Parasitological datas of helminthes parasites of *Macrodon atricauda* 
(Günther, 1880)

**Dados parasitológicos de helmintos parasitos de Macrodon atricauda** 
(Günther, 1880)

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**Fabiana Daniela Mendonça**  
Doctoral student at Programa de Ciências Ambientais e Conservação do Instituto de Biodiversidade e Sustentabilidade (NUPEM)  
Institution: Laboratório de Imunoparasitologia, Instituto de Ciências Médicas, Centro Multidisciplinar Universidade Federal do Rio de Janeiro (UFRJ)  
Address: R. Alcides da Conceição, Vale Encantado, Macaé - RJ, CEP: 27933-378  
E-mail: fabidanibio@gmail.com

**Júlia Peralta Gonçalves**  
Doctor of Science  
Institution: Laboratório de Imunoparasitologia, Instituto de Ciências Médicas, Centro Multidisciplinar Universidade Federal do Rio de Janeiro (UFRJ)  
Address: R. Alcides da Conceição, Vale Encantado, Macaé - RJ, CEP: 27933-378  
E-mail: peraltagoncalves@gmail.com

**Aleksandra Menezes de Oliveira**  
Doctor of Science  
Institution: Laboratório de Imunoparasitologia, Instituto de Ciências Médicas, Centro Multidisciplinar Universidade Federal do Rio de Janeiro (UFRJ)  
Address: R. Alcides da Conceição, Vale Encantado, Macaé - RJ, CEP: 27933-378  
E-mail: alekmenezes@gmail.com

**ABSTRACT**  
Ichthyoparasites can affect the health of fish, cause negative economic repercussions and are causes of parasitic zoonoses in the population. The aim of this study was to evaluate the helminth fauna of *Macrodon atricauda*, as well as to evaluate the zoonotic potential of the parasites that were found. The fishes were collected in two periods in 2014 and 2015. The present study demonstrated that the females presented better conditions than the males, and there was no statistically significant difference between the conditions in both sexes. There is a positive relation regarding total parasite prevalence and fish weight and length. The occurrence of helminth parasites of fish can be dangerous to humans because some species represent a zoonotic potential gives evidence to the need for a change in the hygienic and food habits of the population and the need for control and prevention by the public health agencies.

**Keywords:** ichthyoparasites, parasites ecology, helminth, zoonosis.
RESUMO
Os ictioparasitos podem afetar a saúde dos peixes, causar repercussões econômicas negativas e são causadores de zoonoses parasitárias na população. O objetivo deste estudo foi avaliar a helmintofauna de *Macrodon atricauda*, bem como avaliar o potencial zoonótico dos parasitos encontrados. Os peixes foram coletados em dois períodos em 2014 e 2015. O presente estudo demonstrou que as fêmeas apresentaram melhores condições que os machos, não havendo diferença estatisticamente significativa entre as condições em ambos os sexos. Existe uma relação positiva entre a prevalência total do parasito e o peso e comprimento dos peixes. A ocorrência de helmintos parasitos de peixes pode ser perigosa para o homem, pois algumas espécies apresentam potencial zoonótico evidenciando a necessidade de mudança nos hábitos higiênico-alimentares da população e a necessidade de controle e prevenção por parte dos órgãos de saúde pública.

Palavras-chave: ictioparasitos, ecologia de parasitos, helmintos, zoonoses.

1 INTRODUCTION
Fishery resources are an important source of food and income for thousands of people, contributing to 17% of the world's supply of animal protein (FAO, 2016). Fish meat is a quality food resource, easy to digest, source of vitamins, essential amino acids and an excellent source of calcium, phosphorus, iodine, iron, zinc, selenium and other important minerals for human health (Powers, 2003; Sartori and Amancio, 2012; Tilami and Sampels, 2018).

Although, it is nutritious food, fish that is consumed without proper cooking, becomes a sanitary danger for people, since, like other living beings, the fish can be affected by agents that cause illnesses, whether they are of viral, bacterial, fungal or parasitic origin (Aloo 2000; Iwamoto et al. 2010; Clausen et al. 2012). According to the National Technical Center for the Conservation of Fish and Aquaculture Products (CECOPESCA) (2012), parasitism is a phenomenon, common to all marine fish species, with the process of infection and complementation of the life cycle facilitated by the aquatic environment.

In the world, 8 million cases of parasitic infections transmitted by fish consumption were recorded. In 2005, in Southwest Asia alone, there were around 300,000 cases of infections with 1,323 deaths (FAO/WHO 2014). Helminthiases transmitted by fish were limited to low-income populations, or cultures where consumption of raw, salted or smoked fish is common. However, due to globalization, migration, tourism, growth of the food sector, export and import of food and demand for dishes from other cultures, such as sushi and sashimi, ceviche, fish marinade and green herring, new factors
of introduction and infection of helminths of fish parasites in the world population were taken (Chai et al. 2005; Mladineo and Poljak 2014; FAO 2014).

The municipality of Macaé is located on the northern coast of the state of Rio de Janeiro. Artisanal fishing in this municipality represents an important economic activity. According to the report of the Fishing Foundation of the State of Rio de Janeiro (FIPERJ), in 2014, the annual fish production of the municipality was approximately 533,000 kg, used to supply the national and international market, employing directly and indirectly about 15,000 people (Macaé 2011). Among the main fishing resources landed in Macaé are *Coryphaena hippurus* and the fishes of the Sciaenidae family (Macaé 2012, Rocha 2013; FIPERJ 2014). Sciaenidae family represents an important fishing resource worldwide, counting on approximately 283 species (Nelson 1994; Froese and Pauly 2015).

The genus *Macrodon* consisted of only two distinct species: *M. mordax* Gilbert & Starks, 1904, found in the Pacific Ocean, and *M. ancy lodon* Bloch & Schneides, 1801 found in the Atlantic Ocean. Recent research carried out by Carvalho-Filho *et al.* (2010) demonstrated that there are two species of *Macrodon* in the Atlantic Ocean: *M. ancy lodon*, which is distributed between Venezuela and the Brazilian state of Bahia and *M. atricauda*, which occurs between the Brazilian state of Espírito Santo and Northern Argentina (Carvalho-Filho *et al.* 2010; Fischer *et al.* 2011).

*Macrodon atricauda* Günther, 1880 has an elongated and slightly compressed body, with 27 to 29 dorsal rays and a pectoral fin with 16 to 17 rays and two anal spines with a pointed caudal fin. This species reaches about 50 cm in length and 1 kg in weight. It is a demersal species, whose larvae and juveniles can be found in estuarine waters. The carnivorous habit is evident by its morphological characteristics, with a terminal mouth and canine teeth in the form of an arrow, feeding on fish, crustaceans and mollusks (Carvalho-Filho *et al.* 2010; Fischer *et al.* 2011; Muto *et al.* 2014).

*Macrodon atricauda* is an important fishing resource in the southern and southeastern Brazilian regions, and is captured with bottom trawls, pair trawls, and gillnet (Fischer *et al.* 2011; Cardoso and Haimovici, 2014; Imoto *et al.* 2016). Thus, the aim of the present study was to identify the helminth parasites with zoonotic potential found in the visceral organs of the *Macrodon atricauda*, collected during the Macaé fish landing, and to correlate data on prevalence, mean intensity and average
parasite abundance in *Macrodon atricauda* with biometric parameters such as fish length and weight in order to analyze parasite-host relationships.

**2 MATERIALS AND METHODS**

The fishes were collected at the fish landing of Macaé Fish, placed in individual bags, packed in a thermal box with ice and taken to the laboratory. The samples were identified according to Menezes and Figueiredo (1980), Palko *et al.* (1982), Spilman (2000) and Fischer *et al.* (2011). Fish was measured by using a ruler, and standard length, total length and weighed were determined with a precision scale. The gonads were used for sexual identification according to Vazzoler (1996).

The length-weight relationship was calculated for each sex and condition, by the expression: $W: aL^b$, in its form $\log W = \log a + \log L$, where: $W =$ total fish weight (g); $L =$ total fish length (cm); $a =$ regression constant and $b =$ regression coefficient (Cren 1951; Juras 1980; Costa and Araújo 2003). The Student's t-test for parameters "a" and "b" was applied to both parasitized and non-parasitized males and parasitized and non-parasitized females separately.

The hosts were necropsied, and the organs individually separated in Petri dishes, with 0.9% sodium chloride solution. The organs were inspected by using the stereomicroscope (Olympus SZ51), and the helminths collected were washed in 0.9% NaCl solution, separated according to the inspected organ and the phylum, and packed in flasks containing AFA (Glacial Acetic Acid, Formol 37% and Ethyl Alcohol 70%). Parasitological indices, such as prevalence, mean intensity and mean abundance were calculated according to Margolis *et al.* (1982) and Bush *et al.* (1997), calculated as:

Prevalence = number of fish infected by a given species divided by the number of hosts examined x100;

Mean intensity = total number of parasites of a species divided by the number of hosts infected by this species.

Average Abundance = total number of parasites of a species divided by the total number of hosts examined.

The statistical analysis program "GraphPad Prism 5" was used to determine the Pearson correlation coefficient ($r$) between prevalence and weight and the same was done in relation to host length.
3 RESULTS

Fish harvesting occurred from 3 months and during this period, 139 specimens of fish were collected. Of this total, there were 109 specimens of *Macrodon atricauda*: 66 females and 43 males. The collected specimens were weighed and measured; the weight of the females ranged from 98 - 579.25 g, with a mean value of 355.09 ± 116.50 g, and males, 112.89 - 440.38 g, with a mean value of 278.67 ± 98.45 g. Regarding the length, the values of the females varied from 19 - 39 cm and of the males 23.50 - 37 cm, having average values of 33.77 ± 4.32 cm and 31.27 ± 4.1 cm, respectively (Table I).

Of the 109 adult specimens of *M. atricauda*, 29 were infected with 81 parasites of the Phylum Nematoda and 2 of the Phylum Platyhelminthes. Table II shows the number of fish that is analyzed, the number of infected fish and the total parasite prevalence. Table III shows the quantification and distribution of the parasites in relation to the analyzed habitats of the hosts, showing that the most parasitized sites were kidneys, intestine, mesentery and abdominal cavity.

*M. atricauda* presents the parasite prevalence value of 26.60%. The fish weight and length values were divided into intervals. Among the examined fish, we found a higher percentage of fish in the intervals of 200 - 300 g and 300 - 400 g. When analyzing only the parasitized fish, we observed that the highest percentages were in the same intervals, however there is a higher percentage of parasitized fish in the range of 300 - 400 g (Figure 1). Regarding the length, the defined ranges were: 15-20, 20-25, 25-30, 30-35 and 35-40 cm. We found a higher percentage of fish in the intervals of 25 - 30 cm and 30 - 35 cm, while the parasitized fish are more in the intervals of 30 - 35 cm and 35 - 40 cm (Figure 2).

For the fish length-weight relationship, the following equations were calculated:

For males examined: \( y = 0.0484x^{2.5041}, \) with \( r^2=0.5496, \) for parasitized males; \( y = 0.0557x^{2.4531}, \) with \( r^2=0.5509, \) for non-parasitized males; there was no statistically significant difference between the "a" and "b" parameters between parasitized and non-parasitized males (Figure 3). For females, the following equations were calculated: \( y = 0.0345x^{2.6003}, \) with \( r^2=0.8267, \) for females examined; \( y = 0.0839x^{2.3626}, \) with \( r^2=0.7937, \) for parasitized females; \( y = 0.0377x^{2.5685}, \) with \( r^2=0.8099, \) for non-parasitized females; there was no statistically significant difference between the parameters "a" and "b" between parasitized and non-parasitized females (Figure 4).
The analysis carried out between the parasite prevalence and the *M. atricauda* weight and these analyzes allow us to evaluate if there is a correlation between the weight variation of the host and the increase in the number of parasitized hosts. Through correlation analysis, we can observe as the fish weight increases, the higher the parasite prevalence is (Figure 5A), in addition, it was noticed that there was a significant positive linear correlation ($r = 0.96$ and $p \leq 0.05$) between weight and parasite prevalence in *M. atricauda*.

By analyzing data on parasite prevalence and total length, it is observed that the parasite prevalence increases according to the size of the specimens. We observed a positive correlation between host length and total parasite prevalence ($r = 0.94$ and $p \leq 0.05$), showing that the longer the host length is, the higher the parasite prevalence (Figure 5B).

When analyzing the parasitic quantitative descriptors, such as prevalence, mean abundance and mean intensity of nematodes in each analyzed organ, we can observe that, in all analyzed parameters, the values are highest for the abdominal cavity, showing that this is the place where there is the greatest recovery of nematodes in *M. atricauda* (Table IV).

**4 DISCUSSION**

The commercialization of fish, especially without inspection, may increase the risk of transmission of zoonoses, since fish serves as a reservoir of parasites. According to Hoffman (1970), several fish species have settled in other continents through the transport of live and frozen fish, becoming a potential source of parasitic infection for other hosts, among them humans, causing great concern for world trade (Slifko *et al.* 2000; FAO/WHO 2014).

In our study, we observed that the highest percentage of parasitized fish was in the range of 300 - 400 g of total weight and 30 - 35 cm of total length. Fontenelle *et al.* (2013) analyzed nematodes of 30 specimens of the sciaenidae *Cynoscion guatucupa*, marketed in Rio de Janeiro, Rio de Janeiro State, observed that 83% (25 specimens) were parasitized by at least one species of nematode larvae, whereas in the present study, only 26.60 % (29 specimens) of *Macrodon atricauda* were infected by helminths of the phylum Nematoda.
Fujimoto et al. (2012) studied the helminth fauna of *Macrodon ancyldon* collected in the state of Pará - Brazil, it was found a total of 19 male fish (mean length: 21.6 ± 4.0 cm, total length: 26.6 ± 4.1 cm, average weight: 176.8 ± 95.2 g), 42 females (mean length: 22.2 ± 3.7 cm, total length: 27.5 ± 4.1 cm, mean weight: 202.8 ± 125.9 g), and 36 juveniles (mean length: 18.5 ± 3.9 cm, total length: 23.1 ± 3.8 cm, mean weight: 117.5 ± 74.5 g). Of the 97 collected specimens, 85 were infected (87.6%), and 63 presented intestinal nematodes and 20 infected simultaneously by nematodes and trematodes.

Through the calculation of the length-weight relationship one has the notion of the fish growth. The value of exponent "b" resulting from the length-weight equation may indicate the degree of well-being of the fish.

In the present study, the values of "b" were calculated for parasitized males and females and not parasitized separately, showing that the females presented better condition than the males, and there was no statistically significant difference between the conditions in both sexes. In *M. ancyldon* collected in Amazonia (Brazil), the total length and total weight relationship was calculated for males and females, showing that for both genders the growth was allometric. The minimum and maximum lengths were 4.9 cm to 38.5 cm, the average length was 16 cm. In *M. ancyldon* collected in Rio Grande do Sul (Brazil), there was no difference between the sexes in relation to weight and length (Juras 1980), as was observed by Yamaguti and Santos (1965) in *M. ancyldon* collected on the coast of South of Brazil.

*Macrodon ancyldon* collected in the North Coast of Brazil for biological evaluations, presented length ranging between 13.5 and 43.7 cm and weight between 20.9 and 744.6 g for all specimens. For the length-weight relationship of these fishes, the following equations were calculated: \( y=0.0032x^{3.3109} \), with \( r^2=0.97 \), for separated sexes; \( y=0.0027x^{3.3652} \), with \( r^2=0.97 \), for females; \( y=0.0034x^{3.2979} \), with \( r^2=0.97 \) for males; there was a statistically significant difference between the "a" and "b" parameters between the sexes (Ikeda 2003). In this same study, Ikeda (2003) showed that there was no predominance of males over females, except in lengths less than 25 cm where males predominated and over 37 cm, with a significant predominance of females.

The parasitism of *M. ancyldon* is basically related to carnivorous diet, since the infection with larval phases of many nematodes and flatworms of fish parasites depend on the predation of their hosts. Three groups have already been found in the *M. ancyldon*
diet: shrimp, fish and molluscs (Figueiredo 2014). Castro et al. (2015) showed that, in *M. ancyldon* collected by fishing vessels in the state of Pará - Brazil, the items that presented the highest frequency of occurrence and food importance index were the shrimp fragments, fish fragments, Penaeidae and Polychaetas, showing a basically carnivorous diet. Magro et al. (2000) have already demonstrated that the diet of *M. ancyldon* depends on its degree of growth, varying throughout its life, with a decrease in the preference for crustaceans and an increase in fish consumption, the latter being directly proportional to the growth of the specimen. The latter fact may explain the data found in this study that the highest percentage of parasitized fishes are found in the biggest weight and length ranges which are analyzed. In addition, we observed a positive correlation between helminth prevalence and fish weight and length. Oliveira et al. (2009), analyzed the parasite prevalence of *Macrodon ancyldon*, and observed that this parameter is higher in fish of larger size. Similar results were demonstrated by São Clemente et al. (1995) in *Balistes vetula*, by Luque and Chaves (1999) in *Pomatomus saltator*, and by Alves and Luque (2001) in *Micropogonias furnieri*.

According to Alves and Luque (2001) length may be a factor that may influence the biological process of the fish, and the length reflects the age of the fish, since with the food changes that occur with the biological changes of the fish, which may influence the variation of parasitic infrapopulation, a factor that may be related to the correlation between total prevalence and host length. Fontenelle et al. (2013) observed that the nematode larvae infection sites were: serosa of the liver, mesentery and abdominal cavity, and the main site of infection was the abdominal cavity like that observed in the present study. Fujimoto et al. (2012) who analyzed parasitic nematodes of *M. ancyldon* collected in the State of Pará - Brazil, observed that the stomach and upper intestine were the most infected parts of the digestive tract and that in females the mean parasitic intensity and abundance were higher than in males (Fujimoto et al. 2012). The data differ between the present study and that of Fujimoto et al. (2012), showing that perhaps the fish habitat and diet are diverse at different collection sites, altering the parasitic population which was found.

In conclusion, we observed that *M. ancyldon* collected on the coast of the State of Rio de Janeiro are parasitized by helminths of Phylum Nematoda and Platyhelminthes, showing a total parasite prevalence of 26.60%. The fact that it is parasitized does not alter
the growth of these fishes, and the parasitic prevalence is greater, the greater the length and weight of the fish, which has the abdominal cavity as the main infection site.

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Table 1: Mean and standard deviation of total length and total weight and maximum and minimum values of these patterns of females and males of Macrodon atricauda collected at the city of Macaé.

<table>
<thead>
<tr>
<th></th>
<th>FEMALE</th>
<th>MALE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight (g)</td>
<td>355.09 ± 116.50 (98-579.25)</td>
<td>278.67 ± 98.45 (112,89-440,38)</td>
</tr>
<tr>
<td>Total Length (cm)</td>
<td>33.77 ± 4.32 (19-39)</td>
<td>31.27 ± 4.1 (23,50-37)</td>
</tr>
</tbody>
</table>

Source: The Authors

Table 2: Number of fish infected and examined and total prevalence of helminths in *Macrodon atricauda*.

<table>
<thead>
<tr>
<th>Fish examined</th>
<th>Fish infected</th>
<th>Prevalence (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>109</td>
<td>29</td>
<td>26.60</td>
</tr>
</tbody>
</table>

Source: The Authors

Table 3: Number of helminths founded and the site of infection by helminths.

<table>
<thead>
<tr>
<th>Site of Infection by Helminths</th>
<th>Stomach</th>
<th>Intestine</th>
<th>Gonads</th>
<th>Abdominal cavity</th>
<th>Pancreas</th>
<th>Liver</th>
<th>Mesentery</th>
<th>Kidneys</th>
<th>Swimming bladder</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of helminths found</td>
<td>1</td>
<td>5</td>
<td>6</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>5</td>
<td>6</td>
<td>1</td>
</tr>
</tbody>
</table>

Source: The Authors

Table 4: Prevalence (%), Mean abundance and mean intensity of infection by nematodes in several sites of infection of males and females Macrodon atricauda.

#### Males

<table>
<thead>
<tr>
<th>Site of Infection by Nematodes</th>
<th>Stomach</th>
<th>Intestine</th>
<th>Gonads</th>
<th>Abdominal cavity</th>
<th>Pancreas</th>
<th>Liver</th>
<th>Mesentery</th>
<th>Kidneys</th>
<th>Swimming bladder</th>
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<tbody>
<tr>
<td>Prevalence (%)</td>
<td>0</td>
<td>1,85</td>
<td>0,93</td>
<td>3,70</td>
<td>0</td>
<td>0,93</td>
<td>0,93</td>
<td>1,85</td>
<td>0,93</td>
</tr>
<tr>
<td>Mean intensity</td>
<td>0</td>
<td>0,18</td>
<td>0,09</td>
<td>1,82</td>
<td>0</td>
<td>0,09</td>
<td>0,09</td>
<td>0,55</td>
<td>0,27</td>
</tr>
<tr>
<td>Mean abundance</td>
<td>0</td>
<td>0,01</td>
<td>0,01</td>
<td>0,19</td>
<td>0</td>
<td>0,01</td>
<td>0,01</td>
<td>0,06</td>
<td>0,03</td>
</tr>
</tbody>
</table>

#### Females

<table>
<thead>
<tr>
<th>Site of Infection by Nematodes</th>
<th>Stomach</th>
<th>Intestine</th>
<th>Gonads</th>
<th>Abdominal cavity</th>
<th>Pancreas</th>
<th>Liver</th>
<th>Mesentery</th>
<th>Kidneys</th>
<th>Swimming bladder</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prevalence (%)</td>
<td>0,93</td>
<td>1,85</td>
<td>1,85</td>
<td>13,89</td>
<td>0</td>
<td>0</td>
<td>1,85</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Mean intensity</td>
<td>0,06</td>
<td>0,11</td>
<td>0,11</td>
<td>0,83</td>
<td>0</td>
<td>0</td>
<td>0,11</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Mean abundance</td>
<td>0,01</td>
<td>0,02</td>
<td>0,05</td>
<td>0,32</td>
<td>0</td>
<td>0</td>
<td>0,04</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Source: The Authors
LIST OF FIGURES

Figure 1: Distribution of percentage of parasitized and non-parasitized fish in different weight ranges.

Source: The Authors

Figure 2: Distribution of percentage of parasitized and non-parasitized fish in different length ranges.

Source: The Authors
Figure 3: Weight x total length relationship of total males, parasitized and non-parasitized males of *Macrodon atricauda*.

Source: The Authors

Figure 4: Weight x total length relationship of total females, parasitized and non-parasitized females of *Macrodon atricauda*.

Source: The Authors
Figure 5: Percentage of parasite prevalence in relation to the weight of *Macrodon atricauda*, showing the correlation (Pearson r) between total parasite prevalence and fish weight. Values of the prevalence of each interval were plotted in relation to their respective interval (P <0.05, Pearson - r correlation coefficient values).

Source: The Authors