INFLUENCE OF HOST SEX AND AGE ON INFRACOMMUNITIES OF METAZOAN PARASITES OF *PROCHILODUS LINEATUS* (VALENCIENNES, 1836) (PROCHILODONTIDAE) OF THE UPPER PARANÁ RIVER FLOODPLAIN, BRAZIL

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Summary:

149 specimens of *Prochilodus lineatus* were collected on the upper Paraná River floodplain. Of these, 121 (82.1 %) were parasitized. 33 species of metazoan parasites were recorded. *Rhinonastes pseudocapsaloideum* was classified as secondary, while all other species were classified as satellites. *Ergasilus* sp. and *Tereancistrum curimba* were positively associated and their abundances were positively correlated. *Saccocoelioides magnorchis* and *S. nanii* were positively associated and their abundances were positively correlated. The mean diversity in the infracommunities of *P. lineatus* was H = 0.6875 ± 0.4398. Host standard length was not correlated with parasite diversity (rs = 0.1726; p = 0.0533). The abundances of *T. curimba* and *Kritskyia boegeri*, and *S. magnorchis* and *S. nanii* were significantly correlated with host length. Correlation between fish age and parasite prevalence was not significant. The abundances of *Amplexibranchius* sp., *K. boegeri* and *S. magnorchis* were significantly different among host age classes. For *Amplexibranchius* sp., the three-year old age class had more parasites. For *K. boegeri*, the intermediate age classes had the most numerous parasites. Only *Tereancistrum curimba* showed significant difference in the prevalence between the sexes, with females being more parasitized.

KEY WORDS : metazoan parasite, *Prochilodus lineatus*, upper Paraná River, floodplain, Brazil.

Résumé : INFLUENCE DU SEXE ET DE L'ÂGE DE L'HÔTE SUR LES INFRACOMMUNAUTÉS DE MÉTAZOAIRES PARASITES DE *PROCHILODUS LINEATUS* (VALENCIENNES, 1836) (PROCHILODONTIDAE) DE LA PLAINE INONDABLE DE LA RIVIÈRE SUPÉRIEURE DE PARANÁ, BRÉSIL

149 spécimens de Prochilodus lineatus *ont été recueillis dans la plaine inondable de la Rivière supérieure de Paraná. 121 (82,1 %) étaient parasités. 33 espèces de métazoaires parasites ont été retrouvées.* Rhinonastes pseudocapsaloideum *a été classifié comme étant secondaire, et toutes les autres espèces comme satellites.* Ergasilus *sp. et* Tereancistrum curimba *ont été retrouvés associés et leurs abondances corrélées positivement. Il en est de même pour* Saccocoelioides magnorchis *et* S. nanii. *La diversité moyenne dans les infracommunautés de* P. lineatus *était H = 0,6875 ± 0,4398. La taille de l'hôte n'était pas corrélée à la diversité parasitaire (rs = 0,1726 ; p = 0,0533). Les abondances de* T. curimba *et* Kritskyia boegeri, *et* S. magnorchis *et* S. nanii *étaient significativement corrélées à la longueur de l'hôte. La corrélation entre l'âge du poisson et la prévalence du parasite n'était pas significative. Les abondances de* Amplexibranchius *sp.,* K. boegeri *et* S. magnorchis *étaient significativement différentes selon les classes d'âge de l'hôte. Pour* Amplexibranchius *sp., la classe d'âge de trois ans était la plus parasitée. Pour* K. boegeri, *les classes d'âge intermédiaires étaient les plus parasitées. Seul* Tereancistrum curimba *a montré une différence significative de prévalence selon le sexe, les femelles étant les plus parasitées.*

MOTS CLÉS : *métazoaires parasites,* Prochilodus lineatus, *plaine inondable, Rivière supérieure de Paraná, Brésil.*

INTRODUCTION

The curimba *Prochilodus lineatus* (Valenciennes, 1836) is one of the most abundant species on the upper Paraná River floodplain and of commercial importance. Curimba are large-sized and carry out extensive migrations to feed and reproduce. Iliophagous, its diet is composed primarily of detritus and sediment (Fugi *et al.,* 1996; Agostinho *et al.,* 1997).

Studies about this species have broached prominent aspects of population structure and biology (e.g. Terraes *et al.,* 1999; Lizama, 2000; Ranzani Paiva *et al.,* 2000). Important information about the parasitic fauna of this host has recently been reported. Takemoto *et al.* (2002) described a new species of monogenean parasite of the urinary bladder, Domingues *et al.* (2002) described a new species of monogenean parasite of the nasal cavity and Lizama *et al.* (2004) described two species of gill monogeneans. As regards parasite ecology, Martins *et al.* (2001), referred only to seasonal variation in parasitism levels of the acanthocephalan *Neoechinorhynchus curemai.*

The object of this study was to evaluate the relationships between the host *Prochilodus lineatus* and the metazoan parasite fauna, including the influence of host sex and length/age on parasite infrapopulations.

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MATERIALS AND METHODS

149 specimens of *Prochilodus lineatus* were collected between February 2000 and June 2001 on the upper Paraná River floodplain in the "Ilhas e Várzea do rio Paraná" Protected Area (Brazil) (22º 50'-22º 70' S and 53º 15'-53º 40' W). The total weight, standard length and sex of each fish were recorded. The internal organs and the visceral cavity were analyzed under a stereomicroscope. The collected parasites were treated according to Eiras *et al.* (2000) and identified based on Thatcher (1978, 1979, 1991 and 1993), Thatcher & Boeger (1984a, b), Thatcher & Varella (1981), Moravec (1998), Takemoto *et al.* (2002) and Lizama *et al.* (2004). The age of each specimen was established according to the growth parameters estimated in Lizama (2000) and applied to obtain the mean length of each age class. Statistical tests were applied to species that had presented prevalence higher than 10 % (Bush *et al.,* 1990). Significant difference was assumed when $p \leq 0.05$. The dispersion index and the Green index were used to verify dispersion patterns of the parasite species. The dispersion index was tested using the statistic *d* (Ludwig & Reynolds, 1988). The diversity of each metazoan parasite infracommunity was calculated using the Brillouin index (H). The possible correlation between diversity and host standard length was determined using Spearman's rank correlation (rs). The value of importance (Hanski, 1982; Bush & Holmes, 1986; Esch *et al.*, 1990) was used to verify the importance of each species in the metazoan parasite community. Species considered central were present in more than 66.66 % of the analyzed fish; secondary = presence between 33.33 % and 66.66 %; satellites = less than 33.33 %. The terminology used throughout this study is from Bush *et al.* (1997).

RESULTS

Fish standard length was 4.2-44.0 cm (mean = 25.6 ± 6.9) and weight was 2.1-2,602.2 g (mean = 566.3 ± 403.4).
Of the 149 analyzed fish, 121 (82.1 %) were parasitized by one or more species of metazoan parasite. 33 metazoan parasite species were recorded. The digeneans was the group with the largest number of specimens (Table I).

Ecological aspects of the metazoan parasite infracommunity

A total of 2,662 parasite specimens belonging to 33 species were collected. Endoparasites accounted for 63.35 % of the metazoan parasites. The digeneans *Saccocoelioides magnorchis* and *S. nanii* were the most abundant and the ectoparasites *Rhinonastes pseudocapsaloideum* and *Kritskyia boegeri* were the most prevalent among all parasite species. According to the value of importance, only *Rhinonastes pseudocapsaloideum* was considered secondary, while the other species were considered satellites. No species were classified as central (Table I). The metazoan parasite population of *P. lineatus* was overdispersed and there was low aggregation for all species. The copepod *Amplexibranchius* sp. presented the highest aggregation value (Table I).
No pair of species showed association among the ectoparasites of the nasal cavity. The abundance values of gill ectoparasites *Ergasilus* sp. and *Tereancistrum curimba* were positively correlated, showing positive association (Chi-square with the Yates correction, $\chi^2 = 3.667$; Spearman's rank correlation, rs = 0.215; p = 0.0083). Abundances of *Saccocoelioides magnorchis* and *S. nanii* were positively associated ($\chi^2 = 13.359$; rs = 0.353; $p < 0.001$).
The metazoan parasite community of *P. lineatus* presented mean diversity of H = 0.6875 ± 0.4398. Host standard length was not correlated with diversity (rs = 0.1726; p = 0.0533). Parasite community richness showed a predominance of four species per host, followed by two and five species.

Standard length/age

Among the 11 most prevalent species (> 10 %) of parasites, the monogeneans *T. curimba* (rs = 0.253; p = 0.001) and *K. boegeri* (rs = 0.223; p = 0.006), and the digeneans *S. magnorchis* (rs = 0.190; p = 0.020) and *S. nanii* (rs = 0.252; p = 0.019) presented significant correlations between host standard length and abundance. No metazoan species presented correlation between prevalence and fish age.
Fish up to one year old are not parasitized; after this period, the frequency of parasitism increases to 79.0 % (Fig. 1). There are no differences between the mean

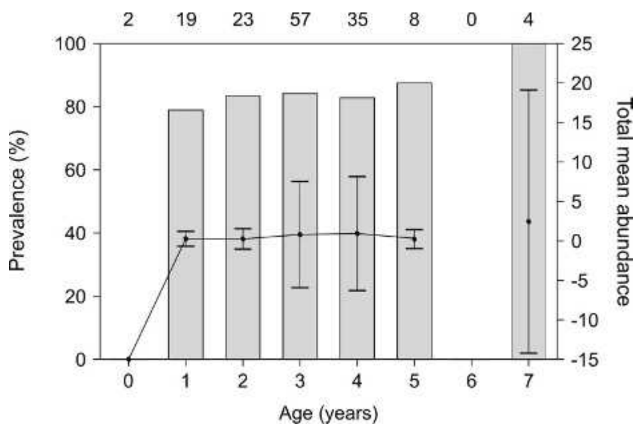

Fig. 1. – Frequency of parasitism for each age class of *Prochilodus lineatus*, captured on the upper Paraná River floodplain from February 2000 to June 2001 (Numbers on the top of the graph refer to the number of examined fishes).

Parasite	P	MA ± SD	AI	Classif.	DI	*d*	GI	Site of infection/infestation
Monogenea								
Rhinonastes pseudocapsaloideum	43.62	1.31 ± 2.35	1-15	Se	4.303	18.390*	0.018	Nasal cavity
Kritskyia boegeri	28.85	1.55 ± 3.53	1-17	Sa	8.037	31.583*	0.030	Urinary bladder
Tereancistrum curimba	22.80	0.75 ± 2.45	1-20	Sa	7.980	31.427*	0.063	Gills
Tereancistrum toksonum	5.30	0.23 ± 1.29	1-13	Sa	–	–	–	Gills
Tereancistrum sp.	0.67	0.01 ± 0.08	1	Sa	–	–	–	Gills
Gyrodactylus sp. 1	3.35	0.05 ± 0.29	1-3	Sa	–	–	–	Nasal cavity
Gyrodactylus sp. 2	3.35	0.05 ± 0.32	1-3	Sa	–	–	–	Gills
Anacanthoroides sp.	2.01	0.05 ± 0.41	1-4	Sa	–	–	–	Gills
Ancyrocephalinae	6.04	0.23 ± 1.16	1-9	Sa	–	–	–	Gills
Digenea								
Saccocoelioides magnorchis	26.84	3.63 ± 11.45	1-114	Sa	38.568	88.758*	0.078	Intestine, stomach, pyloric cecae
Saccocoelioides nanii	26.84	8.97 ± 30.35	1-200	Sa	102.643	157.130*	0.076	Intestine, stomach, pyloric cecae
Saccocoelioides leporinodus	2.68	0.07 ± 0.47	1-5	Sa	–	–	–	Intestine
Saccocoelioides saccodontis	0.67	0.01 ± 0.16	2	Sa	–	–	–	Intestine
Saccocoelioides sp.	0.67	0.04 ± 0.49	6	Sa	–	–	–	Intestine
Unicoelium prochilodorum	5.37	0.20 ± 1.66	1-2	Sa	–	–	–	Intestine
Megacoelium sp.	5.37	0.12 ± 0.64	1-6	Sa	–	–	–	Intestine, stomach
Tylodelphis sp. (metacercariae)	10.74	0.17 ± 0.80	1-9	Sa	3.818	16.441*	0.117	Gills
Colocladorchis sp.	8.05	0.29 ± 2.39	1-29	Sa	–	–	–	Intestine
Sphincterodiplostomum sp. (metac.)	0.67	0.01 ± 0.08	1	Sa	–	–	–	Gills
Lecitobothrioides sp.	0.67	0.01 ± 0.16	2	Sa	–	–	–	Intestine
Digenea 1 (metacercariae)	2.01	0,05 ± 0.43	1-6	Sa	–	–	–	Mesentery
Digenea 2 (metacercariae)	0.67	0.02 ± 0.25	3	Sa	–	–	–	Heart
Cestoda								
Proteocephalidea (plerocercoid)	5.36	0.25 ± 1.28	1-10	Sa	–	–	–	Mesentery
Valipora campylancristrota	5.37	0.09 ± 0.53	1-6	Sa	–	–	–	Gall bladder
Nematoda								
Raphidascaris sp.	2.01	0.02 ± 0.14	1	Sa	–	–	–	Intestine, stomach
Acanthocephala								
Neoechinorhynchus curemai	20.13	0.72 ± 2.27	1-15	Sa	7.148	28.724*	0.058	Intestine, pyloric cecae
Quadrigyrus sp.	3.35	0.05 ± 0.29	1-3	Sa	–	–	–	Intestine, stomach, pyloric cecae
Copepoda								
Gamidactylus jaraquensis	15.43	0.58 ± 1.92	1-12	Sa	5.869	24.510*	0.066	Nasal cavity
Gamispatulus sp.	15.43	0.37 ± 1.14	1-9	Sa	3.464	14.895*	0.043	Nasal cavity
Amplexibranchius sp.	16.10	0.78 ± 4.38	1-48	Sa	25.578	69.836*	0.227	Gills
Ergasilus sp.	15.43	0.41 ± 1.52	1-14	Sa	5.678	23.820*	0.078	Gills
Branchiura								
Dolops sp.	2.68	0.03 ± 0.20	1-2	Sa	–	–	–	Skin, Gills
Hirudinea	2.01	0.02 ± 0.14	1	Sa	–	–	–	Skin

* Significant values

Table I. – Prevalence values (P%), Mean abundance (MA), Amplitude of intensity (AI), Classification according to the importance for the community (Hanski, 1982; Bush & Holmes, 1986) (Central (Ce), Secondary (Se) and Satellite species (Sa)), Dispersion index values (DI), the statistic *d*, the Green index of aggregation (GI) and the site of infection/infestation of the parasite fauna of *Prochilodus lineatus*, captured on the upper Paraná River floodplain from February 2000 to June 2001.

lengths per age class between parasitized and unparasitized fish.

Three-year old fish were the most intensely parasitized by the copepod *Amplexibranchius* sp. In the hosts of intermediate age classes (3, 4 and 5-years old), the monogenean *K. boegeri* was the most frequent. Seven-year old fish had the highest numbers of the digenean *S. magnorchis*. These differences were observed using the Kruskall-Wallis test; but according to the Bonferroni correction, the abundance values are significantly different.

SEX

Of the total fish sample, 77 were females (51.7 %), 70 were males (47 %) and the sex of two fish could not be determined (1.3 %). Among these fish, 68 females (45.61 %), 53 males (35.6 %) and one with undetermined sex (0.7 %) were parasitized by one or more species of parasite. The Log Likelihood G test showed significant difference (G = 0.422; p = 0.040) between the prevalence of the monogenean *Tereancistrum curimba* in male and female hosts, and females harboring more parasites. No significant differences were noted among abundance values based on host sex.

DISCUSSION

The results obtained in this study show the predominance of endoparasites in the metazoan parasite community of *Prochilodus lineatus*. The predominance of endoparasites, according to Pearson (1968), Williams & Jones (1994), Cannon (1977), Kuperman (1973) and Luque *et al.* (1996a), is related to host feeding habits. *P. lineatus*, classified as iliophagous, feeds preferentially on detritus and sediment, which includes many invertebrates (mainly copepods and ostracods) (Hahn *et al.,* 1997). Copepods and ostracods can be intermediate hosts for endoparasites, explaining the predominance in *P. lineatus*.

The presence of only one secondary species (*R. pseudocapsaloideum*) and no central ones indicates that the parasite community is not dominated by any one species. The feeding habit can explain this. Despite having several invertebrates in this food item, a specific species does not exist. Thus, infection by several species of parasites is possible. However, parasite diversity decreased and did not present significant correlation with host size.

The overdispersed distribution pattern of the parasites of *P. lineatus* is in accordance with the typical distribution pattern found in fish parasites and can be explained by the differences between the host populations (Luque *et al.,* 1996a). Niche heterogeneity, unpredictable recruitment or the aggregated utilization of fragmented resources favor species coexistence (Morand *et al.,* 1999).

The occurrence of two associations between parasite species and the absence of negative associations (potential competition) can be explained by the low levels of parasitism and the absence of dominant species (centrals). In the case of *P. lineatus*, the species was positively associated with the copepod *Ergasilus* sp., the monogenean *T. curimba* and the digeneans *Saccocoelioides magnorchis* and *S. nanii*, found in the gills and intestine, respectively. These species find available spaces, and do not interact.

The length of the host, considered an expression of its age, is one of the most important factors in parasite infrapopulation variation. The monogeneans *T. curimba* and *K. boegeri*, and the digeneans *S. magnorchis* and *S. nanii* presented positive correlations – increasing parasitism abundance with the increase in fish length. According to Rohde (1993), this pattern may be due to the cumulative effect that occurs in long-life parasite species. This process is more common in ectoparasites in which the transmission is direct. In addition, fish that present a larger gill cavity and body surface can lodge more parasites (Lo *et al.*, 1998). However, diverse studies observe the same process for endoparasites. This occurs due to changes in the behavior and physiology of the host during its ontogenetic development, as well as in its diet through an increase in the volume consumed and its composition (Luque *et al.,* 1996b; Takemoto & Pavanelli, 2000; Machado *et al.,* 2000).

Influence of host age on parasite abundance is applied only to long-life parasites (Lo *et al.*, 1998). The life cycle of these parasites is unknown in this region; however, it is known that curimba can live more than seven years (Castagnolli, 1971; Carozza & Cordiviola-de-Yuan, 1991). Studies carried out on the floodplain indicate that the species may have a higher life expectancy than observed by other authors (Lizama, 2000). Nascimento & Iriarte (1989), Buchmann (1989) and Machado *et al.* (1994) also showed that the level of parasitism is related to host size, which increases over its ontogeny. The same result was obtained for some endoparasites from the upper Paraná River floodplain (Machado *et al.,* 2000; Takemoto & Pavanelli, 2000; Guidelli *et al.,* 2003).

Until approximately 1.5 to two years of age, juveniles of *P. lineatus* live in lagoons, sites that serve as nurseries and feeding areas for the young population (Vazzoler *et al.,* 1997). The phase of transition and adaptation to a new environment after leaving the lagoons make the fish more vulnerable to parasitism.

The three-year old age class prevailed among the more parasitized classes. The smallest standard length of this class is 23.7 cm for females. This shows that a higher degree of parasitism occurs when the hosts become adults. The prevalence of parasitism in the lower age classes was not significant. Age class preference has been described by diverse authors.

Winch (1983) studied parasites of *Atrispinum labracis* in *Dicentrarchus labrax* and observed that the fish were only infected after three years of age. The same result was obtained by Odening & Bockhardt (1976) for *Azygia lucii* in *Esox lucius*. In *P. lineatus*, significant differences in weight and growth rates for classes more than three years old were also verified. The highest intensity values in the three-year old age class may be related to reproductive and/or alimentary migrations of this species. Therefore, the study of age, as well as length, has become an important tool to understand the relationships between parasites and their hosts.

Lawrence (1970), Muzzall (1980) and Conneely & McCarthy (1986) observed that in addition to age, host sex and flood period also influenced parasite abundance. The action of these factors on the parasite fauna is considerable, mainly for those that have several organisms as intermediate hosts.

Some biotic factors are important in the host-parasite relationship. Host sex is one of them. Differences between the sexes and changes in the infestation of ectoparasites, for example, are probably related to seasonal changes in the composition of the tegument (Pickering, 1977). Endoparasites can infect the two sexes in different ways because some species of fish present different feeding habitats (Rohde, 1993).

In the present study, no influences of host sex on parasitism levels were observed. Only the monogenean *T. curimba* presented significant differences regarding host sex, with the female host being more parasitized. This shows few behavioral and physiological differences between the male and female hosts, considering that the main characteristic of *P. lineatus* is feeding and reproduction migrations.

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REFERENCES

AGOSTINHO A.A., JÚLIO JR. H.F., GOMES L.C., BINI L.M. & AGOSTINHO C.S. Composição, abundância e distribuição espaço-temporal da ictiofauna, *In*: A planície de inundação do alto rio Paraná: aspectos físicos, biológicos e socioeconômicos. Vazzoler A.E.A. de M., Agostinho A.A. & Hahn N.S. (eds), EDUEM, Maringá, 1997, 179-208.

BUCKMANN K. Relationship between host size of A*nguilla anguilla* and the infection level of the monogeneans *Pseudodactylogyrus* spp. *Journal of Fish Biology*, 1989, *35*, 599-661.

BUSH A.O., AHO J.M. & KENNEDY C.R. Ecological versus phylogenetics determinants of helminth parasite community richness. *Evolutionary Ecology*, 1990, *4*, 1-20.

BUSH A.O. & HOLMES J.C. Intestinal helminths of lesser scaup ducks: an interactive community. *Canadian Journal of Zoology*, 1986, *64*, 142-152.

BUSH A.O., LAFFERTY K.D., LOTZ J.M. & SHOSTAK A.W. Parasitology meets ecology on its own terms: Margolis *et al.* revisited. *Journal of Parasitology*, 1997, *83*, 575-583.

CANNON L.R.G. Some ecological relationships of larvas ascaridoids from south-eastern Queensland marine fishes. *International Journal for Parasitology*, 1977, *7*, 227-232.

CAROZZA C. & CORDIVIOLA-DE-YUAN E. Estudios ictiológicos en la Laguna la Cuarentena (Isla Carabajal), Rio Paraná, Argentina: Edad y crecimiento del "sabalo" *Prochilodus lineatus* (Val.), periodo 1984-1985 (Pisces, Curimatidae). *Revue D'Hydrobiologie Tropicale*, 1991, *24*, 119-129.

CASTAGNOLLI N. Idade e crescimento de três espécies da família Characidae do rio Mogi Guassu. *Revista Brasileira de Biologia*, 1971, *31*, 519-524.

CONNEELY J.J. & MCCARTHY T.K. Ecological factors influencing the composition of the parasite fauna of the European eel, *Anguilla anguilla* (L.), in Ireland. *Journal of Fish Biology*, 1986, *28*, 207-219.

DOMINGUES M.V. & BOEGER W.A. Neotropical Monogenoidea. 40. *Protorhinoxenus prochilodi* gen. n., sp. n. (Monogenoidea: Ancyrocephalinae), parasite of *Prochilodus lineatus* (Characiformes: Prochilodontidae) from South Brazil. *Folia Parasitológica*, 2002, *49*, 35-38.

ESCH G.W., SHOSTAK A.W., MARCOGLIESE D.J. & GOATER T.M. Patterns and processes in helminth parasite communities: an overview. *In:* Parasite communities: patterns and processes. Esch G.W, Bush A. & Aho J. (eds), Chapman and Hall, New York, 1990, 1-20.

EIRAS J.C., TAKEMOTO R.M. & PAVANELLI G.C. Métodos de estudio y técnicas laboratoriales en parasitología de peces. Editorial Acribia, Zaragoza, 2000, 133 p.

FUGI R., HAHN N.S. & AGOSTINHO A.A. Feeding styles of five species of bottom-feeding fishes of the high Paraná River. *Environmental Biology of Fishes*, 1996, *46*, 297-307.

GUIDELLI G.M., ISAAC A., TAKEMOTO R.M. & PAVANELLI G.C. Endoparasite Infracommunities of *Hemisorubim platyrhynchus* (Valenciennes, 1840) (Pisces: Pimelodidae) of the Baía River, Upper Paraná River Floodplain, Brazil: specific composition and Ecological Aspects. *Brazilian Journal of Biology*, 2003, *63*, 261-268.

HAHN N.S., ANDRIAN I.F., FUGI R. & ALMEIDA V.L. Ecologia Trófica. *In*: A planície de inundação do alto rio Paraná: aspectos físicos, biológicos e socioeconômicos. Vazzoler A.E.A. de M., Agostinho A.A. & Hahn N.S. (eds), EDUEM, Maringá, 1997, 209-228.

HANSKI J. Dynamics of regional distribution: the core and satellite species hypothesis. *Oikos*, 1982, *38*, 210-221.

KUPERMAN B.I. Infection of young perch by tapeworm *Triaenophorus nodulosus*. *Verhandlungen Der International en Vereiningung für Theoretische und Angewandte Limnologie*, 1973, *18*, 1697-1704.

LAWRENCE J.L. Effects of season, host age and sex on endohelminths of *Catostomi commersoni*. *Journal of Parasitology*, 1970, *56*, 567-571.

LIZAMA M. DE LOS A.P. Estimativa dos parâmetros de crescimento, recrutamento e mortalidade de *Prochilodus lineatus* da planície de inundação do alto Rio Paraná, Brasil. *Boletim do Instituto de Pesca*, 2000, *26*, 121-128.

LIZAMA M. DE LOS A.P., TAKEMOTO R.M. & PAVANELLI G.C. New species of *Tereancistrum* Kritsky, Thatcher & Kayton, 1980 (Monogenea: Dactylogyridae: Ancyrocephalinae) from the gills of *Prochilodus lineatus* (Osteichthyes: Prochilodontidae) from the upper Paraná River floodplain, Brazil. *Systematic Parasitology*, 2004, *57*, 45-49.

LO C.M., MORAND S. & GALZIN R. Parasite diversity/host age and size relationship in three coral-reef fishes from French Polynesia. *International Journal for Parasitology*, 1998, *28*, 1695-1708.

LUDWIG J.A. & REYNOLDS J.F. Statistical Ecology: a primer on methods and computing. Wiley-Interscience Publications, New York, 1988, 337 p.

LUQUE J.L., AMATO J.F.R. & TAKEMOTO R.M. Comparative analysis of the Communities of metazoan parasites of *Ortho-*

pristis ruber and *Haemulon steindachneri* (Osteichthyes: Haemulidae) from the southeastern Brazilian littoral: I. Structure and influence of the size and sex of hosts. *Revista Brasileira de Biologia*, 1996a, *56*, 279-292.

LUQUE J.L., AMATO J.F.R. & TAKEMOTO R.M. Comparative analysis of the communities of metazoan parasites of *Orthopristis ruber* and *Haemulon steindachneri* (Osteichthyes: Haemulidae) from the southeastern Brazilian littoral: II. Diversity, interespecific associations, and distribution of gastrointestinal parasites. *Revista Brasileira de Biologia,* 1996b, *56*, 293-302.

MACHADO M.H., PAVANELLI G.C. & TAKEMOTO R.M. Influence of host's sex and size on endoparasitic infrapopulations of *Pseudoplatystoma corruscans* and *Schizodon borelli* (Osteichthyes) of the high Paraná river, Brazil. *Revista Brasileira de Parasitologia Veterinária,* 1994, *3*, 143-148.

MACHADO P.M., ALMEIDA S.C., PAVANELLI G.C. & TAKEMOTO R.M. Ecological aspects of Endohelminths paraziting *Cichla monoculus* Spix, 1831 (Perciformes: Cichlidae) in the Paraná river near Porto Rico, State of Paraná, Brazil. *Comparative Parasitology*, 2000, *6*, 210-217.

MARTINS M.L., MORAES F.R. DE, FUJIMOTO R.Y., ONAKA E.M. & QUINTANA C.I.F. Prevalence and histopatology of *Neoechinorhynchus curemai* Noronha, 1973 (Acanthocephala: Neoechinorhynchidae) in *Prochilodus lineatus* Valenciennes, 1836 from Volta Grande reservoir, MG, Brazil. *Brazilian Journal of Biology*, 2001, *61*, 517-522.

MORAND S., POULIN R., RHODE K. & HAYWARD C. Aggregation and species coexistence of ectoparasites of marine fishes. *International Journal for Parasitology*, 1999, *29*, 663-672.

MORAVEC F. Nematodes of freshwater fishes of the Neotropical region. Academia Praha, Czech Republic, 1998, 464 p.

MUZZALL P.M. Seasonal distribution and ecology of three Caryophyllaeid cestode species infecting white suckers in SE New Hampshire. *Journal of Parasitology*, 1980, *66*, 542-550.

NASCIMENTO M.J. & IRIARTE J.L. Las infracomunidades de parásitos metazoos del chancharro *Helicolenus lengerichi* Norman, 1937 (Pisces, Scorpaenidae): un ensamble no interactivo de especies. *Revista Chilena de Historia Natural*, 1989, *62*, 217-227.

PEARSON J.C. Observations on the morphology and life-cycle of *Paucivitellosus fragilis* Coil, Reid and Kuntz, 1965 (Trematoda: Bivesiculidae). *Parasitology*, 1968, *58*, 769-788.

PICKERING A.D. Seasonal changes in the epidermis of the brown trout *Salmo trutta* (L.). *Journal of Fish Biology*, 1977, *10*, 505-512.

RANZANI-PAIVA M.J.T., SILVA-SOUZA A.T., PAVANELLI G.C. & TAKEMOTO R.M. Hematological characteristics and relative condition factor (Kn) associated with parasitism in *Schizodon borelli* (Osteichthyes, Anostomidae) and *Prochilodus lineatus* (Osteichthyes, Prochilodontidae) from Paraná River, Porto Rico region, Paraná, Brazil. *Acta Scientiarum*, 2000, *22*, 515-521.

ROHDE K. Ecology of marine parasites. An introduction to marine parasitology. (2nd ed.). CAB International, United Kingdom, 1993, 297 p.

TAKEMOTO R.M., LIZAMA M. DE LOS A.P. & PAVANELLI G.C. A new species of *Kritskyia* (Dactylogyridae, Ancyrocephalinae) parasite of urinary bladder of *Prochilodus lineatus* (Prochilodontidae, Characiformes) from the floodplain of the high Paraná river, Brazil. *Memórias do Instituto Oswaldo Cruz*, 2002, *97*, 313-315.

TAKEMOTO R.M. & PAVANELLI G.C. Aspects of the ecology of Proteocephalid cestodes parasites of *Sorubim lima* (Pimelodidae) of the Upper Paraná river, Brazil: Structure and influence of host's size and sex. *Revista Brasileira de Biologia*, 2000, *60*, 577-584.

TERRAES J.C., BECHARA J.A., ROUX J.P., FLORES QUINTANA C., DOMITROVIC H. & SÁNCHEZ H.A.E. Ciclos reproductivos del sábalo (*Prochilodus lineatus*) y de sardina de río (*Hemiodus orthonops*) (Pisces, Characiformes) en el río Paraná águas debajo de la represa de Yacyretá, Argentina. *Revista de Ictiologia*, 1999, *7*, 91-104.

THATCHER V.E. Quatro espécies novas da família Haploporidae (Trematoda: Digenea) de peixes de água doce da Colômbia, com uma revisão do gênero *Saccocoelioides* Szidat, 1954. *Acta Amazônica*, 1978, *8*, 477-487.

THATCHER V.E. Paramphistomidae (Trematoda: Digenea) de peixes de água doce: dois novos gêneros da Colômbia e uma redescrição de *Dadaytrema oxycephala* (Diesing, 1836) Travassos, 1934, da Amazônia. *Acta Amazônica*, 1979, *9*, 203-208.

THATCHER V.E. Amazon fish parasites. *Amazoniana*, 1991, *11*, 263-571.

THATCHER V.E. Trematódeos Neotropicais. INPA, Manaus, 1993, 553 p.

THATCHER V.E. & VARELLA A.B. Duas novas espécies de *Megacoelium* Szidat, 1954 Trematoda: Haploporidae), parasitas estomacais de peixes da Amazônia Brasileira, com uma redefinição do gênero. *Acta Amazônica*, 1981, *11*, 285-289.

THATCHER V.E. & BOEGER W. The parasitic crustaceans of fishes from the Brazilian Amazon. 13. *Gamidactylus jaraquensis* gen. et sp. nov. (Copepoda: Poecilostomatoida: Vaigamidae) from the nasal fossae of *Semaprochilodus insignis* (Schomburgk). *Amazoniana*, 1984a, *8*, 421-426.

THATCHER V.E. & BOEGER W. The parasitic crustaceans of fishes from the Brazilian Amazon. 15. *Gamispatulus schizodontis* gen. et sp. nov. (Copepoda: Poecilostomatoida: Vaigamidae) from the nasal fossae of *Schizodontidae fasciatus* Agassiz. *Amazoniana*, 1984b, *9*, 119-126.

WILLIAMS H.M. & JONES A. Parasitic worms of fish. Taylor & Francis, London, 1994, 563 p.

WINCH J. The biology of *Atrispinum labracis* n. comb. (Monogenea) on the gills of the bass, *Dicentrarchus labrax*. *Journal of the Marine Biological Association of the United Kingdom*, 1983, *63*, 915-927.

VAZZOLER A.E.A. DE M., SUZUKI H.I., MARQUES E.E. & LIZAMA M. DE LOS A.P. Primeira maturação gonadal, períodos e áreas de reprodução. *In*: A planície de inundação do alto rio Paraná: aspectos físicos, biológicos e socioeconômicos. Vazzoler A.E.A. de M., Agostinho A.A. & Hahn N.S. (eds). EDUEM, Maringá, 1997, 249-265.

ZAR J.H. Biostatistical Analysis. 3rd. Edition, Prentice-Hall, Inc., Upper Saddle River, New Jersey, USA, 1996, 662 p.

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