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BIODIVERSITY OF FISH PARASITES FROM GUANDU RIVER, SOUTHEASTERN BRAZIL: AN ECOLOGICAL APPROACH

BIODIVERSIDAD DE LOS PARÁSITOS DE PECES DE RÍO GUANDU, SURESTE DE BRASIL: UNA APROXIMACIÓN ECOLÓGICA

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Key words: Biodiversity- Brazil- ecology parasite- fishes- Guandu River- parasites.

Abstract

Here, we performed a quantitative analysis of the parasite communities in 21 species of fish from Guandu River, Brazil; we evaluated the effects of some host traits (body size, social behavior, fish's habitat, trophic category and ability to migration) on the diversity of their communities of metazoan parasites. To measure quantitative diversity, we used parasite species richness, as well as the average taxonomic distinctness of the assemblage and its variance. The parasite species richness, the taxonomic distinctness and the variance were unaffected by the number of host individuals examined per species. Fish body length proved to be the main predictor of parasite species richness, although it did not correlate with parasite taxonomic distinctiveness. The mains host features associated with the taxonomic diversity of parasites were schooling behavior and omnivores trophic category. Parasite communities found in fish from Guandu River isolationist communities.

Key words: Biodiversity- Brazil- ecology parasite- fishes- Guandu River- parasites.

Resumen

En el presente trabajo, se realiza un análisis comparativo de las comunidades de parásitos de 21 especies de peces en el río Guandu, Brasil y se evaluó el efecto de algunas de las características del huésped (tamaño corporal, comportamiento social, hábitat de los peces, categoría trófica y capacidad de migrar) en la diversidad de sus comunidades de parásitos metazoarios. Como una medida de diversidad, hemos utilizado la riqueza de especies de parásitos y la diversidad taxonómica. La riqueza de especies de parásitos y la diversidad taxonómica no se vieron afectados por el número de los espécimen examinados por especie. El tamaño del cuerpo de los peces mostró una correlación significativa con la riqueza de especies de parásitos, aunque no hay correlación con la diversidad taxonómica de los parásitos. Las principales características asociadas a la diversidad taxonómica de los parásitos son la formación de cardúmenes y la categoría trófica omnívora. Las comunidades de parásitos de peces en el río Guandu presentaron comunidades parasitarias aisladas.

Palabras clave: Biodiversidad- Brasil- ecología parasitaria- parásitos- peces - río Guandu.
INTRODUCTION

Parasite communities are playing an increasingly important role as models for the study of biodiversity and biogeography (Poulin & Morand, 2000). Given the integral roles played by parasites in natural ecosystems, identifying hotspots of high parasite diversity, as well as areas of relatively low parasite diversity, is crucial for a complete understanding of the functioning of the biosphere. Currently, the biodiversity of marine and freshwater ecosystems of Latin America is threatened, mainly by environmental problems resulting from the destruction and degradation of the ecosystems. In this context, parasite biodiversity can be very important because parasitism plays key roles in ecosystems, regulating the abundance or density of host populations, stabilize food webs and structuring animal communities (Luque & Poulin, 2007).

Takemoto et al. (2005) performed the first study relating the different features of host species and the parasite species richness in freshwater fishes from Neotropical Region. In fish, for instance, some previous studies have found that host body size is a good predictor of parasite species richness whereas others have found no effect of host size. The same is true for a range of other host features. It is therefore difficult to assess the relative importance of different host traits for the evolution of parasite diversity in general (Luque et al., 2004; Luque & Poulin, 2008).

In the present study, we examine the relationship between different features of host species and the diversity of metazoan parasite communities across species of fish hosts from Guandu River (Fig. 1) in function of the strategic importance of this river, which is the main source of potable water in Rio de Janeiro, Brazil. The Guandu River supply water to 90% of population of City of Rio de Janeiro and although be a very impacted environment (Bizerril & Primo, 2001), it maintains an important level of biodiversity of fishes, and consequently, fish parasites (Azevedo et al., 2010). In addition, data about population and community and quantitative descriptors from the fish hosts are given herein.

MATERIAL AND METHODS

Between April 2003 to September 2009 were analyzed 786 specimens of fish, belonging to 21 species (Table 1) from the Guandu river, near the dam of water treatment station (WTS) (22°48´32"S, 43°37´35"W). The taxonomy of the fishes follows that of Reis et al. (2003). Parasites were collected from the body surface, gills, and body cavities, and viscera after examination under a stereoscopic microscope. Washings from gills and gut lumen were strained using a sieve (53 and 75 μm mesh size) to retain even the smallest parasites. Following Bush et al. (1997), prevalence, intensity and abundance mean were calculated for parasites of all fish species.

Pearson's correlation coefficient r was used to analyze the possible correlation between the host's total body length and the abundance of parasites, with previous logarithmic transformation Log (x+1) (Zar, 1999). The analysis included only parasite species with prevalence greater than 10% (Bush et al., 1990).

The following descriptors were calculated at the parasites infracommunity level: total prevalence, total intensity, total abundance, total species richness, endoparasite and ectoparasite species richness, Margalef's richness index (d), Brillouin's diversity index (H) (log 10 based), Pielou's evenness index (J') and Berger-Parker dominance index. In addition the Bray-Curtis similarity index was calculated among infracommunities within host fish species (Magurran, 2004). These descriptors were used for all parasites with exception of myxozoans. Statistical significance level was established at P<0.05. All results were presented in tabular form (Tables 2 and 3). The relative abundance of metazoan parasites was calculated at the level of infracommunities for all species of fish that had more than three species of parasites. The results were presented in graphical form (Figs. 2 and 3).

For each fish species, the average taxonomic distinctness (Δ+) and variance in taxonomic distinctness (Λ+) of the parasite component community were computed, following the procedures and taxonomies used by Luque & Poulin (2008). The effect of host length on taxonomic distinctness, on variance and on total richness were evaluated using the Pearson correlation coefficient on logarithmic transformed data. The Student’s t test or ANOVA test, depending of the number of variables with previous transformation, was used to verify the influence of
the followings variables in the taxonomic distinctness and variance in taxonomic distinctness: (1) whether the fish species forms schools or not, with species adopting schooling only in some parts of the year (e.g. during the reproductive period) classified as schooling; (2) whether the fish’s habitat is benthic, benthopelagic or demersal; (3) the trophic category, where the fish species were distributed into four categories: detritivores, herbivores, omnivores or carnivores and (4) whether species accomplish or not migration, being classified as potamodromous or diadromous. Data were obtained from Fishbase (Froese & Pauly, 2010). Table 4 showed the entire data set of host species included in the analyses. The present study follows the classification and systematic arrangements used by Azevedo et al. (2010). Parasite species names follow those provided in the most recent taxonomic literature. Species of fishes are arranged in alphabetical sequence and valid names are adopted from Froese & Pauly (2010).

RESULTS

A total of 786 specimens of fish was analyzed and were found 15,630 specimens of parasite belonging to 81 species. Nine groups of metazoan parasites were found: Acanthocephala, Cestoda, Crustacea, Digenea, Hirudinea, Mollusca, Monogenea Myxozoa and Nematoda. In these fish,
Table 1. Prevalence, mean abundance, mean intensity, site of infection / infestation of metazoan parasites from fish collected in the Guandu river, State of Rio de Janeiro, Brazil. (s = standard deviation, * parasites that had a positive correlation between abundance and its host’s total length through Pearson’s correlation coefficient $r$).

<table>
<thead>
<tr>
<th>Parasite group</th>
<th>Parasite species</th>
<th>Prevalence (%)</th>
<th>Mean Abundance±s</th>
<th>Mean Intensity±s</th>
<th>Host species</th>
<th>Site of infection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acanthocephala</td>
<td><em>Polymorphus</em> sp. (cystacanth)</td>
<td>17.10</td>
<td>0.60±0.20</td>
<td>7.00±1.20</td>
<td><em>Astronotus ocellatus</em></td>
<td>Intestine</td>
</tr>
<tr>
<td></td>
<td><em>Andracantha</em> sp. (cystacanth)</td>
<td>16.60</td>
<td>0.23±0.02</td>
<td>1.40±0.11</td>
<td><em>Centropomus undecimalis</em></td>
<td>Liver, intestine</td>
</tr>
<tr>
<td></td>
<td><em>Neoechinorhynchus paraguayensis</em></td>
<td>2.00</td>
<td>0.02±0.60</td>
<td>1.00±0.50</td>
<td><em>Geophagus brasiliensis</em></td>
<td>Intestine</td>
</tr>
<tr>
<td></td>
<td><em>Polymorphus</em> sp. (cystacanth)</td>
<td>2.00</td>
<td>0.02±0.60</td>
<td>1.00±0.60</td>
<td><em>Geophagus brasiliensis</em></td>
<td>Mesenteries</td>
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<tr>
<td></td>
<td><em>Neoechinorhynchus</em> sp.</td>
<td>3.00</td>
<td>0.03±1.18</td>
<td>1.00±0.18</td>
<td><em>Gymnotus carapo</em></td>
<td>Intestine</td>
</tr>
<tr>
<td></td>
<td><em>Polymorphus</em> sp. (cystacanth)</td>
<td>7.00</td>
<td>0.07±0.01</td>
<td>1.00±0.13</td>
<td><em>Gymnotus carapo</em></td>
<td>Intestine</td>
</tr>
<tr>
<td></td>
<td><em>Polymorphus</em> sp. (cystacanth)</td>
<td>10.0</td>
<td>3.80±0.41</td>
<td>0.40±0.04</td>
<td><em>Oligosarcus hepsetus</em></td>
<td>Intestine</td>
</tr>
<tr>
<td></td>
<td><em>Polymorphus</em> sp. (cystacanth)</td>
<td>6.66</td>
<td>0.13±0.02</td>
<td>2.00±0.28</td>
<td><em>Rhabdias quelen</em></td>
<td>Intestine</td>
</tr>
<tr>
<td>Cestoda</td>
<td>Trypanorhyncha gen. sp. (plerocercoid)</td>
<td>13.30</td>
<td>0.46±0.07</td>
<td>3.50±0.50</td>
<td><em>Centropomus undecimalis</em></td>
<td>Intestine</td>
</tr>
<tr>
<td></td>
<td><em>Proteocephalus macrophalus</em></td>
<td>100.00</td>
<td>26.38±2.04</td>
<td>26.38±2.05</td>
<td><em>Cichla ocellaris</em></td>
<td>Intestine</td>
</tr>
<tr>
<td></td>
<td><em>Proteocephalus</em> sp.</td>
<td>13.00</td>
<td>0.33±0.04</td>
<td>1.67±0.21</td>
<td><em>Gymnotus carapo</em></td>
<td>Intestine</td>
</tr>
<tr>
<td></td>
<td><em>Nomimoscolex</em> sp.</td>
<td>7.50</td>
<td>0.10±0.01</td>
<td>1.33±0.13</td>
<td><em>Pimelodius maculatus</em></td>
<td>Intestine</td>
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<tr>
<td>Crustacea</td>
<td><em>Lamproglena monodi</em></td>
<td>5.70</td>
<td>0.05±0.10</td>
<td>1.00±0.50</td>
<td><em>Astronotus ocellatus</em></td>
<td>Gills</td>
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<tr>
<td></td>
<td><em>Lamproglena</em> monodi</td>
<td>8.00</td>
<td>0.08±0.01</td>
<td>1.00±0.14</td>
<td><em>Cichla ocellaris</em></td>
<td>Gills</td>
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<td></td>
<td><em>Ergasilus</em> sp.</td>
<td>17.64</td>
<td>0.17±0.01</td>
<td>1.00±0.06</td>
<td><em>Mugil liza</em></td>
<td>Gills</td>
</tr>
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<td></td>
<td><em>Naobranchia lizae</em></td>
<td>2.94</td>
<td>0.03±0.005</td>
<td>1.00±0.17</td>
<td><em>Mugil liza</em></td>
<td>Gills</td>
</tr>
<tr>
<td>Parasite group</td>
<td>Parasite species</td>
<td>Prevalence</td>
<td>Mean (±SD)</td>
<td>Host species</td>
<td>Site of infection</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Neotrop. Helminthol., 5(2), 2011</td>
<td>Lamproglena monodi</td>
<td>84.00</td>
<td>2.80±0.09</td>
<td>Tilapia rendali</td>
<td>Gills</td>
<td></td>
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<tr>
<td></td>
<td>Clinostomum complanatum (metacercariae)</td>
<td>25.00</td>
<td>0.60±0.03</td>
<td>Astyanax bimaculatus</td>
<td>Eyes, palate, intestine, muscle</td>
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<tr>
<td></td>
<td>Clinostomum complanatum (metacercariae)</td>
<td>20.00</td>
<td>0.30±0.02</td>
<td>Astyanax parahybae</td>
<td>Eyes, tongue, palate, intestine, nasal cavity</td>
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<td>Acanthocollaritrema umbilicatum</td>
<td>56.70</td>
<td>5.73±0.32</td>
<td>Centropomus undecimalis</td>
<td>Intestine, stomach, pyloric diverticula</td>
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<tr>
<td></td>
<td>Bucephalus sp.</td>
<td>6.70</td>
<td>0.23±0.03</td>
<td>Centropomus undecimalis</td>
<td>Eyes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Austrodiplostomum compactum (metacercariae)</td>
<td>6.70</td>
<td>0.26±0.03</td>
<td>Centropomus undecimalis</td>
<td>Eyes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Austrodiplostomum compactum (metacercariae)</td>
<td>35.00</td>
<td>0.54±0.03</td>
<td>Cichla ocellaris</td>
<td>Eyes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Austrodiplostomum compactum (metacercariae)</td>
<td>1.70</td>
<td>0.02±0.002</td>
<td>Cyphocharax gilbert</td>
<td>Eyes</td>
<td></td>
</tr>
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<td></td>
<td>Sphincterodiplostomum musculosum (metacercariae)</td>
<td>40.00</td>
<td>4.50±0.13</td>
<td>Cyphocharax gilbert</td>
<td>Eyes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Zonocotyloides harotravassosi</td>
<td>6.70</td>
<td>0.20±0.02</td>
<td>Cyphocharax gilbert</td>
<td>Intestine</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Austrodiplostomum compactum (metacercariae)</td>
<td>14.00</td>
<td>0.22±0.20</td>
<td>Geophagus brasiliensis</td>
<td>Eyes, outer surface of the bladder</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Diplostomum sp. (metacercariae)</td>
<td>4.00</td>
<td>0.10±0.18</td>
<td>Geophagus brasiliensis</td>
<td>Eyes, outer surface of the bladder</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Posthodiplostomum macrocotyle* (metacercariae)</td>
<td>88.00</td>
<td>10.92±2.10</td>
<td>Geophagus brasiliensis</td>
<td>Eyes, oral cavity, stomach, outer surface of the bladder</td>
<td></td>
</tr>
</tbody>
</table>
### Table 1: Biodiversity of Fish Parasites from Guandu River

<table>
<thead>
<tr>
<th>Parasite group</th>
<th>Parasite species</th>
<th>Prevalence</th>
<th>Mean</th>
<th>Mean</th>
<th>Host species</th>
<th>Site of infection</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Digenea</strong></td>
<td><em>Posthodiplostomum</em> sp. (metacercariae)</td>
<td>4.50</td>
<td>0.08±0.15</td>
<td>1.70±1.10</td>
<td><em>Geophagus brasiliensis</em></td>
<td>Eyes</td>
</tr>
<tr>
<td></td>
<td><em>Clinostomum complanatum</em> (metacercariae)</td>
<td>20.00</td>
<td>0.77±0.07</td>
<td>3.83±0.33</td>
<td><em>Gymnotus carapo</em></td>
<td>Stomach</td>
</tr>
<tr>
<td></td>
<td><em>Austrodiplostomum compactum</em> (metacercariae)</td>
<td>7.00</td>
<td>0.10±0.01</td>
<td>1.50±0.20</td>
<td><em>Gymnotus carapo</em></td>
<td>Stomach</td>
</tr>
<tr>
<td></td>
<td><em>Clinostomum complanatum</em> (metacercariae)</td>
<td>6.00</td>
<td>0.18±0.10</td>
<td>3.00±2.10</td>
<td><em>Hoplosternum littorale</em></td>
<td>Eyes</td>
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<td><em>Herpetodiplostomum caimancola</em> (metacercariae)</td>
<td>11.00</td>
<td>0.28±0.30</td>
<td>2.54±0.87</td>
<td><em>Hoplosternum littorale</em></td>
<td>Intestine</td>
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<td><em>Magnivitellinum corvitellinum</em></td>
<td>61.00</td>
<td>1.45±2.10</td>
<td>2.37±1.21</td>
<td><em>Hoplosternum littorale</em></td>
<td>Stomach</td>
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<td><em>Austrodiplostomum compactum</em> (metacercariae)</td>
<td>3.22</td>
<td>0.03±0.005</td>
<td>1.00±0.18</td>
<td><em>Hyphostomus affinis</em></td>
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<td><em>Creptotrema creptotrema</em></td>
<td>61.00</td>
<td>27.33±3.80</td>
<td>44.72±6.23</td>
<td><em>Leporinus conirostris</em></td>
<td>Stomach, intestine</td>
</tr>
<tr>
<td></td>
<td><em>Austrodiplostomum compactum</em> (metacercariae)</td>
<td>37.50</td>
<td>0.97±0.06</td>
<td>2.58±0.15</td>
<td><em>Loricariichthys castaneus</em></td>
<td>Stomach</td>
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<tr>
<td></td>
<td><em>Ascoscoyle sp.</em> (metacercariae)</td>
<td>11.76</td>
<td>0.20±0.02</td>
<td>1.75±0.16</td>
<td><em>Mugil liza</em></td>
<td>Gills</td>
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<td><em>Haplosplanchnidae gen. sp.</em></td>
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<td>0.29±0.02</td>
<td>1.66±0.12</td>
<td><em>Mugil liza</em></td>
<td>Intestine</td>
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<td><em>Hysterocheilus brasiliensis</em></td>
<td>20.58</td>
<td>1.29±0.12</td>
<td>6.28±0.58</td>
<td><em>Mugil liza</em></td>
<td>Stomach, intestine</td>
</tr>
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<td><em>Saccolcomoeces elongatus</em></td>
<td>23.52</td>
<td>6.20±0.77</td>
<td>26.37±3.27</td>
<td><em>Mugil liza</em></td>
<td>Intestine</td>
</tr>
<tr>
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<td><em>Clinostomum complanatum</em> (metacercariae)</td>
<td>15.0</td>
<td>1.40±0.07</td>
<td>0.20±0.01</td>
<td><em>Oligosarcus hepsetus</em></td>
<td>Eyes, palate, Intestine</td>
</tr>
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<td></td>
<td><em>Austrodiplostomum compactum</em> (metacercariae)</td>
<td>5.00</td>
<td>0.05±0.005</td>
<td>1.00±0.11</td>
<td><em>Pimelodus maculatus</em></td>
<td>Eyes, intestine</td>
</tr>
<tr>
<td></td>
<td><em>Diplostomum sp.</em> (metacercariae)</td>
<td>15.00</td>
<td>0.50±0.05</td>
<td>3.33±0.35</td>
<td><em>Pimelodus maculatus</em></td>
<td>Eyes, intestine</td>
</tr>
<tr>
<td>Parasite group</td>
<td>Parasite species</td>
<td>Prevalence</td>
<td>Mean</td>
<td>Mean</td>
<td>Host species</td>
<td>Site of infection</td>
</tr>
<tr>
<td>----------------</td>
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<td>------------------------</td>
<td>---------------------------------------------</td>
</tr>
<tr>
<td>Digenea</td>
<td><em>Clinostomum detruncatum</em> (metacercariae)</td>
<td>26.66</td>
<td>4.83±0.48</td>
<td>18.12±1.81</td>
<td><em>Rhamdia quelen</em></td>
<td>Gills, fins, operculum, wattles, muscle, surface</td>
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<tr>
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<td>11.70</td>
<td>0.20±1.30</td>
<td>1.70±1.90</td>
<td><em>Trachelyopterus striatulus</em></td>
<td>Muscle</td>
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<td><em>Austrodiplostomum compactum</em> (metacercariae)</td>
<td>1.70</td>
<td>0.02±0.30</td>
<td>1.00±0.50</td>
<td><em>Trachelyopterus striatulus</em></td>
<td>Eyes</td>
</tr>
<tr>
<td></td>
<td><em>Posthodiplostomum macrocotyle</em> (metacercariae)</td>
<td>3.30</td>
<td>0.03±0.45</td>
<td>1.00±0.57</td>
<td><em>Trachelyopterus striatulus</em></td>
<td>Stomach</td>
</tr>
<tr>
<td>Hirudinea</td>
<td><em>Placobdella sp.</em></td>
<td>5.70</td>
<td>0.30±0.10</td>
<td>2.10±1.30</td>
<td><em>Astronotus ocellatus</em></td>
<td>Gills</td>
</tr>
<tr>
<td></td>
<td><em>Piscicolidae gen. sp.</em></td>
<td>10.00</td>
<td>0.13±0.01</td>
<td>1.33±0.14</td>
<td><em>Centropomus undecimatis</em></td>
<td>Gills</td>
</tr>
<tr>
<td></td>
<td><em>Placobdella sp.</em></td>
<td>5.00</td>
<td>0.05±0.04</td>
<td>1.00±0.07</td>
<td><em>Cyphocaraix gilbert</em></td>
<td>Gills</td>
</tr>
<tr>
<td></td>
<td><em>Glossiphoniidae gen. sp.</em></td>
<td>10.00</td>
<td>0.16±0.40</td>
<td>1.60±0.40</td>
<td><em>Geophagus brasiliensis</em></td>
<td>Gills, oral cavity</td>
</tr>
<tr>
<td></td>
<td><em>Placobdella sp.</em></td>
<td>2.00</td>
<td>0.02±0.50</td>
<td>1.00±1.50</td>
<td><em>Geophagus brasiliensis</em></td>
<td>Gills</td>
</tr>
<tr>
<td></td>
<td><em>Glossiphoniidae gen. sp.</em></td>
<td>3.00</td>
<td>0.03±1.18</td>
<td>1.00±0.18</td>
<td><em>Gymnotus carapo</em></td>
<td>Gills</td>
</tr>
<tr>
<td></td>
<td><em>Glossiphoniidae gen. sp.</em></td>
<td>20.00</td>
<td>0.72±0.60</td>
<td>3.60±2.40</td>
<td><em>Hoplosternum littorale</em></td>
<td>Gills</td>
</tr>
<tr>
<td></td>
<td><em>Placobdella sp.</em></td>
<td>3.00</td>
<td>0.04±0.10</td>
<td>1.33±0.90</td>
<td><em>Hoplosternum littorale</em></td>
<td>Gills</td>
</tr>
<tr>
<td></td>
<td><em>Placobdella sp.</em></td>
<td>32.25</td>
<td>0.6±0.03</td>
<td>1.80±0.10</td>
<td><em>Hypostomus affinis</em></td>
<td>Gills</td>
</tr>
<tr>
<td></td>
<td><em>Helobdella sp.</em></td>
<td>15.62</td>
<td>0.22±0.02</td>
<td>1.40±0.12</td>
<td><em>Loricariichthys castaneus</em></td>
<td>Gills</td>
</tr>
<tr>
<td></td>
<td><em>Helobdella sp.</em></td>
<td>2.50</td>
<td>0.02±0.004</td>
<td>1.00±0.16</td>
<td><em>Pimelodus maculatus</em></td>
<td>Gills</td>
</tr>
<tr>
<td></td>
<td><em>Piscicolidae gen. sp.</em></td>
<td>3.33</td>
<td>0.03±0.01</td>
<td>1.00±1.81</td>
<td><em>Rhamdia quelen</em></td>
<td>Gills</td>
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<tr>
<td></td>
<td><em>Helobdella sp.</em></td>
<td>1.70</td>
<td>0.02±0.40</td>
<td>1.00±1.20</td>
<td><em>Trachelyopterus striatulus</em></td>
<td>Gills</td>
</tr>
<tr>
<td>Parasite group</td>
<td>Parasite species</td>
<td>Prevalence</td>
<td>Mean</td>
<td>Mean</td>
<td>Host species</td>
<td>Site of infection</td>
</tr>
<tr>
<td>----------------</td>
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<tr>
<td>Mollusca</td>
<td>Glochidia (larvae)</td>
<td>8.60</td>
<td>0.60±1.00</td>
<td>7.00±1.80</td>
<td><em>Astronotus ocellatus</em></td>
<td>Gills</td>
</tr>
<tr>
<td></td>
<td>Glochidia (larvae)</td>
<td>2.00</td>
<td>0.24±0.50</td>
<td>12.00±1.20</td>
<td><em>Geophagus brasilensis</em></td>
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<td>Monogenea</td>
<td><em>Gussevia asotia</em></td>
<td>65.70</td>
<td>7.37±0.23</td>
<td>11.21±0.36</td>
<td><em>Astronotus ocellatus</em></td>
<td>Gills</td>
</tr>
<tr>
<td></td>
<td><em>Gussevia astronoti</em></td>
<td>71.40</td>
<td>5.23±0.15</td>
<td>7.32±0.21</td>
<td><em>Astronotus ocellatus</em></td>
<td>Gills</td>
</tr>
<tr>
<td></td>
<td><em>Gyrodaectylus sp.</em></td>
<td>10.00</td>
<td>0.37±0.03</td>
<td>3.75±0.29</td>
<td><em>Astyanax bimaculatus</em></td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Gyrodaectylus sp.</em></td>
<td>10.00</td>
<td>0.30±0.02</td>
<td>3.00±0.23</td>
<td><em>Astyanax parahybae</em></td>
<td>Gills</td>
</tr>
<tr>
<td></td>
<td><em>Anakhonnia brasiliana</em></td>
<td>30.00</td>
<td>0.83±0.05</td>
<td>2.77±0.16</td>
<td><em>Centropomus undecimalis</em></td>
<td>Gills</td>
</tr>
<tr>
<td></td>
<td><em>Rhabdosynochus hargisi</em></td>
<td>66.60</td>
<td>6.63±0.31</td>
<td>9.95±0.46</td>
<td><em>Centropomus undecimalis</em></td>
<td>Gills</td>
</tr>
<tr>
<td></td>
<td><em>Rhabdosynochus sp.</em></td>
<td>53.30</td>
<td>3.56±0.18</td>
<td>6.68±0.35</td>
<td><em>Centropomus undecimalis</em></td>
<td>Gills</td>
</tr>
<tr>
<td></td>
<td><em>Gussevia tucumarensensis</em></td>
<td>27.00</td>
<td>2.15±0.26</td>
<td>8.00±0.96</td>
<td><em>Cichla ocellaris</em></td>
<td>Gills</td>
</tr>
<tr>
<td></td>
<td><em>Gussevia undulata</em></td>
<td>19.00</td>
<td>1.42±0.19</td>
<td>7.40±0.99</td>
<td><em>Cichla ocellaris</em></td>
<td>Gills</td>
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<tr>
<td></td>
<td><em>Sciadieothrum ergensi</em></td>
<td>15.00</td>
<td>0.50±0.07</td>
<td>3.25±0.49</td>
<td><em>Cichla ocellaris</em></td>
<td>Gills</td>
</tr>
<tr>
<td></td>
<td><em>Hyperoplectes malimbergi</em></td>
<td>22.58</td>
<td>0.45±0.03</td>
<td>2.00±0.14</td>
<td><em>Hypostomus affinis</em></td>
<td>Gills</td>
</tr>
<tr>
<td></td>
<td><em>Phanerothecoides agostinhoi</em></td>
<td>67.74</td>
<td>4.03±0.21</td>
<td>5.95±0.31</td>
<td><em>Hypostomus affinis</em></td>
<td>Gills</td>
</tr>
<tr>
<td></td>
<td><em>Trinigrus hypostomatis</em></td>
<td>80.64</td>
<td>21.1±0.97</td>
<td>26.28±1.20</td>
<td><em>Hypostomus affinis</em></td>
<td>Gills</td>
</tr>
<tr>
<td></td>
<td><em>Jatinus sp.</em></td>
<td>13.33</td>
<td>1.66±0.25</td>
<td>12.50±1.87</td>
<td><em>Leporinus copelandii</em></td>
<td>Gills</td>
</tr>
<tr>
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<td><em>Sclerochicus yuncensis</em></td>
<td>3.33</td>
<td>0.03±0.01</td>
<td>1.00±0.18</td>
<td><em>Leporinus copelandii</em></td>
<td>Gills</td>
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<tr>
<td></td>
<td><em>Demidiospermus sp.</em></td>
<td>62.50</td>
<td>19.75±0.76</td>
<td>31.6±1.22</td>
<td><em>Loricariichthys</em></td>
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<tr>
<td></td>
<td><em>Ligophorus brasiliensis</em></td>
<td>20.58</td>
<td>0.94±0.08</td>
<td>4.57±0.38</td>
<td><em>Mugil liza</em></td>
<td>Gills</td>
</tr>
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<td></td>
<td><em>Ligophorus guanánsensis</em></td>
<td>20.58</td>
<td>0.79±0.06</td>
<td>3.85±0.31</td>
<td><em>Mugil liza</em></td>
<td>Gills</td>
</tr>
<tr>
<td></td>
<td><em>Ligophorus lizae</em></td>
<td>11.76</td>
<td>0.23±0.02</td>
<td>2.00±0.17</td>
<td><em>Mugil liza</em></td>
<td>Gills</td>
</tr>
<tr>
<td></td>
<td><em>Ligophorus tainhe</em></td>
<td>23.52</td>
<td>2.26±0.19</td>
<td>9.62±0.79</td>
<td><em>Mugil liza</em></td>
<td>Gills</td>
</tr>
<tr>
<td></td>
<td><em>Anacanthorbus</em></td>
<td>76.47</td>
<td>19.82±2.96</td>
<td>25.92±3.88</td>
<td><em>Mylossoma aureum</em></td>
<td>Gills</td>
</tr>
<tr>
<td></td>
<td><em>parapatahus</em></td>
<td></td>
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<tr>
<td></td>
<td><em>Demidiospermus armostus</em></td>
<td>40.00</td>
<td>5.65±0.23</td>
<td>14.12±0.58</td>
<td><em>Pimelodus maculatus</em></td>
<td>Gills</td>
</tr>
<tr>
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<td><em>Demidiospermus</em></td>
<td>75.00</td>
<td>40.22±1.14</td>
<td>53.63±1.52</td>
<td><em>Pimelodus maculatus</em></td>
<td>Gills</td>
</tr>
<tr>
<td></td>
<td><em>leptosynophallus</em></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Parasite group</td>
<td>Parasite species</td>
<td>Prevalence</td>
<td>Mean</td>
<td>Mean</td>
<td>Host species</td>
<td>Site of infection</td>
</tr>
<tr>
<td>---------------</td>
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<td>------</td>
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<tr>
<td>Demodosperrum paravalenciennesi</td>
<td>66.66</td>
<td>34.53±1.97</td>
<td>51.80±2.95</td>
<td>Rhomdia quelen</td>
<td>Gills</td>
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<td>40.03±4.50</td>
<td>42.14±4.80</td>
<td>Trachelyopterus striatus</td>
<td>Gills</td>
<td></td>
</tr>
<tr>
<td>Cosmetocleithrum sp.</td>
<td></td>
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<td></td>
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<tr>
<td>Myxozoa</td>
<td>Henneguya sp.</td>
<td>80.00</td>
<td>—</td>
<td>—</td>
<td>Astyanax bimaculatus</td>
<td>Gills</td>
</tr>
<tr>
<td>Henneguya sp.</td>
<td>65.00</td>
<td>—</td>
<td>—</td>
<td>Astyanax parahybae</td>
<td>Gills</td>
<td></td>
</tr>
<tr>
<td>Myxobolus sp.</td>
<td>6.70</td>
<td>—</td>
<td>—</td>
<td>Centropomus undecimalis</td>
<td>Gills</td>
<td></td>
</tr>
<tr>
<td>Henneguya cyphocharax</td>
<td>85.00</td>
<td>—</td>
<td>—</td>
<td>Cyphocharax gilbert</td>
<td>Gills</td>
<td></td>
</tr>
<tr>
<td>Henneguya guanduensis</td>
<td>83.00</td>
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<td>—</td>
<td>Hoplosternum littorale</td>
<td>Gills</td>
<td></td>
</tr>
<tr>
<td>Henneguya sp.</td>
<td>11.00</td>
<td>—</td>
<td>—</td>
<td>Leporinus conirostris</td>
<td>Gills</td>
<td></td>
</tr>
<tr>
<td>Henneguya sp.</td>
<td>40.00</td>
<td>—</td>
<td>—</td>
<td>Leporinus copelandii</td>
<td>Gills</td>
<td></td>
</tr>
<tr>
<td>Myxobolus sp.</td>
<td>5.88</td>
<td>—</td>
<td>—</td>
<td>Mugil liza</td>
<td>Gills</td>
<td></td>
</tr>
<tr>
<td>Henneguya sp.</td>
<td>52.50</td>
<td>—</td>
<td>—</td>
<td>Oligosarcus hepsetus</td>
<td>Gills</td>
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<tr>
<td>Nematoda</td>
<td>Contracaecum sp. (larval)</td>
<td>2.80</td>
<td>0.03±0.20</td>
<td>1.00±0.80</td>
<td>Astrotornus ocellatus</td>
<td>Mesenteries</td>
</tr>
<tr>
<td>Procammallus (Spirocamallanus) hilarii</td>
<td>2.50</td>
<td>0.025±0.004</td>
<td>1.00±0.16</td>
<td>Astyanax bimaculatus</td>
<td>Intestine, pyloric diverticula</td>
<td></td>
</tr>
<tr>
<td>Procammallus (Spirocamallanus) hilarii</td>
<td>5.00</td>
<td>0.05±0.005</td>
<td>1.00±0.11</td>
<td>Astyanax parahybae</td>
<td>Intestine</td>
<td></td>
</tr>
<tr>
<td>Contracaecum sp. (larval)</td>
<td>3.30</td>
<td>0.50±0.09</td>
<td>15.0±2.74</td>
<td>Centropomus undecimalis</td>
<td>Mesenteries</td>
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<tr>
<td>Rhabdochona sp.</td>
<td>6.70</td>
<td>0.13±0.02</td>
<td>2.00±0.25</td>
<td>Centropomus undecimalis</td>
<td>Intestine</td>
<td></td>
</tr>
<tr>
<td>Procammallus (Procammallus) peraccurus</td>
<td>15.00</td>
<td>1.42±0.18</td>
<td>9.25±1.18</td>
<td>Cichla ocellaris</td>
<td>Intestine</td>
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<tr>
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<td>23.00</td>
<td>0.60±0.02</td>
<td>2.40±0.11</td>
<td>Cyphocharax gilbert</td>
<td>Intestine</td>
<td></td>
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<td>Raphidascaris sp. (larval)</td>
<td>3.40</td>
<td>0.05±0.005</td>
<td>1.50±0.14</td>
<td>Cyphocharax gilbert</td>
<td>Intestine</td>
<td></td>
</tr>
<tr>
<td>Parasite group</td>
<td>Parasite species</td>
<td>Prevalence</td>
<td>Mean</td>
<td>Mean</td>
<td>Host species</td>
<td>Site of infection</td>
</tr>
<tr>
<td>---------------</td>
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<tr>
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<td>1.50±0.08</td>
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<td>Intestine</td>
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<td></td>
<td><em>Contracaecum</em> sp. (larval)</td>
<td>6.00</td>
<td>0.06±0.02</td>
<td>1.00±0.50</td>
<td>Geophagus brasiliensis</td>
<td>Mesenteries</td>
</tr>
<tr>
<td></td>
<td>Capillariidae gen. sp.</td>
<td>3.00</td>
<td>0.03±0.18</td>
<td>1.00±0.18</td>
<td>Gymnotus carapo</td>
<td>Intestine</td>
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<tr>
<td></td>
<td><em>Contracaecum</em> sp. (larval)</td>
<td>33.00</td>
<td>0.57±0.03</td>
<td>1.70±0.09</td>
<td>Gymnotus carapo</td>
<td>Stomach, mesenteries, intestine</td>
</tr>
<tr>
<td></td>
<td><em>Procamallanus</em> (Procamallanus)</td>
<td>7.00</td>
<td>0.30±0.04</td>
<td>4.50±0.66</td>
<td>Gymnotus carapo</td>
<td>Intestine</td>
</tr>
<tr>
<td></td>
<td>peraccratus</td>
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<td></td>
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<td></td>
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<tr>
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<td>Capillariidae gen. sp.</td>
<td>6.00</td>
<td>0.07±0.05</td>
<td>1.17±1.20</td>
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<td>Intestine</td>
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<tr>
<td></td>
<td><em>Goezia</em> sp.</td>
<td>2.00</td>
<td>0.02±0.01</td>
<td>1.00±0.80</td>
<td>Hoplosternum litorale</td>
<td>Intestine</td>
</tr>
<tr>
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<td><em>Paracapillaria piscicola</em></td>
<td>3.22</td>
<td>0.03±0.005</td>
<td>1.00±0.18</td>
<td>Hypostomus affinis</td>
<td>Stomach</td>
</tr>
<tr>
<td></td>
<td><em>Cucullanus</em> (Cucullanus) brevispiculutus</td>
<td>6.66</td>
<td>0.06±0.01</td>
<td>1.00±0.13</td>
<td>Leporinus copelandii</td>
<td>Intestine</td>
</tr>
<tr>
<td></td>
<td><em>Procamallanus</em> (Spiropracallanus)</td>
<td>6.66</td>
<td>0.10±0.01</td>
<td>1.50±0.20</td>
<td>Leporinus copelandii</td>
<td>Intestine</td>
</tr>
<tr>
<td></td>
<td>ineopinatus</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td><em>Contracaecum</em> sp. (larval)</td>
<td>6.25</td>
<td>0.09±0.01</td>
<td>1.50±0.19</td>
<td>Loricariichthys castaneus</td>
<td>Mesenteries</td>
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<tr>
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<td><em>Cucullanus</em> (Cucullanus) grandistomis</td>
<td>2.94</td>
<td>0.03±0.005</td>
<td>1.00±0.17</td>
<td>Mugil liza</td>
<td>Intestine</td>
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<tr>
<td></td>
<td><em>Hysterothyacium</em> sp. (larval)</td>
<td>2.94</td>
<td>0.03±0.005</td>
<td>1.00±0.17</td>
<td>Mugil liza</td>
<td>Intestine</td>
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<td>88.23</td>
<td>203.88±13.29</td>
<td>231.06±15.06</td>
<td>Mylossoma aureum</td>
<td>Intestine</td>
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<tr>
<td></td>
<td><em>Cucullanus</em> (Cucullanus) pinnai *</td>
<td>45.00</td>
<td>0.85±0.03</td>
<td>1.88±0.06</td>
<td>Pimelodus maculatus</td>
<td>Intestine</td>
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<tr>
<td></td>
<td><em>Rhabdochona uryueni</em></td>
<td>5.00</td>
<td>0.07±0.01</td>
<td>1.5±0.17</td>
<td>Pimelodus maculatus</td>
<td>Intestine</td>
</tr>
<tr>
<td></td>
<td>Capillariidae gen. sp.</td>
<td>6.66</td>
<td>0.06±0.01</td>
<td>1.00±0.13</td>
<td><em>Rhamdia quelen</em></td>
<td>Intestine</td>
</tr>
<tr>
<td></td>
<td><em>Contracaecum</em> sp. (larval)</td>
<td>26.66</td>
<td>0.30±0.02</td>
<td>1.13±0.07</td>
<td><em>Rhamdia anelen</em></td>
<td>Mesenteries</td>
</tr>
</tbody>
</table>
a total of 69% were parasitized by at least one species of metazoan parasite. The percentage of parasitism was 55% for endoparasite and 45% for ectoparasites.

The monogeneans had higher species richness at component community level. Of all the parasites found, the digenean had lower specificity, since the metacercaria *Austrodiplostomum compactum* (Lutz, 1928) was found parasitizing nine different species of fish. Of all the species of parasites collected only four showed positive correlation between the hosts' total length and abundance: in *Geophagus brasiliensis* (Quoy and Gaimard, 1824) the digenean *Posthodiplostomum macracotyle* Dubois, 1937 (*r* = -0.289; *p* = 0.041), in *Hypostomus affinis* (Steindachner, 1877) the monogenean *Hyperopletes malmbergi* Boeger, Kritsky and Belmont-Jégu, 1994 (*r* = 0.394; *p* = 0.028), in *Mylossoma aureum* (Spix and Agassiz, 1829) the monogenean *Anacanthorus paraspathulatus* Kritsky, Boeger and van Every, 1992 (*r* = 0.484; *p* = 0.049) and in *Pimelodus maculatus* Lacépède, 1803 the nematoda *Cucullanus (Cucullanus) pinnae pinnae* Travassos, Artigas and Pereira, 1928 (*r* = 0.513; *p* = 0.001).

**DISCUSSION**

The results of this study indicate that the parasite communities of fish in the Guandu River were characterized by low parasite species richness and evenness, by isolationist communities and by greater values of taxonomic diversity in omnivores and schooling fish species.

According to Kennedy (2009) all parasite species have a niche selection to a greater or lesser degree, but isolationist communities have species poor and the species are independent of each other. By contrast, interactive communities have highest species richness. Communities could be located anywhere along this continuum, and those of freshwater fish tend to be found towards the isolationist end.
Our results suggesting that host feeding habits and the formation of schools may influence the taxonomic diversity, since omnivores and schooling fish species had higher parasite diversity than other groups. According to Luque et al. (2004) many researches have found that schooling fish species are used by more species of parasites than solitary species, for both external parasites and all parasites combined. The fact of omnivores fish species present greater diversity can also be explained, because the greater the variety of food, the greater the intake of various intermediate hosts and easier to contamination by parasites is acquired via the food web.

A study by Takemoto et al. (2005) in the floodplain of the upper Paraná River found that parasite species richness in freshwater fish species was not associated with several host characteristics, with the exception of host population density. However, in the study by Luque et al. (2004), the fish size proved to be the main predictor of total parasite species richness in marine fish. This result was also found in this study. According to Luque et al. (2004) following from island biogeographical theory larger-bodied hosts should be able to accommodate more parasite species than small ones; they may also incur higher exposure to internal parasites because of the quantities of food they ingest, and to external parasites because their larger surface area facilitates contact with infective stages.

Considering both the approach and the results, the present study includes both key improvements on earlier studies of this kind and novel findings, making its contribution particularly relevant. The majority of earlier studies on the richness of freshwater fish parasites have used data from fish species that do not occur in the same geographical areas, with exception to work of Takemoto et al. (2005). The present study focused on a set of fish species from the same general area (Guandu river), thus minimizing any differences in parasite availability. In addition, this study was the first to incorporate the average taxonomic distinctness of the assemblage and its variance as a measure of taxonomic diversity in freshwater fish. For data, all study in freshwater fish has used species richness as their sole measure of the diversity of parasite assemblages. According to Luque et al. (2004) the richness is a convenient measure, but it does not capture all facets of diversity. It ignores the evolutionary relationships among species coexisting in an assemblage. Applied to parasite assemblages, measures of diversity that incorporate information on the relationships among parasite species can shed light on how the assemblage has been structured.

**ACKNOWLEDGMENTS**

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Table 2. Number of hosts examined (N), total prevalence P(%), mean total abundance (MA), mean total intensity (MI), mean length of hosts (ML), mean total species richness (MR), parasites richness and Margalef's richness index (d) of metazoan parasites from Guandu River, State of Rio de Janeiro, Brazil.

<table>
<thead>
<tr>
<th>Hosts</th>
<th>(N)</th>
<th>P(%)</th>
<th>MA</th>
<th>MI</th>
<th>ML (cm)</th>
<th>MR</th>
<th>Parasite richness §</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Astronotus ocellatus</td>
<td>35</td>
<td>74.00</td>
<td>13.7±0.38</td>
<td>18.46±0.51</td>
<td>20.44</td>
<td>1.77±1.23</td>
<td>2 (5)</td>
<td>0.43±0.41</td>
</tr>
<tr>
<td>Astyanax bimaculatus</td>
<td>40</td>
<td>30.00</td>
<td>0.95±0.05</td>
<td>3.16±0.15</td>
<td>9.92</td>
<td>0.37±0.58</td>
<td>2 (2)</td>
<td>0.03±0.12</td>
</tr>
<tr>
<td>Astyanax parahybae</td>
<td>40</td>
<td>35.00</td>
<td>0.65±0.03</td>
<td>1.86±0.08</td>
<td>10.39</td>
<td>0.35±0.48</td>
<td>2 (2)</td>
<td>0</td>
</tr>
<tr>
<td>Centropomus undecimalis</td>
<td>31</td>
<td>90.00</td>
<td>18.73±0.57</td>
<td>20.81±0.27</td>
<td>28.75</td>
<td>2.76±1.63</td>
<td>7 (5)</td>
<td>0.64±0.48</td>
</tr>
<tr>
<td>Cichla ocellaris</td>
<td>26</td>
<td>100.00</td>
<td>32.50±2.10</td>
<td>32.50±2.10</td>
<td>26.36</td>
<td>2.30±1.31</td>
<td>3 (4)</td>
<td>0.51±0.46</td>
</tr>
<tr>
<td>Cyphocharax gilbert</td>
<td>60</td>
<td>58.00</td>
<td>5.50±0.002</td>
<td>9.42±0.004</td>
<td>16.32</td>
<td>0.86±0.89</td>
<td>6 (1)</td>
<td>0.17±0.37</td>
</tr>
<tr>
<td>Geophagus brasiliensis</td>
<td>50</td>
<td>90.00</td>
<td>11.68±0.25</td>
<td>12.97±0.28</td>
<td>15.49</td>
<td>1.26±0.69</td>
<td>7 (3)</td>
<td>0.19±0.30</td>
</tr>
<tr>
<td>Gymnotus carapo</td>
<td>30</td>
<td>67.00</td>
<td>2.33±0.10</td>
<td>3.50±0.15</td>
<td>10.39</td>
<td>0.35±0.48</td>
<td>2 (2)</td>
<td>0</td>
</tr>
<tr>
<td>Hoplosternum littorale</td>
<td>10</td>
<td>60.00</td>
<td>2.91±0.05</td>
<td>4.85±0.08</td>
<td>19.65</td>
<td>1.03±1.13</td>
<td>5 (2)</td>
<td>0.25±0.52</td>
</tr>
<tr>
<td>Hyphostrous affinis</td>
<td>31</td>
<td>87.00</td>
<td>26.35±0.002</td>
<td>30.25±1.26</td>
<td>28.75</td>
<td>2.09±1.30</td>
<td>2 (5)</td>
<td>0.46±0.38</td>
</tr>
<tr>
<td>Leporinus conirostris</td>
<td>18</td>
<td>61.00</td>
<td>27.33±3.80</td>
<td>44.72±6.23</td>
<td>36.60</td>
<td>0.72±0.57</td>
<td>1 (1)</td>
<td>0</td>
</tr>
<tr>
<td>Leporinus copelandi</td>
<td>30</td>
<td>60.00</td>
<td>2.91±0.05</td>
<td>4.85±0.08</td>
<td>19.65</td>
<td>1.03±1.13</td>
<td>5 (2)</td>
<td>0.25±0.52</td>
</tr>
<tr>
<td>Loricariichthys castaneus</td>
<td>32</td>
<td>75.00</td>
<td>21.06±0.76</td>
<td>28.08±1.01</td>
<td>34.05</td>
<td>0.72±0.57</td>
<td>1 (1)</td>
<td>0</td>
</tr>
<tr>
<td>Mylossoma aureum</td>
<td>17</td>
<td>100.00</td>
<td>223.70±12.96</td>
<td>223.70±12.96</td>
<td>15.66</td>
<td>1.64±0.49</td>
<td>2 (5)</td>
<td>0.46±0.38</td>
</tr>
<tr>
<td>Oligosarcus hepsetus</td>
<td>40</td>
<td>25.00</td>
<td>0.57±0.04</td>
<td>7.00±0.96</td>
<td>34.75</td>
<td>0.70±0.75</td>
<td>2 (3)</td>
<td>0.01±0.05</td>
</tr>
<tr>
<td>Pimelodus maculatus</td>
<td>40</td>
<td>100.00</td>
<td>0.45±0.42</td>
<td>0.60±0.39</td>
<td>33.04</td>
<td>0.45±0.30</td>
<td>95.60</td>
<td>311.30</td>
</tr>
<tr>
<td>Rhamdia quelen</td>
<td>32</td>
<td>80.00</td>
<td>40.16±1.99</td>
<td>50.20±2.49</td>
<td>32.68</td>
<td>1.46±1.00</td>
<td>5 (3)</td>
<td>0.21±0.25</td>
</tr>
<tr>
<td>Tilapia rendali</td>
<td>30</td>
<td>84.00</td>
<td>2.8±0.09</td>
<td>3.36±0.10</td>
<td>22.14</td>
<td>0.83±0.38</td>
<td>0 (1)</td>
<td>0</td>
</tr>
<tr>
<td>Trachelyopterus striatulus</td>
<td>60</td>
<td>95.00</td>
<td>40.83±0.64</td>
<td>42.98±0.67</td>
<td>19.20</td>
<td>1.46±0.74</td>
<td>8 (3)</td>
<td>0.16±0.22</td>
</tr>
</tbody>
</table>

(§) Endoparasites and ectoparasites (in parentheses).

Table 3. Brillouin's diversity index (H), Pielou's evenness index (J'), dominant taxon, Bray-Curtis similarity index, Berger-Parker dominance index, average taxonomic distinctness (Δ) and variance in taxonomic distinctness (Λ) of metazoan parasites from Guandu River, State of Rio de Janeiro, Brazil.

<table>
<thead>
<tr>
<th>Hosts</th>
<th>(H)</th>
<th>J'</th>
<th>Dominant taxon</th>
<th>Bray-Curtis</th>
<th>Berger-Parker</th>
<th>Δ</th>
<th>Λ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Astronotus ocellatus</td>
<td>0.45±0.34</td>
<td>0.62±0.43</td>
<td>Monogenea</td>
<td>41.70(39.90-48.40)</td>
<td>0.45±0.30</td>
<td>95.60</td>
<td>311.30</td>
</tr>
<tr>
<td>Astyanax bimaculatus</td>
<td>0.02±0.09</td>
<td>0.04±0.19</td>
<td>Digenea</td>
<td>8.10(6.10-9.50)</td>
<td>0.31±0.46</td>
<td>90.10</td>
<td>355.50</td>
</tr>
<tr>
<td>Astyanax parahybae</td>
<td>0</td>
<td>0.005±0.03</td>
<td>Digenea</td>
<td>6.30(4.40-7.70)</td>
<td>0.35±0.48</td>
<td>90.90</td>
<td>278.30</td>
</tr>
<tr>
<td>Centropomus undecimalis</td>
<td>0.57±0.42</td>
<td>0.60±0.39</td>
<td>Monogenea</td>
<td>33.04(26.90-38.40)</td>
<td>0.57±0.29</td>
<td>87.50</td>
<td>176.30</td>
</tr>
<tr>
<td>Cichla ocellaris</td>
<td>0.31±0.32</td>
<td>0.45±0.41</td>
<td>Cestoda</td>
<td>43.10(38.60-48.06)</td>
<td>0.80±0.20</td>
<td>83.80</td>
<td>589.60</td>
</tr>
<tr>
<td>Cyphocharax gilbert</td>
<td>0.08±0.16</td>
<td>0.16±0.32</td>
<td>Digenea</td>
<td>13.60(11.70-15.80)</td>
<td>0.51±0.46</td>
<td>91.60</td>
<td>68.89</td>
</tr>
<tr>
<td>Geophagus brasiliensis</td>
<td>0.11±0.11</td>
<td>0.12±0.32</td>
<td>Nematoda</td>
<td>6.90(5.90-13.00)</td>
<td>0.52±0.42</td>
<td>94.90</td>
<td>115.70</td>
</tr>
<tr>
<td>Gymnotus carapo</td>
<td>0.13±0.20</td>
<td>0.21±0.37</td>
<td>Monogenea</td>
<td>20.40(11.70-15.80)</td>
<td>0.50±0.45</td>
<td>90.10</td>
<td>355.50</td>
</tr>
<tr>
<td>Hoplosternum littorale</td>
<td>0.07±0.13</td>
<td>0.11±0.19</td>
<td>Digenea</td>
<td>22.70(22.10-27.00)</td>
<td>0.72±0.30</td>
<td>90.90</td>
<td>278.30</td>
</tr>
<tr>
<td>Loricariichthys castaneus</td>
<td>0.13±0.20</td>
<td>0.23±0.33</td>
<td>Monogenea</td>
<td>32.90(27.00-37.40)</td>
<td>0.67±0.41</td>
<td>97.94</td>
<td>24.80</td>
</tr>
<tr>
<td>Mylossoma aureum</td>
<td>0.26±0.40</td>
<td>0.32±0.42</td>
<td>Monogenea</td>
<td>9.40(7.06-12.20)</td>
<td>0.62±0.39</td>
<td>80.60</td>
<td>642.10</td>
</tr>
<tr>
<td>Oligosarcus hepsetus</td>
<td>0.14±0.18</td>
<td>0.25±0.32</td>
<td>Nematoda</td>
<td>43.70(37.90-49.0)</td>
<td>0.78±0.17</td>
<td>87.50</td>
<td>556.60</td>
</tr>
<tr>
<td>Trachelyopterus striatulus</td>
<td>0.07±0.13</td>
<td>0.11±0.19</td>
<td>Monogenea</td>
<td>60.90(58.10-63.5)</td>
<td>0.92±0.22</td>
<td>92.60</td>
<td>35.80</td>
</tr>
</tbody>
</table>
Table 4. Summary of the data (obtained from Fishbase) on the 20 fish species included in the analyses.

<table>
<thead>
<tr>
<th>Hosts</th>
<th>Family</th>
<th>Mean length of hosts (cm)</th>
<th>Formation of schools</th>
<th>Environment</th>
<th>Trophic category</th>
<th>Potamodromous</th>
<th>Diadromous</th>
</tr>
</thead>
<tbody>
<tr>
<td>Astronotus ocellatus</td>
<td>Cichlidae</td>
<td>45.70</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Astyanax bimaculatus</td>
<td>Characidae</td>
<td>17.50</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Astyanax parahybae</td>
<td>Characidae</td>
<td>5.60</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Centropomus undecimalis</td>
<td>Centropomidae</td>
<td>140.00</td>
<td>1</td>
<td>3</td>
<td>4</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Cichla ocellaris</td>
<td>Cichlidae</td>
<td>74.00</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Cyphoccharax gilbert</td>
<td>Curimatidae</td>
<td>12.60</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Geophagus brasiliensis</td>
<td>Cichlidae</td>
<td>28.00</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Gymnotus carapo</td>
<td>Gymnotidae</td>
<td>60.00</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Hoplosternum littorale</td>
<td>Callithyridae</td>
<td>24.00</td>
<td>1</td>
<td>1</td>
<td>4</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Hypostomus affinis</td>
<td>Loricariidae</td>
<td>39.70</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Leporinus coninistris</td>
<td>Anostomidae</td>
<td>24.50</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Leporinus copelandi</td>
<td>Anostomidae</td>
<td>23.00</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Loricariichthys castaneus</td>
<td>Loricariidae</td>
<td>25.00</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Mugil liza</td>
<td>Mugilidae</td>
<td>80.00</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Mylossoma aureum</td>
<td>Characidae</td>
<td>20.00</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Oligosarcus bepessatus</td>
<td>Characidae</td>
<td>23.80</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Pimelodus maculatus</td>
<td>Pimelodidae</td>
<td>36.00</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Rhamdia quelen</td>
<td>Heptapteridae</td>
<td>35.00</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Tilapia rendali</td>
<td>Cichlidae</td>
<td>45.00</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Trachelyopterus striatulus</td>
<td>Auchenipterida</td>
<td>20.00</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

*1(1) schooling, (2) non-schooling
§1(1) benthic, (2) benthopelagic, (3) demersal
†1(1) detritivores, (2) herbivores, (3) omnivores, (4) carnivores
‡1(1) potamodromous, (2) non-potamodromous
†1(1) diadromous, (2) non-diadromous

BIBLIOGRAPHIC REFERENCES


