COMMUNITY ECOLOGY OF METAZOAN PARASITES OF THE ANCHOVY *Anchoa tricolor* (OSTEICHTHYES: ENGRAULIDAE) FROM THE COASTAL ZONE OF THE STATE OF RIO DE JANEIRO, BRAZIL

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ABSTRACT

Between October 2001 and March 2002, 103 specimens of *A. tricolor* from Angra dos Reis (23°01'S, 44°19'W), in the coastal zone of the State of Rio de Janeiro, Brazil, were analyzed in order to study their metazoan parasite infracommunities. Ten species of metazoan parasites were collected: 4 digeneans, 1 cestode, 1 acantocephalan, 2 nematodes, 1 copepod, and 1 hirudinean; 77.7% of the fishes were parasitized by one or more metazoan, with a mean of 3.5 ± 6.2 parasite/fish. Digenean was the most dominant with 4 species that accounted for 53.2% of the total parasites collected; *Ergasilus* sp. was the most abundant species. Abundance and prevalence of *Parahemiurus merus* (Linton, 1910) were positively correlated with the total length of host. Relationships between total body length of fish and both total parasite abundance and mean parasite species richness were observed. Mean parasite diversity of species was correlated to host's total length, with significant differences found between male and female fishes. Two pairs of larval species showed significant positive association and covariation. The metazoan parasite infracommunities of *A. tricolor* presented dominance of larval endoparasites; correlation of parasite abundance, diversity, and species richness with host total length; and low number of parasite interspecific relationships. The parasite community of *A. tricolor* showed some similarities with the parasite community of another South American Atlantic engraulid.

Key words: parasite ecology, community structure, marine fish, Engraulidae, *Anchoa tricolor*, Brazil.

RESUMO

Ecologia da comunidade de metazoários parasitos de manjuba *Anchoa tricolor* (Osteichthyes: Engraulidae) do litoral do Estado do Rio de Janeiro, Brasil

Entre outubro de 2001 e março de 2002, foram examinados 103 espécimes de *A. tricolor* provenientes de Angra dos Reis (23°01'S, 44°19'W), litoral do Estado do Rio de Janeiro, Brasil, para o estudo de suas infracomunidades de metazoários parasitos. Foram coletadas 10 espécies de metazoários parasitos: 4 digenéticos, 1 cestóide, 1 acantocéfalo, 2 nematóides, 1 copépode e 1 hirudíneo; e 77% dos peixes estavam parasitados por 1 ou mais metazoários, com média de 3,5 ± 6,2 parasitos/peixe. Os digenéticos foram dominantes, representando 53,2% do total de parasitos coletados, e *Ergasilus* sp., a espécie mais abundante. A abundância e a prevalência de *Parahemiurus merus* (Linton, 1910) foram positivamente correlacionadas ao comprimento total dos hospedeiros. Relações entre a abundância parasitária total e a riqueza parasitária média ao comprimento total dos hospedeiros foram observadas. A diversidade parasitária média foi corrrelacionada com o comprimento total dos hospedeiros, apresentando diferenças significativas entre os peixes machos e fêmeas. Dois pares de espécies de larvas apresentaram associação e covariação positiva significativas. As infracomunidades de metazoários parasitos de *A. tricolor*

demonstraram dominância nas larvas de endoparasitos, correlação entre abundância parasitária, diversidade e riqueza de espécies e o comprimento total dos hospedeiros e o baixo número de associações interespecíficas parasitárias. A comunidade parasitária de *A. tricolor* apresentou algumas semelhanças com a comunidade parasitária de outros engraulídeos do Atlântico Sul-Americano.

Palavras-chave: ecologia parasitária, estrutura comunitária, peixes marinhos, Engraulidae, *Anchoa tricolor*, Brasil.

INTRODUCTION

Engraulid fishes are among the principal components of the marine ecosystems in South America. In addition, as primary feeders in the marine food web, engraulids are the main prey item for many species of fishes and are of significant commercial importance in this region (Castello & Castello, 2003; Pessanha & Araújo, 2003).

The anchovy *Anchoa tricolor* (Agassiz, 1829) is a planktivorous pelagic fish that occurs in coastal zone, in marine and estuarine habitats, and is known to be geographically distributed in the southwestern Atlantic Ocean, from Ceará, Brazil, to Argentina (Figueiredo & Menezes, 1978). Usually occurring in large schools, anchovies feed mainly on crustaceans, larvae, and molluscs. *Anchoa tricolor* is largely used as bait for commercial fishery, oil, flour, and also canned fish (Silva & Araújo, 2000; Pessanha & Araújo, 2003).

Taxonomic studies on the metazoan parasites of anchovies from the western Atlantic Ocean include those of Timi *et al.* (1999a) on Trematoda; Kohn *et al*. (1992) and Timi *et al*. (1999b) on Monogenean; Navone *et al.* (1998) and Timi *et al*. (2001) on Nematoda; Montú (1980), Thatcher & Boeger (1983), Amado & Rocha (1996), Timi & Sardella (1997), and Thatcher *et al.* (2003) on Crustacea; and Timi (2003) and Timi & Poulin (2003) on populational and ecological features. The majority of these papers are about parasites of *Engraulis anchoita* Hubbs & Marini, 1935, which is a very common engraulid species in Argentinean and southern Brazilian coastal zones (Angelescu, 1982; Castello & Castello, 2003). Studies on parasites of *A. tricolor* are unknown.

In this report, we analyze at the component and infracommunity levels a metazoan parasite community of *A. tricolor* from the coastal zone of the State of Rio de Janeiro.

MATERIALS AND METHODS

Between October 2001 and March 2002, we studied 103 specimens of *A. tricolor* from Angra dos Reis, coastal zone of the State of Rio de Janeiro (23°01'S, 44°19'W), Brazil. These fish, which were identified according to Figueiredo & Menezes (1978), measured 11.12 ± 0.86 (9.4-13.4 cm) in total length, with the average total length of males (10.8 ± 0.8 cm, n = 65) and females (11.6 ± 0.8 cm, n = 38) fishes being significantly different (t = 2.27, p = 0.03).

The analysis included only parasite species with prevalence higher than 10% (Bush *et al.,* 1990). The quotient between variance and mean of parasite abundance (index of dispersion) was used to determine distribution patterns; significance was tested using the *d* statistical test. 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 Spearman's rank correlation coefficient r_s 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, 1999). The effect of host sex on abundance and prevalence of parasites was tested using the Z_c (normal) approximation to the Mann-Whitney test and the Fisher exact test, respectively. Parasite species diversity was calculated using the Brillouin index (*H*) (Zar, 1999). 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 and hirudineans were deposited in the Coleção Helmintológica do Instituto Oswaldo Cruz (CHIOC), Rio de Janeiro, Brazil; copepods were deposited in the Coleção de Crustacea do Museu Nacional (MNRJ), Quinta da Boa Vista, Rio de Janeiro, RJ, Brazil.

RESULTS

Component community

Ten species of metazoan parasites were found (Table 1). Digeneans was the most prevalent, with 4 species accounting for 53.2% of total parasites collected (Table 2). *Ergasilus* sp. was the most abundant species, with 122 specimens collected (33.8% of all parasites).

TABLE 1

Prevalence, intensity, mean intensity, mean abundance, and site of infection/infestation of the metazoan parasites of *Anchoa tricolor* from the coastal zone of the State of Rio de Janeiro, Brazil.

Parasites	Prevalence (%)	Intensity	Mean intensity	Mean abundance	Site of infection
Digenea					
Digenean not identified (metacercaria) CHIOC 36257	35	1-11	2.0 ± 1.99	0.7 ± 1.5	Intestine
Hemiurid not identified (metacercaria) CHIOC 36256	17.5	1-5	1.6 ± 1.1	0.3 ± 0.7	Intestine
Parahemiurus merus CHIOC 34945	23.3	1-14	3.9 ± 3.6	0.9 ± 2.4	Stomach
Rhipidocotyle sp. (metacercaria) CHIOC 36255a, b	13.6	1-5	1.1 ± 0.5	0.2 ± 0.4	Intestine
Cestoda					
Scolex pleuronectis CHIOC 36258	15.5	1-3	1.3 ± 0.7	0.2 ± 0.5	Intestine
Acanthocephala					
Polymorphus sp. (cystacanth) CHIOC 36259	2	–	1	< 0.1	Intestine
Nematoda					
Hysterothylacium sp. (larval) CHIOC 35262	3	1-3	1.7 ± 1.2	< 0.1	Mesenteries
Terranova sp. (larval) CHIOC 35263	0.01	–	1	< 0.1	Mesenteries
Copepoda					
Ergasilus sp. 19142 MNRJ	22.3	1-56	5.3 ± 11.4	1.2 ± 5.7	Gills
Hirudinea					
Piscicolid not identified CHIOC 34691	2	–	1	< 0.1	Gills

Larval endoparasites species represented 39.9% of all parasites collected, adult endoparasites amounted to 25.8%, and ectoparasites made up 34.4%. All parasites of *A. tricolor* had the typically aggregated distribution pattern observed in many parasite systems (Table 3). Abundance and prevalence of *Parahemiurus merus* (Linton, 1910) were positively correlated with host's total length (Table 4). The mean abundance and prevalence of all parasite species did not differ significantly between female and male hosts.

Infracommunities

Seventy-eight percent of *A. tricolor* were parasitized by at least one metazoan species, and 361 specimens of metazoan parasites were collected, with a mean of 3.5 ± 6.2 parasite/fish (1-57). Relationships between the total parasite abundance and total host length were observed ($r_s = 0.414$, $p < 0.01$). The mean parasite species richness 1.4 ± 1.1 (1-5) was correlated with total body length of fish ($r_s = 0.327$, $p < 0.01$). Forty hosts (38.9%) showed infection with one parasite species; 23 (22.3%), 12 (11.7%), 3 (2.9%), and 1 (0.9%) had multiple infections with 2, 3, 4, and 5 species, respectively. The mean parasite species diversity ($H = 0.08 \pm 0.11$; 0-0.43) was correlated to host total length ($r_s = 0.299$, $p < 0.01$), with significant differences between male ($H = 0.067 \pm 0.115$) and female ($H = 0.096 \pm 0.106$) fishes ($Z_c = -1.614$, $p = 0.05$).

Only endoparasitic larval stages were used to verify possible interspecific associations. Adult endoparasites and ectoparasites were not included in this analysis because only one ectoparasitic species showed a prevalence higher than 10% and only one adult endoparasite species was collected (see Table 1). Two pairs of larval species demonstrated significant positive association and covariation: digenean (not identified) and *Rhipidocotyle* sp. ($\chi^2 = 18.4$, $p < 0.01$; $r_s = 0.39$, $p < 0.01$); hemiurid (not identified) and *Scolex pleuronectis* ($\chi^2 = 5.3$, $p = 0.02$; $r_s = 0.24$, $p = 0.02$).

TABLE 2

Frequency of dominance and mean relative dominance of the metazoan parasites of *Anchoa tricolor* from the coastal zone of the State of Rio de Janeiro, Brazil.

Parasite	Frequency of dominance	Frequency of dominance shared with one or more species	Mean relative dominance
Digenean not identified	17	15	0.194 ± 0.335
Hemiurid not identified	4	7	0.079 ± 0.209
Parahemiurus merus	16	2	0.145 ± 0.3
Rhipidocotyle sp.	2	10	0.05 ± 0.153
Scolex pleuronectis	5	8	0.069 ± 0.207
Ergasilus sp.	20	2	0.186 ± 0.367

TABLE 3

Dispersion index (DI) and *d* test of the metazoan parasites of *Anchoa tricolor* from the coastal zone of the State of Rio de Janeiro, Brazil.

Parasites	DI	*d*
Digenean not identified	3.27	11.59
Hemiurid not identified	2.03	6.12
Parahemiurus merus	6.18	21.25
Rhipidocotyle sp.	1.23	1.61
Scolex pleuronectis	1.48	3.11
Ergasilus sp.	27.83	61.1

TABLE 4

Spearman's rank correlation coefficient (r_s) and Pearson's correlation coefficient (r) values used to evaluate possible relationships among the total length of *Anchoa tricolor* from the coastal zone of the State of Rio de Janeiro, Brazil, and the abundance and prevalence of its parasite community components.

Parasites	r_s	p	r	p
Digenean not identified	0.041	0.676	0.06	0.754
Hemiurid not identified	0.062	0.535	0.14	0.626
Parahemiurus merus	0.502*	< 0.01	0.941*	0.029
Rhipidocotyle sp.	–0.055	0.581	0.349	0.409
Scolex pleuronectis	0.131	0.189	0.307	0.446
Ergasilus sp.	0.018	0.859	0.504	0.289

*Significant values.

DISCUSSION

Some patterns in the structure and composition of the community of metazoan parasites of *A. tricolor* from Brazil were detected: (1) dominance of endoparasitic larval stage; (2) positive correlation of parasitic abundance and richness with the size of the host; (3) low number of parasitic interspecific relationships.

Dominance of endoparasitic larval stages should be expected because the anchovies feed mainly on zooplanktonic organisms and act as intermediate and/or paratenic hosts for parasites of fishes, birds, and marine mammals. According to Lafferty (1999), some trophically transmitted parasites may infect the same intermediate host and show positive correlations among its intensities that suggest an alternative strategy that increases trophic transmission. Timi *et al.* (1999a) recorded four species of digeneans parasitic, two of which were in larval stages (metacercaria), in *E. anchoita* from Argentina and Uruguay. In addition, 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 *et al.,* 2000; Silva *et al.,* 2000; Luque & Alves, 2001; Tavares & Luque, 2004a, among others).

The copepod *Ergasilus* sp. showed the highest values of mean abundance and intensity, a pattern possibly related to schooling behavior of *A. tricolor* (Silva & Araújo, 2000). Parasite transmission between host individuals could have a significant group-living cost (Krause *et al.*, 1999; Ward *et al.*, 2002), and schooling behavior is determinant on a broad scale for parasitic species richness in fishes from the coastal zone of the State of Rio de Janeiro (Luque *et al*., 2004). Besides, high levels of infestation by copepod ectoparasites has been recorded for some parasite communities of marine fishes from the coastal zone of southeastern Brazil (Cezar & Luque, 1999; Tavares *et al.*, 2001, 2004b).

Correlations of parasite abundance, diversity, and species richness with total length of host were also detected in some fishes from the coastal zone of Rio de Janeiro State (Luque & Chaves, 1999; Alves & Luque, 2001; Luque & Alves, 2001; Alves *et al.*, 2002) and are in accordance with the patterns detected by Timi & Poulin (2003) for *E. anchoita* from Argentina. According to Poulin (1995, 2001a) and Bush *et al.* (2001), larger hosts are also expected to harbor richer parasite fauna because they provide a greater niche variety and can sustain a greater absolute number of parasites. Moreover, Bush *et al.* (2001) stated that large fish often show ontogenetic shifts in their diet, suggesting that they may be exposed to a greater number of intermediate/paratenic hosts than small fish, whether detritivorous or phytoplanktivorous.

Timi (2003) and Timi & Poulin (2003) have extensively researched the use of parasites of *E. anchoita* as indicators of population stocks and for modeling predictability for other the parasite

communities. Although the sample of *A. tricolor* was smaller and from one locality only, some similar components such as community richness, mean infracommunity richness, and total prevalence were detected in descriptors of the parasite community. However, the infracommunity composition shows some differences, mainly in the ectoparasites: monogeneans were the only ones recorded for *E. anchoita.*

On the other hand, in the coastal zone of Rio de Janeiro the digenean *Parahemiurus merus* prefers a wide spectrum of fish hosts with heterogeneus habitats and feeding behavior (Takemoto *et al.*, 1996; Knoff *et al.*, 1997; Luque & Chaves, 1999; Luque & Alves, 2001; Paraguassú *et al.*, 2002). Timi (2003) also recorded this species parasitizing *E. anchoita*; however, lower values of prevalence and intensity were recorded.

Poulin (2001b) and Poulin & Valtonen (2001) pointed out that many helminth parasites use fish either as a second intermediate or a paratenic host, and if two or more species of larval helminthes simultaneously accumulate in fish over time, a statistical association among these species may be expected. In this study, two pairs of larval endoparasite species were positively associated, although these quantitative relationships should be regarded with caution when explaining a parasite community structure. Lafferty (1999) and Poulin & Valtonen (2001) strongly suggested the possibility that parasites with similar life cycles could enhance their chances of transmission along the food web by associating with intermediate or paratenic host individuals. However, it would be extremely difficult to check this hypothesis. To date, six engraulid species, four of them belonging to *Anchoa* (Araújo *et al.*, 1997; Silva & Araújo, 2000), have been recorded from the coastal zone of Rio de Janeiro State; studies on the metazoan parasite communities harbored by these species could indicate possible populational patterns and their influence on the structure and predictability of its parasite communities.

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