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MONOGENOIDEA AND DIGENEA PARASITES OF *THUNNUS ATLANTICUS* (PERCIFORMES, SCOMBRIDAE) FROM RIO DE JANEIRO COAST, BRAZIL

MONOGENOIDEA Y DIGENEA PARÁSITOS DE *THUNNUS ATLANTICUS* (PERCIFORMES, SCOMBRIDAE) DE LA COSTA DE RIO DE JANEIRO, BRASIL

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Abstract

Thunnus atlanticus is of great commercial importance in Brazil, but infections caused by helminth parasites can reduce its commercial value. In this paper, 15 species of Digenea and three of Monogenoidea were recovered from 61 specimens of *T. atlanticus* collected from the coastal zone of the State of Rio de Janeiro. Species of the family Didymozoidae were the dominant species, with highest prevalence and abundance values. The parasites showed the typical aggregated distribution pattern, except for *Nasicola brasiliensis*, which had an aleatory distribution pattern. Prevalence and abundance of *Didymosulcus philobranchiarca, Didymocystis lamotheargumedoi* and *Didymosulcus wedli* and prevalence of *Koellikerioides internogastricus* were positively correlated with the total length of the host. The abundance of *Coeliotrema thynni* was negatively correlated with total length of the host. New hosts records resulted for four Digenea: *Didymosulcus orbitalis, Didymosulcus wedli, Rhipidocotyle pentagonum* and *Lecithochirium microstomum*, and one Monogenoidea: *Nasicola brasiliensis*.

Keywords: Digenea - Fish parasites - Monogenoidea – Scombridae.

Resumen

Thunnus atlanticus es de gran importancia comercial en Brasil, pero las infecciones causadas por helmintos parásitos puede reducir su valor comercial. En este trabajo, 15 especies de Digenea y tres de Monogenoidea fueron recuperados de 61 ejemplares de *T. atlanticus* recogidos de la zona costera del Estado de Río de Janeiro. Las especies de la familia Didymozoidae eran las especies dominantes, con mayores valores de prevalencia y de abundancia. Los parásitos mostraron el patrón de distribución agregado típico, excepto para *Nasicola brasiliensis*, que tenía un patrón de distribución aleatoria. La prevalencia y abundancia de *Didymosulcus philobranchiarca*, *Didymocystis lamotheargumedoi* y *Didymosulcus wedli* y la prevalencia de *Koellikerioides internogastricus* se correlacionaron positivamente con la longitud total del hospedador. La abundancia de *Coeliotrema thynni* se correlacionó negativamente con la longitud total del hospedador. Nuevos registros de hospedadores resultaron para cuatro especies de Digenea: *Didymosulcus orbitalis*, *Didymosulcus wedli*, *Rhipidocotyle pentagonum* y *Lecithochirium microstomum*, y uno Monogenoidea: *Nasicola brasiliensis*.

Palabras clave: Digenea - Monogenoidea - Parásitos de peces - Scombridae

INTRODUCTION

Studies on helminth parasites of Brazilian scombrids had been published by Alves *et al.* (2003), Alves & Luque (2006), Cardenas *et al*. (2009), Dias *et al*. (2011), Fernandes *et al*. (2002), Hsu (1968), Justo & Kohn (2005, 2009, 2010, 2011, 2012a, 2012b), Justo *et al.* (2008, 2009, 2013), Kohn & Justo (2006, 2008), Kohn *et al*. (2001, 2003, 2004), Mogrovejo *et al.* (2004), Mogrovejo & Santos (2002), Moravec *et al.* (1999), Rego & Eiras (1987), Rego & Santos (1983) and Pamplona-Basilio *et al.* (2001). Tunas (Thunnini) are unique among bony fishes in having counter-current heat exchange systems that allow them to retain metabolic heat, maintaining a warmer internal temperature than the surrounding water (Collette & Nauem, 1983). In addition to their endothermic adaptations, they have a suite of morphological characters appear to be adaptations for efficient, and relativity rapid, sustained swimming (Altringham & Block, 1997). *Thunnus atlanticus* (Lesson, 1831) is the only tuna scombrid species whose distribution limits are in the western Atlantic. It is reported from the North of the USA to the Southeast of Brazil, where is known as "albacorinha". It is a highly migratory species, mainly found in coastal waters, in temperatures above 20° C. "Albacorinhas" form schools with other species of tuna, spawn near the coast and feed on small fish, squids, crustaceans, and plankton (Collette & Nauen, 1983). *T. atlanticus* is commercially very important in Brazil, where high rates of infection caused by helminth parasites often reduce the commercial value of the fish. According to Mladineo *et al.* (2009), the long-distance migrations typical of tuna fish and their consequent exposure to a wide range of ambient water temperatures facilitate infections with several parasitic groups, mainly by members of Didymozoidae Monticelli, 1888, which display remarkable diversity and high levels of prevalence and abundance.

MATERIALS AND METHODS

Sixty one specimens of *T. atlanticus* (45 - 82 cm total body length; 1.3 - 6.0 kg) were surveyed for helminth parasites. Fish were obtained from local fishermen, from the coastal zone of the State of Rio de Janeiro, Cabo Frio, Brazil (22º52'46"S, 42º01'07" W). The parasites were fixed with or without compression in AFA (alcohol 93%, formalin 5% and acetic acid 2%), stained in alcoholic-acid carmine, dehydrated in alcohol series, cleared in beachwood creosote and mounted in Canada balsam. Parasitism indexes proposed by Bush *et al.,* (1997) were used. The quotient between variance and mean parasite abundance (index of dispersion) was used to determine distribution patterns and was tested by the *d* statistical index (Ludwig & Reynolds, 1988).

The Spearman's rank correlation coefficient (r_s) was used to determine possible host length correlations with parasitism abundance. Pearson's coefficient of correlation (r) was used to determine possible correlations between total length and prevalence, with angular transformation of prevalence values. 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 (Zar, 1996). The tests were only applied to species that showed prevalence higher than 10% (Bush *et al.,* 1990). The significance level adopted was $p \leqslant 0.05$. The studied specimens are deposited in the Helminthological Collection of Instituto Oswaldo Cruz (CHIOC), Rio de Janeiro, Brazil.

RESULTS

A total of 61 specimens of *T. atlanticus* were examined, of which 24 (39.4%) were males and 37 (60.6%) females. All hosts were parasitized by at least three helminth species. Eighteen different species had been identified: 15 species of Digenea and three Monogenoidea. Among the Digenea, 13 species (86.6%) belong to the family Didymozoidae: *Coeliotrema thynni* Yamaguti, 1938 – CHIOC: 37100, 37101, 37209-37211; *Didymocystis bifasciatus* (Yamaguti, 1970) – CHIOC: 37966, 37967;

Didymocystis lamotheargumedoi Kohn & Justo, 2008 – CHIOC: 36927, 36929, 36930-36932; *Didymocystis neothunni* (Yamaguti, 1970) – CHIOC: 37128, 37129*; Didymosulcus orbitalis* (Yamaguti, 1970) – CHIOC: 37969, 37970a-b; *Didymosulcus palati* (Yamaguti, 1970) – CHIOC: 36944, 36945, 36947; *Didymosulcus philobranchiarca* (Yamaguti, 1970) – CHIOC: 37971, 37972; *Didymosulcus wedli* (Ariola, 1902) – CHIOC: 37968a-b; *Didymozoon longicolle* Ishii, 1935 – CHIOC: 37160, 37133; *Koellikerioides apicalis* Yamaguti, 1970 – CHIOC: 37143, 37148; *Koellikerioides internogastricus* Yamaguti, 1970 – CHIOC: 37010, 37011; *Koellikerioides intestinalis* Yamaguti, 1970 – CHIOC: 37132 and *Nephrodidymotrema ahi* Yamaguti, 1970 – CHIOC: 37139-37142; one Bucephalidae (6.7%): *Rhipidocotyle pentagonum* (Ozaki, 1924) – CHIOC: 37062 and one Hemiuridae (6.7%): *Lecithochirium microstomum* Chandler, 1935 – CHIOC: 37071. Three species of Monogenoidea were found, representing 16.7% of all parasites: *Capsala biparasitica* (Goto, 1894) – CHIOC: 37976, 37977; *Capsala katsuwoni* (Ishii, 1936) – CHIOC: 37975 and

Table 1. Prevalence (P), intensity range (IR), intensity (I), mean intensity (IM), mean abundance (AM) and site infection (SI) of parasites of *T. atlanticus,* from the coastal zone of the State of Rio de Janeiro coast, Brazil. Standard deviation follows of mean values.

PARASITES	P (%)	IR	I*/IM	AM	SI
DIGENEA					
Didymozoidae					
Coeliotrema thynni	37.8	1 - 71	12.12 ± 8.61	4.58 ± 3.60	Caeca
Didymocystis bifasciatus	13.3	8 - 71	31.50 ± 22.06	4.20 ± 4.30	Gills, operculum
Didymocystis lamotheargumedoi	26.7	20 - 1000	273.33 ± 198.07	72.89 ± 62.40	Operculum, palate
Didymocystis neothunni	4.4	2 - 14	8.00±11.76	0.36 ± 0.61	Tongue
Didymosulcus orbitalis♦	20.0	2 - 40	9.78 ± 7.71	1.96 ± 1.90	Periorbital region
Didymosulcus palati	15.6	4 - 280	68.86 ± 73.75	10.71 ± 13.00	Gills, operculum
Didymosulcus philobranchiarca	42.2	32 - 1400	267.37 ± 145.32	112.89 ± 71.90	Operculum
Didymosulcus wedli♦	11.1	4 - 32	16.80 ± 9.07	1.87 ± 1.80	Gills
Didymozoon longicolle	6.7	1 - 92	39.00 ± 53.55	2.60 ± 4.12	Gills
Koellikerioides apicalis	4.4	1 - 4	2.50 ± 2.9	0.11 ± 0.18	Gills
Koellikerioides internogastricus	75.6	1 - 92	120.88 ± 48.09	91.33 ± 39.30	Stomach
Koellikerioides intestinalis	35.6	6 - 88	49.75 ± 18.13	17.69 ± 9.50	Intestine
Nephrodidymotrema ahi	11.1	1 - 12	4.20 ± 3.94	0.47± 0.60	Kidney
Bucephalidae					
Rhipidocotyle pentagonum ♦	4.4	8 - 11	9.50 ± 2.94	0.42 ± 0.59	Stomach
Hemiuridae					
Lecithochirium microstomum ♦	8.9	4 - 20	7.50 ± 8.22	0.67 ± 0.90	Stomach
MONOGENOIDEA					
Capsalidae					
Capsala biparasitica	4.4	1 - 7	4.00 ± 5.88	0.18 ± 031	Gills
Capsala katsuwoni	6.6	-	1*	0.07 ± 0.07	Gills
Nasicola brasiliensis ♦	68.9	1 - 4	3.03 ± 0.34	2.09 ± 0.50	Nasal cavities

* Only one specimen was parasitized; ♦ New host record.

Nasicola brasiliensis Kohn, Baptista-Farias, Santos & Gibson, 2004 – CHIOC: 37973, 37974.

From the different Digenea species recovered, the Didymozoidae represent the dominant group, with 14,537 specimens collected (81,25% of all digenetic parasites). The dominant species among Monogenoidea was *Nasicola brasiliensis*, with 94 specimens collected (89.5% of all monogenetic).

Among the didymozoid species found, *D. lamotheargumedoi, D. philobranchiarca* and *K. internogastricus* were the dominant species with highest average intensity and abundance. Infection parameters are shown in table 1.

The studied parasites showed the typical aggregated distribution pattern, except for *N. brasiliensis* that showed an aleatory distribution pattern. *Didymocystis lamotheargumedoi, D. philobranchiarca*, *D. palati* and *K. internogastricus* presented the highest dispersion index (table 2).

Spearman's correlation coefficient (r_s) showed that the abundance of *D. philobranchiarca*, *D. wedli* and *D. lamotheargumedoi* were positively correlated with total length of the host (r_s =

Table 2. Dispersion index (DI) and *d* statistical of the parasites of *T. atlanticus* from the coastal zone of the State of Rio de Janeiro coast, Brazil.

Parasites	DI	*d*
Didymosulcus philobranchiarca	536.5	208.0
Didymosulcus palati	185.7	118.5
Didymocystis lamotheargumedoi	625.3	225.3
Koellikerioides intestinalis	59.7	63.2
Didymosulcus orbitalis	21.0	33.6
Didymocystis wedli	20.5	33.1
Didymocystis bifasciatus	52.1	58.4
Koellikerioides internogastricus	198.3	122.8
Nephrodidymotrema ahi	7.8	16.8
Coeliotrema thynni	33.8	45.2
Nasicola brasiliensis	1.3	1.3

Table 3. Values of Spearman's rank correlation coefficient (r_s) to evaluated possible relationships among the host total length abundance of the helminth parasites of *T. atlanticus* from the coastal zone of the State of Rio de Janeiro coast, Brazil.

Parasites	r_s	P
Didymosulcus philobranchiarca	0.326	0.029*
Didymosulcus palati	0.041	0.789
Didymocystis lamotheargumedoi	0.309	0.039*
Koellikerioides intestinalis	-0.186	0.221
Didymosulcus orbitalis	0.193	0.204
Didymocystis wedli	0.335	0.024*
Didymocystis bifasciatus	-0.007	0.965
Koellikerioides internogastricus	0.047	0.759
Nephrodidymotrema ahi	-0.033	0.830
Coeliotrema thynni	-0.407	0.006*
Nasicola brasiliensis	-0.126	0.411

* Significant values.

0.326, $P = 0.029$; $r_s = 0.335$, $P = 0.024$; $r_s = 0.309$, $P = 0.039$) respectively, and *C. thynni* was negatively correlated with total length of the host ($r_s = -0.407$, $P = 0.006$) (table 3). Pearson's correlation coefficient (r) demonstrated that the prevalence of *K. internogastricus* was correlated with the total length of the host ($r = 0.668$, $P = 0.025$) (table 4).

Sex and parasite abundance were not correlated, while sex and parasite prevalence were correlated in *C. thynni* ($F = 0.023$) (table 5).

In this paper *T. atlanticus* represents a new host record to four species of Digenea (*D. orbitalis, D. wedli, R. pentagonum* e *L. microstomum*) and one species of Monogenoidea (*N. brasiliensis*).

Table 4. Values of Pearson's correlation coefficient (r) obtained in relations between total length and prevalence of the helminth parasites of *T. atlanticus* from the coastal zone of the State of Rio de Janeiro coast, Brazil.

Parasites	*r*	P
Coeliotrema thynni	-0.458	0.157
Didymocystis bifasciatus	-0.338	0.309
Didymocystis lamotheargumedoi	0.142	0.677
Didymosulcus orbitalis	0.229	0.497
Didymocystis wedli	0.484	0.131
Didymosulcus palati	0.122	0.720
Didymosulcus philobranchiarca	0.534	0.091
Koellikerioides internogastricus	0.668	0.025*
Koellikerioides intestinalis	-0.114	0.739
Nasicola brasiliensis	0.005	0.988
Nephrodidymotrema ahi	-0.372	0.260

*Significant values.

Table 5. Normal approximation Z_c of Mann-Whitney test and Fisher's (F) test values used to evaluate possible relationships between the sex and abundance and prevalence of the helminth parasites of *T. atlanticus* from the coastal zone of the State of Rio de Janeiro coast, Brazil.

Parasites	Z_c	P	*F*
Coeliotrema thynni	-1.9	0.059	0.023*
Didymocystis bifasciatus	-0.3	0.764	0.686
Didymocystis lamotheargumedoi	-0.2	0.855	0.728
Didymosulcus orbitalis	-0.7	0.508	0.700
Didymocystis wedli	-0.3	0.728	1.000
Didymosulcus palati	-0.3	0.764	1.000
Didymosulcus philobranchiarca	-1.7	0.089	0.212
Koellikerioides internogastricus	-0.7	0.474	1.000
Koellikerioides intestinalis	-0.5	0.624	0.749
Nasicola brasiliensis	-1.2	0.230	0.197
Nephrodidymotrema ahi	-0.7	0.501	0.641

*Significant values.

DISCUSSION

A diverse community of Digenea and Monogenoidea parasites infect *T. atlanticus* in the coastal zone of southeastern Brazil. In this study, didymozoids were the dominant parasites of this tuna. The highly migratory habits of widely distributed tuna, which migrate to different oceans may leave the fish vulnerable to several parasitic groups, mainly didymozoids, which are widely distributed among oceanic fishes. The dominance of didymozoids among the Digenea parasitizing *T. atlanticus* in this study is consistent with observations for other tunas studied in other oceans (Madhavi & Ram 2000; Mladineo *et al.,* 2008). This result was expected, since tunas have a broad predatory diet consisting of small fish, crustaceans and squids, which brings them into contact with several potential intermediate didymozoid hosts. According to Sasal *et al.* (1999), the diet of the host species is the main factor affecting parasite community structure, especially for digenean trematodes, since their final host is infected by predating on the intermediate host. Several reports on the didymozoids larvae parasitizing small fishes (Køie & Lester, 1985; Korotaeva, 1985; Karlsbakk, 2001) and squids (Naidenova *et al.,* 1985; Shukhgalter & Nigmatullin, 2001; Nigmatullin *et al.,* 2009) confirm this hypothesis. According to Naidenova *et al.* (1985) heavy infection of squids is correlated with high infection rates of the final hosts, mainly scombrids.

According to Sasal *et al.* (1999), larger fish generally eat more and for that reason they tend to ingest greater amounts of intermediate hosts. The correlation coefficient found between total host length and the abundance of *D. philobranchiarca*, *D. wedli* and *D. lamotheargumedoi* may explain accumulative infections.

Among all parasite species identified, only one, *C. thynni*, showed sex preferences, being more prevalent on *T. atlanticus* males. This is surprising, because biological differences between males and females of *T. atlanticus* have not been reported in the literature.

The presence of didymozoid species in Atlantic Ocean is evidence of their cosmopolitan distribution and the cosmopolitan geographical distribution of the host, showing that tuna fish migration in different oceans may facilitate infections by members of Didymozoidae.

Among the 15 species of Digenea and three Monogenoidea studied, we report herein *T. atlanticus* as a new host record for *Didymosulcus orbitalis, Didymosulcus wedli, Rhipidocotyle pentagonum, Lecithochirium microstomum*, and *Nasicola brasiliensis*.

Didymosulcus orbitalis was originally described from *T. albacares* and *T. obesus* by Yamaguti (1970) from Hawaii and later redescribed by Pozdnyakov (1989) from the shark *Pterolamiops longimanus;* In Brazil, South America this parasite was referred by Justo & Kohn (2005) from *T. obesus. D. wedli,* had been found in different oceans and hosts: in the Mediterranean from *Euthynnus alletteratus*, *Thynnus vulgaris*, *Thunnus thynnus* and *Katsuwonus pelamis* (Ariola, 1902; Dollfus, 1926; Okada, 1926, Mladineo & Tudor, 2004); in the Pacific from *Scomber japonicus*, *K. pelamis*, *T. thynnus*, *Seriola quinqueradiata* and *Thunnus orientalis* (Kobayashi, 1921; Yamaguti, 1934; Ishii, 1935); in India from *Auxis thazard* and *Thunnus tonggol* (Madhavi, 1982; Murugesh & Madhavi, 1995) and in the Atlantic from *T. albacares* (Kohn *et al*., 2001). Since its original description from *Scomberomorus nipponicus* in Japan, *R. pentagonum* had been referred in different hosts and localities: It was found parasitizing *T. thynnus* in the Mediterranean by Eckmann (1932) and in the Pacific by Yamaguti (1938); In the Gulf of Bengal from *A. thazard* by Madhavi (1974) and *Euthynnus affinis* by Madhavi & Ram (2000); In Mexico from *Euthynnus lineatus* by Castillo-Sanchez *et al.* (1997) and in South America from *A. thazard* and *K. pelamis* by Fernandes *et al*. (2002). *L. microstomum* was referred by different authors in several hosts: by Manter (1940) from *E. alletteratus* in Galapagos; by Pozdnyakov (1990) from *E. alletteratus* and *E. affinis* from Pacific and by Mogrovejo *et al*. (2004) from *A. thazard* in the

Atlantic Ocean. *N. brasiliensis* was described from nasal cavities from *T. obesus* in Brazil, South America.

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