites of fish form networks with different structures. *Parasitology*, *142*(7), 901-909. DOI: https://doi.org/10.1017/S0031182015000128

Benzaquén, L. (2013). *Inventario de los humedales de Argentina: sistema de paisajes de humedales del corredor fluvial Paraná Paraguay*. Buenos Aires, AR: Secretaría de Ambiente y Desarrollo Sustentable de la Nación.

Bessa, E., Carvalho, L. N., Sabino, J., & Tomazzelli, P. (2011). Juveniles of the piscivorous dourado *Salminus brasiliensis* mimic the piraputanga *Brycon hilarii* as an alternative predation tactic. *Neotropical Ichthyology*, *9*(2), 351-354. DOI: https://doi.org/10.1590/S1679-62252011005000016

Carlson, C. J., Dallas, T. A., Alexander, L. W., Phelan, A. L., & Phillips, A. J. (2020). What would it take to describe the global diversity of parasites? *Proceedings of the Royal Society B: Biological Sciences, 287*(1939), 1-12. DOI: https://doi.org/10.1098/rspb.2020.1841

Chemes, S. B., & Takemoto, R. M. (2011). Diversity of parasites from Middle Paraná System freshwater fishes, Argentina. *International Journal of Biodiversity and Conservation*, *3(7)*, 249-266. DOI: https://doi.org/10.1590/S1984-29612020066

Chemes, S. B., & Takemoto, R. M. (2020). Nuevos registros de helmintos parásitos de peces Pimelodidae en el Sistema Paraná Medio (Argentina). *Neotropical Helminthology*, *14*(1), 19-34. DOI: https://doi.org/10.24039/rnh2020141611

Chemes, S. B., Gervasoni, S. H., Rossi, L. M., & Lizama, M. A. P. (2022). *Spinitectus asperus* and *Klossinemella iheringi*, intestinal nematodes of *Prochilodus lineatus* (Pisces, Prochilodontidae) from the alluvial plain of the Middle Paraná River, Argentina. *Anais da Academia Brasileira de Ciências*, *94*(3), e20201687. DOI: https://doi.org/10.1590/0001-3765202220201687

Cohen, S., Kohn, A., & Boeger, W. A. (2012). Neotropical Monogenoidea. 57. Nine new species of Dactylogyridae (Monogenoidea) from the gill of *Salminus brasiliensis* (Characidae, Characiformes) from the Paraná River, State of Paraná, Brazil. *Zootaxa*, *3049*(1), 57-68. DOI: https://doi.org/10.11646/zootaxa.3149.1.3

Colwell, R. K., Mao, C. X., & Chang, J. (2004). Interpolating, extrapolating, and comparing incidence-based species accumulation curves. *Ecology, 85*(10)*,* 2717-2727. DOI: https://doi.org/10.1890/03-0557

Costa, D., Monteiro, C., & Brasil-Sato, M. (2015). Digenea of *Hoplias intermedius* and *Hoplias malabaricus* (Actinopterygii, Erythrinidae) from Upper São Francisco River, Brazil. *Revista Brasileira de Parasitologia Veterinária*, *24*(2), 129-135. DOI: https://doi.org/10.1590/S1984-29612015038

Deflem, I. O. S., Van Den Eeckhaut, F., Vandevoorde, M., Calboli, F. C. F., Raeymaekers, J. A. M., & Volckaert, F. A. M. (2022). Environmental and spatial determinants of parasite communities in invasive and native freshwater fishes. *Hydrobiology*, *849*(1), 913-928. DOI: https://doi.org/10.1007/s10750-021-04746-z

Dirección de Hidráulica de Entre Ríos. (2018). *Cuencas entrerrianas* (Official website). Retrieved from http://www.hidraulica.gob.ar/cuencas.php

Eiras, J. C., Takemoto, R. M., & Pavanelli, G. C. (2006). *Métodos de estudo e técnicas laboratoriais em parasitologia de peixes.* Maringá, PR: Eduem.

Fernandes, E. D. S, Casali, G. P., & Takemoto, R. M. (2019). Metazoan endoparasites of *Brycon orbignyanus* (Characidae: Bryconinae) in a neotropical floodplain. *Acta Scientiarum: Biological Sciences*, *41*(1), e40493. DOI: https://doi.org/10.4025/actascibiolsci.v41i1.40493

Gervasoni, S. H., Chemes, S. B., Scaglione, M. C., & Cerutti, R. D. (2018). First report of *Lernaea cyprinacea* (Crustacea: Lernaeidae) parasiting *Rhamdia quelen* (Pisces: Heptapteridae) in Santa Fe (Argentina) under hatchery conditions. *Revista Colombiana de Ciencias Pecuarias*, *31*(3), 229-234. DOI: https://doi.org/10.17533/udea.rccp.v31n3a08

Gotelli, N. J., & Entsminger, G. L. (2011). *EcoSim: null models software for ecology. Version 7.0*. Jericho, NY: Acquired Intelligence Inc. & Kesey-Bear. Retrieved from http://garyentsminger.com/ecosim/index.htm

Graça, W. J. D., & Pavanelli, C. S. (2007). *Peixes da planície de inundação do alto do rio Paraná e áreas adjacentes*. Maringá, PR: Eduem.

Hammer, Ø., Harper, D., & Ryan, P. (2001). PAST: Paleontological statistics software package for education and data analysis. *Electronica Palaeontology*, *4*(1), 1-9.

Klaschka, J., & Reiczigel, J. (2021). On matching confidence intervals and tests for some discrete distributions: methodological and computational aspects. *Computational Statistics, 36*(1), 1775-1790. DOI: https://doi.org/10.1007/s00180-020-00986-0

Lafferty, K. D., Allesina, S., Arim, M., Briggs, C. J., Leo, G., Dobson, A. P., … Thieltges, D. W. (2008). Parasites in food webs: the ultimate missing links. *Ecology Letters*, *11(6)*, 533-546. DOI: https://doi.org/10.1111/j.1461-0248.2008.01174.x.

Le Cren, E. D. (1951). The length-weight relationship and seasonal cycle in gonad weight and condition in the perch (*Perca fluviatilis*). *Journal of Animal Ecology*, *20*(2), 201-219. DOI: https://doi.org/10.2307/1540

Lehun, A. L., Hasuike, W. T., Silva, J. O. S., Ciccheto, J. R. M., Michelan, G., Rodrigues, A., … Takemoto, R. M. (2020). Checklist of parasites in fish from the Upper Paraná River floodplain: An update. *Revista Brasileira de Parasitologia Veterinária*, *29*(3), e008720. DOI: https://doi.org/10.1590/S1984-29612020066

Lizama, M. D. L., Takemoto, R. M., & Pavanelli, G. C. (2006). Parasitism influence on the hepato, splenosomatic and weight/length relation and relative condition factor of *Prochilodus lineatus* (Valenciennes, 1836) (Prochilodontidae) of the Upper Paraná River Floodplain, Brazil. *Revista Brasileira de Parasitologia Veterinária*, *15*(3), 116-122.

Luque, J. L., & Poulin, R. (2007). Metazoan parasite species richness in Neotropical fishes: hotspots and the geography of biodiversity. *Parasitology*, *134*(6), 865-878. DOI: https://doi.org/10.1017/S0031182007002272

Luque, J. L., & Poulin, R. (2008). Linking ecology with parasite diversity in Neotropical fishes. *Journal of Fish Biology*, *72*(1), 189-204. DOI: https://doi.org/10.1111/j.1095-8649.2007.01695.x

Marcogliese, D. J. (2002). Food webs and the transmission of parasites to marine fish. *Parasitology*, *124*(7), 83-99. DOI: https://doi.org/10.1017/s003118200200149x.

Marcogliese, D. J. (2016). The distribution and abundance of parasites in aquatic ecosystems in a changing climate: more than just temperature. *Integrative and Comparative Biology*, *56*(4), 611-619. DOI: https://doi.org/10.1093/icb/icw036

Marcogliese, D. J., & Pietrock, M. (2011). Combined effects of parasites and contaminants on animal health: parasites do matter. *Trends Parasitology*, *27*(3), 123-130. DOI: https://doi.org/10.1016/j.pt.2010.11.002

Moreno, C. (2001). *Métodos para medir la biodiversidad* (Vol. 1). Zaragoza, ES: M&T SEA.

Moreno, C. E., Barragán, F., Pineda, E., & Pavón, N. P. (2011). Reanálisis de la diversidad alfa: alternativas para interpretar y comparar información sobre comunidades ecológicas. *Revista Mexicana de Biodiversidad*, *82*(4), 1249-1261. DOI: https://doi.org/10.22201/ib.20078706e.2011.4.745

Morris, T., Avenant-Oldewage, A., Lamberth, A., & Reed, C. (2016). Shark parasites as bio-indicators of metals in two South African embayments. *Marine Pollution Bulletin*, *104*(1-2), 221-228. DOI: https://doi.org/10.1016/j.marpolbul.2016.01.027

Neff, B. D., & Cargnelli, L. M. (2004). Relationships between condition factors, parasite load and paternity in bluegill sunfish, *Lepomis macrochirus*. *Environmental Biology of Fishes*, *71*(1), 297-304. DOI: https://doi.org/10.1007/s10641-004-1263-8

Neiffer, D., & Stamper, M. (2009). Fish sedation, anesthesia, analgesia, and euthanasia: considerations, methods, and types of drugs. *ILAR Journal, 50*(4), 343-360. DOI: https://doi.org/10.1093/ilar.50.4.343

Oliveira, M. S., Prestes, L., Adriano, E., & Tavares-Dias, M. (2022). Morphological and functional structure of two Ergasilidae parasites determine their microhabitat affinity on the gills of an Anostomidae fish from the Amazon. *Parasitology Research*, *121*(8), 2295-2305. DOI: https://doi.org/10.1007/s00436-022-07569-6

Oliveira, M. S. B., Lima Corrêa, L., Prestes, L., Neves, L. R., Brasiliense, A. R. P., ... Tavares-Dias, M. (2018). Comparison of the endoparasite fauna of *Hoplias malabaricus* and *Hoplerythrinus unitaeniatus* (Erythrinidae), sympatric hosts in the eastern Amazon region (Brazil). *Helminthology*, *55*(1), 157-165. DOI: https://doi.org/10.2478/helm-2018-0003

Österlinga, M. E., & Larsenb, B. M. (2013). Impact of origin and condition of host fish (*Salmo trutta*) on parasitic larvae of *Margaritifera margaritifera*. *Aquatic Conservation*, *23*(4), 564-570. DOI: https://doi.org/10.1002/aqc.2320

Ostrowski de Núñez, M., Arredondo, N. J., & Gil de Pertierra, A. A. (2017). Adult trematodes (Platyhelminthes) of freshwater fishes from Argentina: a checklist. *Revue Suisse de Zoologie*, *124(1)*, 91-113. DOI: https://doi.org/10.5281/zenodo.1040686

Pardo, S. C., Zumaque, A. M., Hernando Noble, C., & Héctor Suárez, M. (2008). *Contracaecum* sp. (Anisakidae) en el pez *Hoplias malabaricus*, capturado en la Ciénaga Grande de Lorica, Córdoba. *CES Medicina Veterinaria y Zootecnia Córdoba*, *13*(2), 1304-1314.

Pavanelli, G. C., Eiras, J. C., & Takemoto, R. M. (2008). *Doenças de peixes: profilaxia, diagnóstico e tratamento*. Maringá, PR: Eduem.

Piasecki, W., Goodwin, A. E., Eiras, J. C., & Nowak, B. F. (2004). Importance of Copepoda in freshwater Aquaculture. *Zoological Studies*, *43*(2), 193-205.

Reiczigel, J., Marozzi, M., Fábián, I., & Rózsa, L. (2019). Biostatistics for parasitologists – a primer to Quantitative Parasitology. *Trends in Parasitology, 35*(4), 277-281. DOI: https://doi.org/10.1016/j.pt.2019.01.003

Reis, R. E., Albert, J. S., Di, D. F., Mincarone, M. M., Petry, P., & Rocha, L. A. (2016). Fish biodiversity and conservation in South America. *Journal of Fish Biology, 89*(1), 12-47. DOI: https://doi.org/10.1111/jfb.13016

Rossi, L. M., & Chemes, S. B. (2022). Endoparasites of *Hypostomus commersoni* (Siluriformes, Loricariidae) from two shallow lagoons, Argentina. *Acta Scientiarum Biological Sciences*, *44*(1), e59554. DOI: https://doi.org/10.4025/actascibiolsci.v44i1.59554

R Studio Team. (2020). *R Studio: integrated development for R. RStudio, PBC*. Boston, MA: rTT Technology. Retrieved from http://www.rstudio.com/

Ruiz Díaz, F. (2015). Alimentación. In A. Almiron, J. Casciotta, L. Ciotek, & P. Giorgis, *Guía de los peces del Parque Nacional Pre-Delta* (p. 41-45). Buenos Aires, AR: Administración de Parques Nacionales.

Satake, F., Mayumi Ishikawa, M., Hisano, H., Benites de Pádua, S., & Tavares-Dias, M. (2009). *Relação peso-comprimento, fator de condição e parâmetros hematológicos de dourado* Salminus brasiliensis *cultivado em condições experimentais.* Dourados, MS: Embrapa Agropecuária.

Scarabotti, P. A., López, J. A., & Pouilly, M. (2011). Flood pulse and the dynamics of fish assemblage structure from neotropical floodplain lakes. *Ecology of Freshwater Fish*, *20*(40, 605-618. DOI: https://doi.org/10.1111/j.1600-0633.2011.00510.x

Schludermann, C., Konecny, R., Laimgruber, S., Lewis, J., Schiemer, F., ... Sures, B. (2003). Fish macroparasites as indicators of heavy metal pollution in river sites in Austria. *Parasitology*, *126*(7), S61-S69. DOI: https://doi.org/10.1017/s0031182003003743

Soto, J., Muñoz, G., González, K., Ojeda, P. F., Castro, M., & George-Nascimento, M. (2016). Interacciones parásito-hospedero en peces del intermareal rocoso de la zona centro y centro-sur de Chile: comparación de la diversidad, conectancia y densidad de vínculos. *Latin American Journal of Aquatic Research*, *44*(4), 815-824. DOI: https://doi.org/10.3856/vol44-issue4-fulltext-17

Takemoto, R. M., Pavanelli, G. C., Lizama, M. A. P., Luque; J. L., & Poulin, R. (2005). Host population density as the major determinant of endoparasite species richness in floodplain fishes of the Upper Paraná River, Brazil. *Journal of Helminthology*, *79*(1), 75-84. DOI: https://doi.org/10.1079/joh2004264

Takemoto, R. M., Pavanelli, G. C., Lizama, M. A. P., Lacerda, A. C. F., Yamada, F. H., Moreira, L. H. A., … Bellay, S. (2009). Diversity of parasites of fish from the Upper Paraná River floodplain, Brazil. *Brazilian Journal of Biology*, *69* (2 suppl), 691-705. DOI: https://doi.org/10.1590/S1519-69842009000300023

Thatcher, V. E., & Paredes, V. (1985). A parasitic copepod, *Amplexibranchius bryconis* gen. et sp. nov. (Ergasilidae: Acusicolinae), from an Amazonian fish and remarks on the importance of leg morphology in this subfamily. *Amazoniana*, *9*(2), 205-214.

Timi, J. T., & Poulin, R. (2020). Why ignoring parasites in fish ecology is a mistake. *International Journal for Parasitology*, *50*(10-11), 755-761. DOI: https://doi.org/10.1016/j.ijpara.2020.04.007

Timi, J. T., Rossin, M. A., Alarcos, A. J., Braicovich, P. E., Cantatore, D. M. P., & Lanfranchi, A. L. (2011). Fish trophic level and the similarity of non-specific larval parasite assemblages. *International Journal for Parasitology*, *41*(3-4), 309-316. DOI: https://doi.org/10.1016/j.ijpara.2010.10.002

Tonella, L. H, Dias, M. R., Vitorio, O. B., Fugi, R., & Agostinho, A. A. (2019). Conservation status and bio-ecology of *Brycon orbignyanus* (Characiformes: Bryconidae), an endemic fish species from the Paraná River basin (Brazil) threatened with extinction. *Neotropical Ichthyology*, *17*(3), e190030. DOI: https://doi.org/10.1590/1982-0224-20190030

Zaniboni Filho, E., Reynalte-Tataje, D., & Weingartner, M. (2006). Potencialidad del género *Brycon* en la piscicultura brasileña. *Revista Colombiana de Ciencias Pecuarias*, *19*(1), 233-240.