# Community ecology of the metazoan parasites of Brazilian sardinella, *Sardinella brasiliensis* (Steindachner, 1879) (Actinopterygii: Clupeidae) from the coastal zone of the State of Rio de Janeiro, Brazil

*Moreira, J.*[a], *Paschoal, F.*[b], *Cezar, AD.*[c] *and Luque, JL.*[d]*

[a]Curso de Pós-Graduação em Ciências Veterinárias, Departamento de Parasitologia Animal, Universidade Federal Rural do Rio de Janeiro – UFRRJ, BR 465, Km 7, CEP 23890-000, Seropédica, RJ, Brazil

[b]Programa de Pós-Graduação em Biologia Animal, Universidade Federal Rural do Rio de Janeiro – UFRRJ, BR 465, Km 7, CEP 23890-000, Seropédica, RJ, Brazil

[c]Centro de Estudos e Pesquisas Biológicas – CEPBio, Universidade Castelo Branco – UCB, Avenida Santa Cruz, 1631, Realengo, CEP 21710-250, Rio de Janeiro, RJ, Brazil

[d]Departamento de Parasitologia Animal, Universidade Federal Rural do Rio de Janeiro – UFRRJ, CP 74540, CEP 23851-970, Seropédica, RJ, Brazil

*e-mail: luqueufrrj@gmail.com

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## Abstract

Between March 2010 and August 2011 were necropsied 100 specimens of *Sardinella brasiliensis* (Steindachner, 1879), from the coast of the State of Rio de Janeiro, Brazil (22°51'S, 43°56'W), to study their community of metazoan parasites. All specimens of *S. brasiliensis* were parasitized by at least one species of metazoan parasite, with mean of 68.7 ± 71.2 parasites/fish. Eleven species were collected: 3 digeneans, 1 monogenean, 2 cestodes, 3 nematodes and 2 copepods. The digenean *Myosaccium ecaude* Montgomery was the most abundant, prevalent, and dominant species, representing 72.7% of metazoan parasites collected, showing positive correlation between host's total length and parasite abundance. Total parasite abundance was positively correlated with host's total length. Three pairs of adult endoparasites showed significant positive association and covariation. The parasite community of *S. brasiliensis* showed dominance by digeneans. *Sardinella brasiliensis* represents new host record for most found parasite species.

*Keywords:* parasite ecology, community structure, Clupeidae, *Sardinella brasiliensis*, Brazil.

## Ecologia da comunidade dos metazoários parasitos da sardinha *Sardinella brasiliensis* (Steindachner, 1879) (Actinopterygii: Clupeidae) do litoral do Estado do Rio de Janeiro, Brasil

## Resumo

Entre março de 2010 e agosto de 2011 foram necropsiados 100 espécimes de *Sardinella brasiliensis* (Steindachner, 1879), do litoral do Estado do Rio de Janeiro, Brasil (22°51'S, 43°56'O), para estudo da sua comunidade de metazoários parasitos. Todos os espécimes de *S. brasiliensis* estavam parasitados por pelo menos uma espécie de metazoário, com média de 68,7 ± 71,2 parasitos/peixe. Onze espécies foram coletadas: 3 digenéticos, 1 monogenético, 2 cestóides, 3 nematóides e 2 copépodes. O digenético *Myosaccium ecaude* Montgomery foi a espécie mais abundante, prevalente, e dominante, representando 72,7% dos metazoários parasitos, apresentando correlação positiva entre o comprimento total do hospedeiro e a abundância parasitária. A abundância parasitária total foi positivamente correlacionada com o comprimento total do hospedeiro. Três pares de endoparasitos adultos apresentaram associação e covariação positivas significativas. A comunidade parasitária de *S. brasiliensis* apresentou dominância por digenéticos. *Sardinella brasiliensis* representa novo registro de hospedeiro para a maioria dos parasitos encontrados.

*Palavras-chave:* ecologia parasitária, estrutura comunitária, Clupeidae, *Sardinella brasiliensis*, Brasil.

## 1. Introduction

The Brazilian sardinella, *Sardinella brasiliensis* (Steindachner) is a marine finfish that inhabits coastal waters from Rio de Janeiro to south Brazil, always forming large schools. This species feeds mainly of the planktonic organisms filtered by gill rakers (Figueiredo and Menezes, 1978). It's the most important marine fishery resource of Brazil, in volume production, with landings concentrated in the States of Rio de Janeiro, São Paulo e Santa Catarina, contributing to world food resources in two ways: directly, through actual consumption (fresh, frozen or processed) and indirectly, by providing products used for animal feeds and fertilizers or by serving as bait to catch other fishes. (Paiva, 1997; Whitehead, 1985).

In Brazil, the parasitic fauna of clupeid fishes is poorly known, with most studies of taxonomy origin, performed by Vaz and Pereira (1930), Kohn and Bührnheim (1964), Travassos et al. (1967), Feijó et al. (1979), Wallet and Kohn (1987), Fabio (1988), Fernandes and Goulart (1989), with descriptions and records of digenetic trematodes; Kohn and Santos (1988) and Santos and Kohn (1992) for monogeneans; Palm (1997) and Rodrigues et al. (1990) for cestodes; Vicente et al. (1985) and Feijó et al. (1979) for nematodes; Montú (1980) and Amado and Falavigna (1996) for copepods. Studies regarding to ecological aspects were performed by Luque et al. (2000) and Tavares et al. (2004), on the parasitic fauna of *Harengula clupeola* (Cuvier) and *S. brasiliensis*, and *Brevoortia aurea* (Spix and Agassiz), respectively.

In this report, we analyze the composition and structure of the metazoan parasite communities of *S. brasiliensis* from the coastal zone of the State of Rio de Janeiro, Brazil.

## 2. Material and Methods

Between March 2010 and August 2011, 100 specimens of *S. brasiliensis* were necropsied, from the coast of Cabo Frio, Rio de Janeiro, Brazil (22°51›S, 43°56›O), to study their community of metazoan parasites. Fishes were identified according to Figueiredo and Menezes (1978). The analysis included only parasite species with prevalence higher than 10% (Bush et al., 1990).

The variance-to-mean ratio of parasite abundance (index of dispersion) and the discrepancy index, computed using the program Quantitative Parasitology 3.0 (Rózsa et al., 2000), were used to detect distribution patterns of the infrapopulations (Poulin, 1993). The dominance frequency and the relative dominance (number of specimens of one species/total number of specimens of all species in the infracommunity) of each parasite species were calculated according to Rohde et al. (1995). The parasite species diversity was calculated using the Brillouin index ($H$), because each fish analyzed corresponded to a fully censused community (Zar, 1996). The Spearman's rank correlation coefficient $rs$ was calculated to determine possible correlations between the total length of hosts and parasite abundance. Pearson's correlation coefficient $r$ was used to indicate the relationship between the host's total length and parasite prevalence, with previous arcsine transformation of the prevalence data (Zar, 1996). The effect of host sex on abundance and prevalence of parasites was tested using the $Zc$ (normal) approximation to the Mann-Whitney test and the Fisher exact test, respectively. Parasite species diversity was calculated using the Brillouin's index ($H$) (Zar, 1996). The probable variation of diversity in relation to host sex (Mann-Whitney test) and to host total length (Spearman's rank correlation coefficient) was tested. Possible interspecific association between concurrent species was determined using the chi-square test. Possible covariation among the abundance of concurrent species was analyzed using the Spearman's rank correlation coefficient. The ecological terminology used follows Bush et al. (1997). Statistical significance level was evaluated at $p \leq 0.05$. Voucher specimens of helminths were deposited in the Helminthological Collection of Institute Oswaldo Cruz (CHIOC), Rio de Janeiro, Brazil; copepods were deposited in the Carcinological Collection of National Museum of Rio de Janeiro (MNRJ), Brazil.

## 3. Results

The average total length of the fish was 12.7 – 24.8 (20.4 ± 1.91) cm, and the weight was 25 – 120 (77.6 ± 19.8) g. The average total length of male (20.6 ± 1.2, $n = 79$) and female (20 ± 2.8, $n = 21$) fishes in the studied sample were significantly different ($t = -2.890$, $P = 0.005$).

### *3.1. Component community*

Eleven species of metazoan parasites were collected (Table 1). *Sardinella brasiliensis* is a new host record for most of these species with exceptions made for the digeneans *Myosaccium ecaude* Montgomery and *Parahemiurus merus* Price (Luque et al., 2000), and for the copepod *Clavellisa ilishae* Pillai (Moreira et al., 2013). The digenetic trematode *M. ecaude* was the most abundant, prevalent, and dominant species, representing 72.7% of metazoan parasites collected with greatest values of mean relative dominance and frequency of dominance (Table 2).

Adult endoparasites represented 98.98% of all parasites collected, larval endoparasites amounted to 0.64%, and ectoparasites made up 0.38%. All parasites of *S. brasiliensis* had the typical aggregated pattern of distribution, except the cestode *Callitetrarhynchus gracilis* Rudolphi that showed dispersion index lower than 1, indicating a uniform pattern of distribution (Table 3). Only *M. ecaude* showed positively correlation between host's total length and parasite abundance ($rs = 0.197$, $p = 0.049$). The host's total length was not correlated with the prevalence of any species. The sex of hosts did not influence prevalence and abundance of any parasite species.

### *3.2. Infracommunities*

All specimens of *S. brasiliensis* were parasitized by at least one parasite species. A total of 6,866 individual parasites were collected, with mean of 68.7 ± 71.2 parasites/fish. Positive correlations were detected between parasite abundance and host's total length ($rs = 0.222$, $p = 0.026$), but the host's total length was not correlated with parasite species richness ($rs = 0.193$, $p = 0.055$). Six hosts (6%) showed infection with one parasite species, and 48 (48%), 36 (36%), 7 (7%) e 3 (3%) had multiple infections with 2, 3, 4, 5 parasite species, respectively (Figure 1). Mean parasite species diversity ($H = 0.545 \pm 0.228$) was not correlated with host's total length ($rs = 0.168$, $p = 0.094$) and no significant differences in parasite diversity were observed between male ($H = 0.529 \pm 0.239$) and female ($H = 0.605 \pm 0.175$) fishes ($Z_c = -1.292$, $p = 0.196$).

**Table 1.** Prevalence, mean intensity, mean abundance, and site of infection of metazoan parasites of *Sardinella brasiliensis* from the coastal zone of the State of Rio de Janeiro.

| Parasites | Prevalence (%) | Mean intensity | Mean abundance | Site of infection/ infestation |
|---|---|---|---|---|
| **Digenea** | | | | |
| *Parahemiurus merus* CHIOC Nº 37932 | 94 | 18.9 ± 15.7 | 17.8 ± 15.9 | Stomach |
| *Myosaccium ecaude* CHIOC Nº 37933 | 98 | 50.9 ± 61.6 | 49.9 ± 61.4 | Stomach |
| *Prodistomum gracile* CHIOC Nº 37935 | 13 | 2.2 ± 2.0 | 0.3 ± 1.0 | Intestine |
| **Monogenea** | | | | |
| *Cribomazocraes travassosi* CHIOC Nº 37938 | 3 | 1.3 ± 0.6 | 0.04 ± 0.2 | Gills |
| **Cestoda** | | | | |
| *Callitetrarhynchus gracilis* (plerocercoid) CHIOC Nº 37936/37937 | 15 | 1.1 ± 0.3 | 0.2 ± 0.4 | Body cavity |
| *Nybelinia* sp. (plerocercoid) CHIOC Nº 37939 | 1 | 1 | 0.01 ± 0.1 | Body cavity |
| **Nematoda** | | | | |
| *Hysterothylacium* sp. (larval) CHIOC Nº 35924 | 13 | 1.8 ± 1.5 | 0.2 ± 0.8 | Mesenteries |
| *Pseudoterranova* sp. (larval) CHIOC Nº 35925 | 1 | 1 | 0.01 ± 0.1 | Mesenteries |
| *Raphidascaris* sp. (larval) CHIOC Nº 35926/35927 | 2 | 1 | 0.02 ± 0.1 | Mesenteries |
| **Copepoda** | | | | |
| *Clavellisa ilishae* MNRJ Nº 23421 | 4 | 2.8 ± 2.9 | 0.1 ± 0.7 | Gills |
| *Nothobolochus cresseyi* MNRJ Nº 24144 | 10 | 1.1 ± 0.3 | 0.1 ± 0.3 | Gills |

**Table 2.** Frequency of dominance and mean relative dominance of metazoan parasites of *Sardinella brasiliensis* from the coastal zone of the State of Rio de Janeiro.

| Parasites | Frequency of dominance | Frequency of dominance shared with one or more species | Mean relative dominance |
|---|---|---|---|
| *Parahemiurus merus* | 15 | 3 | 0.313 ± 0.213 |
| *Myosaccium ecaude* | 82 | 3 | 0.662 ± 0.222 |

**Table 3.** Values of variance to mean ratio of parasite abundance (ID) and index of Discrepancy (D) of metazoan parasites of *Sardinella brasiliensis* from the coastal zone of the State of Rio de Janeiro.

| Parasites | ID | D |
|---|---|---|
| *Parahemiurus merus* | 14.213 | 0.454 |
| *Myosaccium ecaude* | 75.513 | 0.538 |
| *Prodistomum gracile* | 3.613 | 0.912 |
| *Callitetrarhynchus gracilis* | 0.975* | 0.850 |
| *Hysterothylacium* sp. | 2.704 | 0.906 |

*significant values.

The endoparasites were separated into two groups – helminth larval stages (cestodes and nematodes) and adult endoparasites (digeneans) – and were used to determine possible interspecific associations. Ectoparasites (copepods and monogeneans) were not included in this analysis because none of the species of this group showed prevalence higher than 10%. The helminth larval stages pair, *C. gracilis* – *Hysterothylacium* sp., did not share significant association and covariation ($\chi^2 = 0.63, p = 0.429$; $r_s = -0.083, p = 0.412$). The three pairs of endoparasites species *M. ecaude* – *P. merus*, *M. ecaude* – *Prodistomum gracile*, *P. merus* – *P. gracile*, showed positive covariation (Table 4).

**Table 4.** Concurrent species pairs of endoparasites in *Sardinella brasiliensis* from the coastal zone of the State of Rio de Janeiro.

| Parasites | $\chi^2$ | $p$ | $r_s$ | $p$ |
|---|---|---|---|---|
| *Parahemiurus merus – Myosaccium ecaude* | 0.13 | 0.718 | 0.558* | <0.0001 |
| *P. merus – Prodistomum gracile* | 0.95 | 0.329 | 0.231* | 0.021 |
| *M. ecaude – P.gracile* | 0.31 | 0.581 | 0.222* | 0.026 |

($\chi^2$) Chi-square test; ($r_s$) values of Spearman's rank correlation coefficient. ($p$) significant level. *significant values.

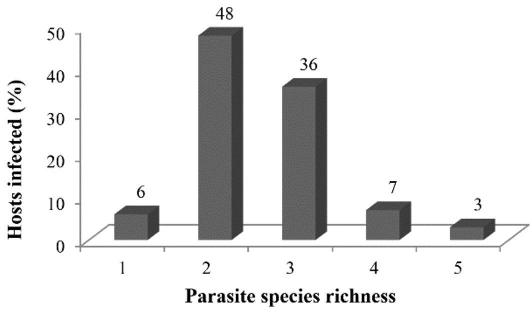


**Figure 1.** Distribution of species richness in the parasite infracommunities of *Sardinella brasiliensis* from the coastal zone of the State of Rio de Janeiro.

## 4. Discussion

The parasite community of *S. brasiliensis* showed digenetic trematodes dominance, which was previously reported by Luque et al. (2000) in a quantitative study of clupeid fishes from the coastal zone of the state of Rio de Janeiro. The dominance of digenean endoparasites has been described for several parasite communities of marine fishes from the coastal zone of southeastern Brazil (Luque et al., 1996; Takemoto et al., 1996; Knoff et al., 1997; Luque and Chaves, 1999; Silva et al., 2000; Luque and Alves, 2001; Tavares and Luque, 2004). The feeding of *S. brasiliensis*, which is predominantly composed by zooplanktonic copepods (Schneider and Schwingel, 1999), may favor the transmission of these parasites, since many of them act as intermediate hosts for digeneans.

Regarding to the study previously performed by Luque et al. (2000), the parasite species richness has increased and another important change was the presence of larval stages of helminths that were absent in the previous study, the nematodes *Hysterothylacium* sp., *Pseudoterranova* sp. and *Raphidascaris* sp., and the cestodes *C. gracilis* and *Nybelinia* sp. These differences may be related to the number of specimens necropsied, changes in coastal ecological features, seasonality, and the lack of studies on the parasites of clupeid fishes in the region. This low infection of larval stages of helminths was also observed in other clupeid fishes by Pérez-Ponce de León et al. (2000), in Mexico. And according to some authors, the presence of larval stages of helminths can be considered as a reflection of the intermediate trophic level of the host (George-Nascimento, 1987; Luque and Poulin, 2004).

The schooling habits of herrings might facilitate the transmission of some ectoparasites with direct life cycle, such as copepods and monogeneans (Luque and Alves, 2001). However, in this study a low prevalence in both taxa was observed, which may have been influenced by host biology, parasite specificity, hydrological conditions or environmental and ecological conditions of the region (Cone and Burt, 1982; Ibagy and Sinque, 1985). The monogenean *Cribomazocraes travassosi* Kohn and Santos was originally described parasitizing *Harengula clupeola*, and this paper reports the first occurrence of this species in *S. brasiliensis*, but with a low prevalence as previously mentioned, which may be an indication of the host specificity demonstrated by many monogeneans.

The parasite community of *S. brasiliensis* had the typically aggregated pattern of distribution, with exception made for *Callitetrarhynchus gracilis* who had an index of dispersion less than 1, thus indicating a uniform pattern of distribution, which is not a common occurrence in helminths. According to Von Zuben (1997) there are three factors that can lead to a uniform pattern of distribution: (1) mortality of parasites; (2) density dependent processes; and (3) the mortality of the host induced by the parasite (mortality rate positively correlated with parasite charge).

Unlike the pattern previously observed, the parasite abundance was positively correlated with host's total length. According to Polyansky (1961) quantitative and qualitative changes in parasitism are expected with fish growth. Diet, body mass and school formation are factors considered by Polyansky and Bychowsky (1963) as responsible for the number of parasite species harbored by a host. But according to Luque and Alves (2001), generalizations about the influence of host size on the quantitative and qualitative composition of parasitic infracommunities should be avoided.

The absence of correlations between host gender and the prevalence and abundance of the parasite community of *S. brasiliensis* has been reported before by Luque et al. (2000). However, different patterns have already been observed for other clupeid fishes from the coastal zone of the State of Rio de Janeiro (Luque et al., 2000; Tavares et al., 2004), which suggests a heterogeneous pattern, but additional studies are needed to evaluate the community structure of clupeid fishes in the Neotropical region.

*Sardinella brasiliensis* showed a lack of parasite species associated pairs, but according to Rohde et al. (1995) this is a common pattern in the majority of studied marine fish. Positive and negative associations between helminth species can provide strong evidence that species interactions exist and act on community structure (Poulin, 2001). But according to Rohde et al. (1995) and Poulin

(2001), interspecific relationships can only be considered valid when tested under experimental conditions.

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