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ORIGINAL ARTICLE / ARTÍCULO ORIGINAL

PARASITES OF THE WHITE MULLET, *MUGIL CUREMA* VALENCIENNES, 1836 (MUGILIFORMES: MUGILIDAE), FROM SANTA CATARINA STATE, SOUTHERN BRAZIL

PARÁSITOS DE LA LISA BLANCA, *MUGIL CUREMA* VALENCIENNES, 1836 (MUGILIFORMES: MUGILIDAE), DEL ESTADO DE SANTA CATARINA, SUR DE BRASIL

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ABSTRACT

This study investigates the parasitic fauna of *Mugil curema* Valenciennes, 1836 (Mugilidae) from Laguna, southern Santa Catarina, Brazil, being the first parasitological survey of this species in the region. A total of 52 specimens were examined for ecto- and endoparasites. The external examination revealed Ergasilidae specimens and copepod eggs on the gills, while the monogenean *Metamicrocotyla macracantha* (Alexander, 1954) was identified. Internal prospection showed the presence of the acanthocephalan *Neoechinorhynchus curemai* Noronha, 1973 and one unidentified digenean from the family Haploporidae. Histopathological analysis revealed hepatic lesions and mild inflammation in intestinal tissue. These findings underscore the importance of parasites in *M. curema*, contributing to the ecological understanding of parasitism in marine fish and its potential implications for human health and environmental monitoring.

Keywords: Environmental indicators – Fish health – Histopathology – Parasitology – Southern Brazil

RESUMEN

Este estudio investiga la fauna parasitaria de *Mugil curema* Valenciennes, 1836 (Mugilidae) de Laguna, en el sur de Santa Catarina, Brasil, siendo el primer relevamiento parasitológico de esta especie en la región. Se examinaron un total de 52 ejemplares en busca de ecto e endoparásitos. El examen externo reveló la presencia de ejemplares de Ergasilidae y huevos de copépodos en las branquias, mientras que se identificó el monogeneo *Metamicrocotyla macracantha* (Alexander, 1954). La prospección interna mostró la presencia de acanthocephala *Neoechinorhynchus curemai* Noronha, 1973 y de un digeneo no identificado de la familia Haploporidae. El análisis histopatológico reveló lesiones hepáticas e inflamación leve en el tejido intestinal. Estos hallazgos resaltan la importancia de los parásitos en *M. curema*, contribuyendo a la comprensión ecológica del parasitismo en peces marinos y sus posibles implicancias para la salud humana y el monitoreo ambiental.

Palabras clave: Indicadores ambientales – Salud de los peces – Histopatología – Parasitología – Sur de Brasil

INTRODUCTION

The family Mugilidae Jarocki, 1822 consists of 20 genera and 78 valid species (Froese & Pauly, 2024), with a wide geographic distribution, occurring in tropical and subtropical regions worldwide, particularly along coastal areas and estuaries (Falkenberg *et al.,* 2021). In Brazil, the only genus of this family recorded is *Mugil* L., 1758, which includes six species: *Mugil brevirostris* Miranda-Ribeiro, 1915; *Mugil curema* Valenciennes, 1836; *Mugil curvidens* Valenciennes, 1836; *Mugil incilis* Hancock, 1830; *Mugil liza* Valenciennes, 1836; and *Mugil rubrioculus* Harrison, Nirchio, Oliveira, Ron & Gaviria, 2007 (Fischer *et al.*, 2011; Nascimento *et al.,* 2022).

According to the FAO (2022), mugilids are among the most produced fish in global coastal and marine aquaculture, ranking just behind two species: Atlantic salmon, *Salmo salar* L., 1758 (Salmoniformes: Salmonidae) and milkfish, *Chanos chanos* Forsskål, 1775 (Gonorynchiformes:

Chanidae). The production of farmed mugilids reached 291.2 thousand tons in 2020, marking a 125% increase over the previous five years (FAO, 2022). Brazil is recognized as one of the largest producers of mullet worldwide (FAO, 2015; Santos *et al*., 2021).

Among the species found in the country, *M. curema* stands out due to its high demand, reflected not only in fishing statistics but also in its significance as a farmed species. This species displays pelagic behavior and is found in a variety of habitats, including sandy shores, coastal pools, brackish lagoons, estuaries, and muddy bottoms (Moutinho & Alves, 2014). In its natural environment, *M. curema* has a diverse diet, feeding on algae, particularly diatoms, and zooplankton.

Fish parasites represent an important component of aquatic biodiversity, as fish are directly affected by their environment or indirectly through their hosts (Mehana *et al.,* 2020). These parasites are notably diverse and abundant compared to other vertebrate classes, likely due to evolutionary processes that have fostered a close association with a wide range of invertebrates over time (Dezfuli & Scholz, 2022). Understanding the biological dynamics of marine populations and species is closely linked to the study of evolutionary processes that govern the history of biodiversity (Broglia & Kapel, 2011).

The family Mugilidae, with its broad distribution and diverse species, plays a significant role in both natural ecosystems and global aquaculture. Additionally, the study of fish parasites provides valuable insights into aquatic biodiversity, as evidenced by various studies on *Mugil* species, which have revealed a wide range of parasites. This diversity was summarized by Falkenberg *et al*. (2022), who highlighted that the most extensively studied regions in Brazil are the Northeast and Southeast. In this context, the present study aims to assess the occurrence of parasites in *M. curema*, representing the first parasitological investigation of this species in Laguna, a municipality in southern Santa Catarina, where fishing and fish consumption hold great economic and historical importance.

MATERIAL AND METHODS

Host specimens' collection

The study was conducted in the municipality of Laguna (28° 28' 57" S, 48° 46' 53" W), located in the southern state of Santa Catarina (Figure 1). With a population of just over 50,000 inhabitants, the region's main economic activities are fishing, commerce, and tourism. A total of 52 *M. curema* specimens were studied, all commercially sold at the Tesoura Beach, a small stretch of beach approximately 150 meters long, situated within the Barra Beach Mole.

These specimens, which had an average length of 40±55 cm and an average weight of 150±380 grams, were purchased from local fishermen between November 2019 and March 2020. After being kept refrigerated, the specimens were transported to the Zoology Laboratory at the State University of Santa Catarina (UDESC), located in Laguna Municipality.

Parasitological analyses

External and internal examinations were conducted at the Microbiology and Parasitology Laboratory at the Department of Fisheries Engineering and Biological Sciences, University of the State of Santa Catarina (UDESC). The inspection began with the oral, nasal, and opercular cavities. Skin mucus samples were then scraped using a microscope slide, and the contents were analyzed under a Nikon Eclipse optical microscope. While, the gills were removed through a lateral incision of the opercula and examined fresh under an Olympus SZ61 stereomicroscope.

In addition, a ventral incision was made from the operculum to near the anus to expose the abdominal cavity, muscle tissue fragments were placed in Petri dishes and examined under the same stereomicroscope for the detection of zoonotic nematodes. The intestinal content was also transferred to Petri dishes and inspected for acanthocephalans, nematodes, cestodes and trematodes.

Preparation and identification of the helminthofauna

Acanthocephalans and nematodes were fixed in AFA solution (70% ethanol, 5% formalin, and 2% glacial acetic acid), then preserved in 70% ethanol for later identification. Trematodes were stained following the protocol by Amato *et al.* (1991), and their identification was based on internal parasite structures, observed using a Nikon Eclipse optical microscope coupled with a Canon EOS R8 camera. For species-level identification of the Monogenea specimen, we followed the studies of Hendrix (1994) and Kohn *et al.* (1994). The identification of Acanthocephala was based on the work of Martins *et al.* (2000), while the classification of the Trematoda family followed the studies of Thatcher (1978) and Andres *et al.* (2018). All parasites are deposited in the didactic collection of the Laboratory of Zoology and Parasitology at the Universidade do Planalto Catarinense (UNIPLAC), in Lages, Santa Catarina, Brazil.

Histopathological analyses

Following standard histopathological procedures, liver and intestinal samples were collected and preserved in formalin (10%), prepared with destilated water, for these analyses. These organs were subjected to dehydration in a graded ethanol series, clarified in xylene, and embedded in paraffin at 60°C. Tissue sections were stained with Harris hematoxylin and eosin (HHE) for subsequent examination under a Nikon Eclipse optical microscope. All histopathological analysis was conducted at the Pathology Laboratory of the Department of Veterinary Medicine at the University of the State of Santa Catarina (UDESC), Lages, Santa Catarina, Brazil.

Ethis acpects: The fish were obtained directly from the fishermen at their beach sales. Ethics approval Not applicable.

RESULTS

Parasites' identification

After completing all the processes described above, a total of 18 *M. curema* specimens were found to be parasitized. Among these, copepod eggs were observed in the gills of nine individuals, along with two unidentified adult specimens of Ergasilidae (Copepoda: Cyclopoida). In another *M. curema* specimen, a digenetic trematode of the family Haploporidae Nicoll, 1914 (Platyhelminthes: Trematoda) was found, a family commonly associated with fish of the genus *Mugil*. Additionally, in the gills of one *M. curema* specimen, *Metamicrocotyla macracantha* (Alexander, 1954) (Monogenea: Mazocraeidea: Microcotylidae) was identified (Figure 2). Furthermore, three specimens of *Neoechinorhynchus curemai* Noronha, 1973 (Acanthocephala: Neoechinorhynchidae) were recovered from the intestines examined.

The species *M. macracantha* is characterized by an elongated, lanceolate body, measuring 15.2 mm in length and 4 mm in width, dorsoventrally flattened and tapering anteriorly. The apical glands have ducts extending up to the level of the pharynx. The buccal opening is median, subterminal, and ventral, located between the anterior extremity and the pharynx. It has two latero-median suckers (0.7 mm in length × 0.6 mm in width), situated between the buccal opening and the pharynx. The intestinal ceca are long. The haptor measures 1.8 mm in length and 1.3 mm in width, featuring 21 pairs of clamps arranged in two longitudinal rows along the body. The clamps are composed of dark structures (sclerites). The genital opening is median and ventral, located at the level of the cecal bifurcation, and armed with atrial spines (0.6 mm in length × 0.1 mm in width), organized into two bilateral groups arranged in two parallel rows (six anterior and eleven posterior). The testes are elongated and numerous (3.3 mm in length × 1.7 mm in width). The vitelline gland extends from the cecal bifurcation to the anterior end of the haptor. Eggs were not observed. While, the species *N. curemai*, which is host-specific, is characterized by a cylindrical trunk that is wider in the anterior third, a short proboscis armed with two large hooks and three circles of smaller hooks, and elliptical eggs, consistent with the specimens examined in this study.

Although the study involved the identification of several parasites, high-quality images are available only for *M. macracantha*. Images of the other listed parasites were not obtained due to limitations in the collection process or viewing conditions. However, morphological descriptions and bibliographic references were rigorously followed, ensuring the accuracy of the identification.

Histopathological analyses

The liver samples with light-colored spots and ulcerative lesions were analyzed and histopathologically revealed the presence of larval migration (Figure 3A) and areas of moderate to severe, diffuse hepatocellular degeneration. In the intestinal samples, the presence of parasites was observed in the submucosa, surrounded by a mild inflammatory reaction, with a predominance of macrophages (Figure 3B). Unfortunately, it was not possible to identify the causative agent of the lesions described above, requiring further studies.

DISCUSSION

Fish parasites, especially those in marine environments, can cause significant economic losses and pose public health concerns. Despite this, specific studies on parasite diversity, particularly nematodes in marine fish from the Americas, are scarce, with most research focusing on isolated cases of particular species (Pereira & González-Solís, 2022). In the present study, the absence of ectoparasites on the body surface may be attributed to the capture method, as the friction between the fish and the net could dislodge these parasites. This hypothesis is supported by the finding of parasites in the gills, an area protected from such mechanical effects.

While gill parasites typically exhibit low diversity and density, their interactions are often reported as isolated incidents. However, the coexistence of monogeneans on gills is well documented, with some studies, such as this one, reporting the presence of copepods alongside monogeneans (Baker *et al*., 2005). For *M. curema*, the only record of coinfection by Monogenea and ergasilids on the gills of this species in Brazil comes from Falkenberg *et al*. (2021), who found evidence suggesting interactions between these parasites in this species in northeastern Brazil. In the present study, we identified ergasilid copepods and the monogenean species *M. macracantha* on the gills of *M. curema*.

Ergasilid copepods, which predominantly inhabit the gills, can cause inflammatory reactions, increased mucus production, changes in gill filament anatomy, and cellular infiltration. In some cases, these changes can lead to hyperplasia, potentially affecting host growth, fertility, and survival (Cavalcanti *et al*., 2005; Mentz *et al*., 2016). Herein, only two complete copepod specimens were identified, with the remaining samples being eggs, making it difficult to observe any significant gill alterations. Similar findings were reported in *M. curema* specimens from the northern region of Santa Catarina, where ergasilid specimens were also found on the gills of *M. curema* specimens (Gueretz *et al*., 2022).

Regarding to the monogenean species collected, we were able to identified up to species level as *M. macracantha*, a monogenean from the family Metamicrocotylidae, which has been sparsely documented in Brazil, particularly in *M. liza* (Kohn *et al*., 1994; Cohen *et al*., 2004). Known to parasitize the gills of marine fish, particularly those of the genus *Mugil*, this parasite can cause gill lamella hyperplasia in cases of massive infection, thereby interfering with ion absorption and gas exchange (Mentz *et al.,* 2016). While this parasite has been previously reported in other *Mugil* species in various regions (Vidal-Martínez *et al*., 2017), this study presents the first record of *M. macracantha* in *M. curema* from southern Brazil.

Additionally, the present study identified *N. curemai* acanthocephalans in the intestines of three specimens. This species has also been reported in *M. curema* from the northern region of Santa Catarina, with a prevalence of 3.39%, further supporting the findings of this study (Gueretz *et al*., 2022). *Mugil* species are catadromous, their migratory behavior could explain the distribution of *N. curemai* across coastal and estuarine environments (Cavalcanti *et al*., 2012; Gueretz *et al*., 2022). Acanthocephalans are significant in ecological studies because they can accumulate contaminants, making them valuable indicators of environmental quality (Sures, 2008; Roohi *et al*., 2015). Fish, being highly susceptible to pollutants through diet or living in degraded ecosystems, often harbor high concentrations of metals in the tissues of acanthocephalans, suggesting the environmental conditions to which they are exposed (Abdallah *et al*., 2019). The relationship between fish, parasites, and contaminants provides an effective means of assessing ecosystem health. As biological indicators, fish parasites can reflect the ecology of their hosts, including migration patterns, feeding habits, and population structures (Mehana *et al.*, 2020).

Digeneans from the family Haploporidae, which primarily parasitize herbivorous or omnivorous fish, are common in marine ecosystems. In Brazil, these parasites have been recorded in several *Mugil* species (Eiras *et al*., 2016; Andres *et al*., 2018). The present study adds to the knowledge of these trematodes, though taxonomic identification remains incomplete due to limited specimen availability and morphological challenges. Similarly, the histological analysis of hepatic tissue revealed larvae resembling *Ascocotyle longa* metacercariae, a zoonotic parasite. While precise identification could not be made, previous studies in *M. curema* have also reported the presence of *A. longa* larvae in muscle tissue (Namba *et al.*, 2012; Gueretz *et al*., 2022). Digenean trematodes may not be immediately concerning due to their typically asymptomatic nature, due the fact that their potential pathogenic effects are still debated and dependent on various factors as parasite type, host condition, and the presence of intermediate hosts (Aly *et al.,* 2020). However, these findings contribute to the growing understanding of digenean trematodes and their potential implications for fish health, highlighting the need for further research to clarify the pathogenicity and ecological roles of these parasites.

In conclusion, this study contributes important insights into the diversity of parasitic fauna in *M. curema* and highlights the ecological interactions between fish and their parasites. The findings not only expand the knowledge of parasitic species in Brazilian marine ecosystems but also emphasize the role of parasites as indicators of environmental health. Continued research is crucial to further understand these interactions and their implications for both fish health and human safety, particularly in relation to zoonotic parasites in fish consumed by humans.

Author contributions: CRediT (Contributor Roles Taxonomy)

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Supervision: RMQ
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Visualization: RMQ, RBS
Writing – original draft: RMQ, ABFR, JACJ, PVC, RAC, RBS
Writing - review & editing: RMQ, RBS

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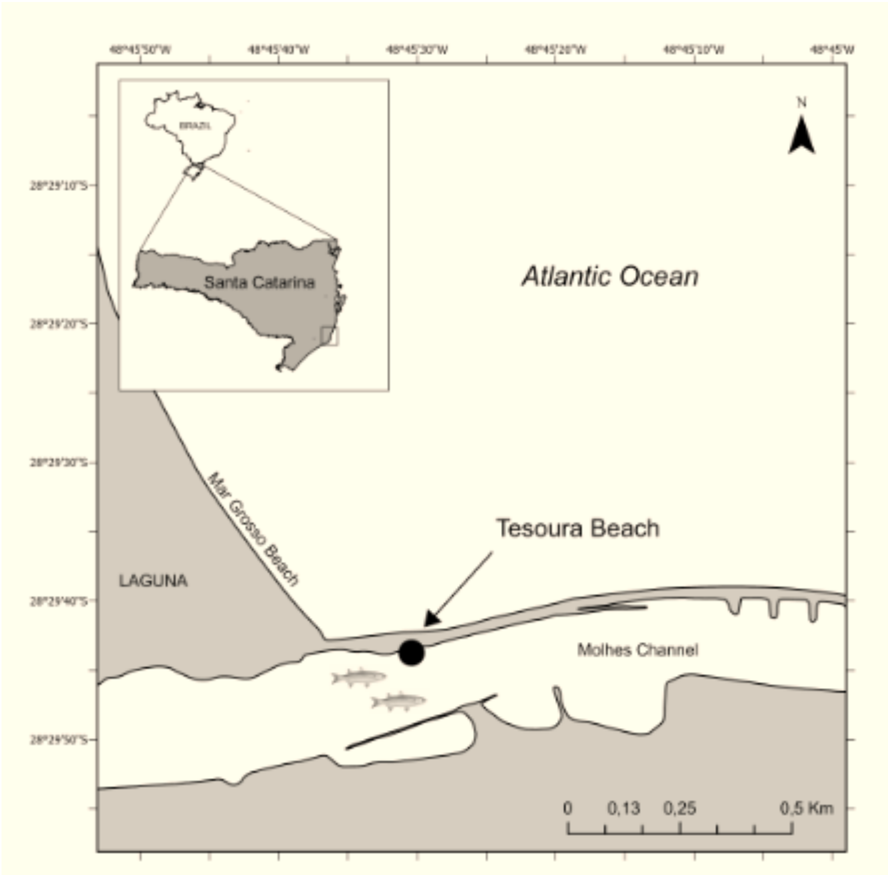

Figure 1. Location of Tesoura Beach, Laguna Municipality, Santa Catarina State, Brazil.

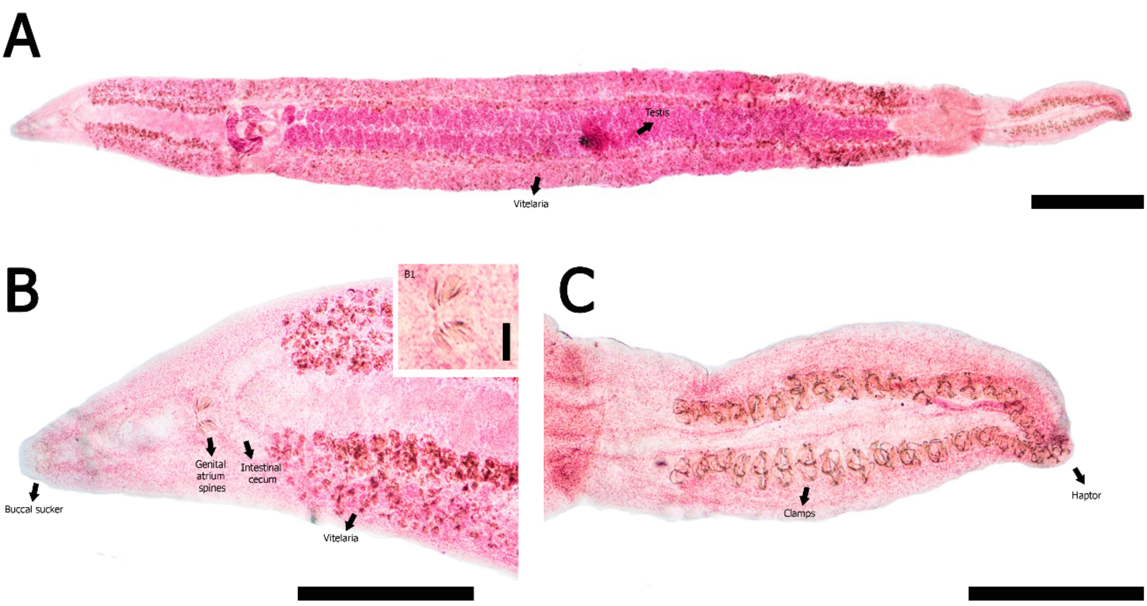

Figure 2. Microscope image of the *Metamicrocotyla macracantha* (Alexander, 1954) (Monogenea: Mazocraeidea: Microcotylidae) collected from the gills of the white mullet, *M. curema*. A – General view of the endoparasite; B – Close up of the anterior region; B_1 – Close up of the genital atrium; C – Close up of the posterior region. Scale bar: A 1.5 mm, B, B_1 and C 0.5 mm.

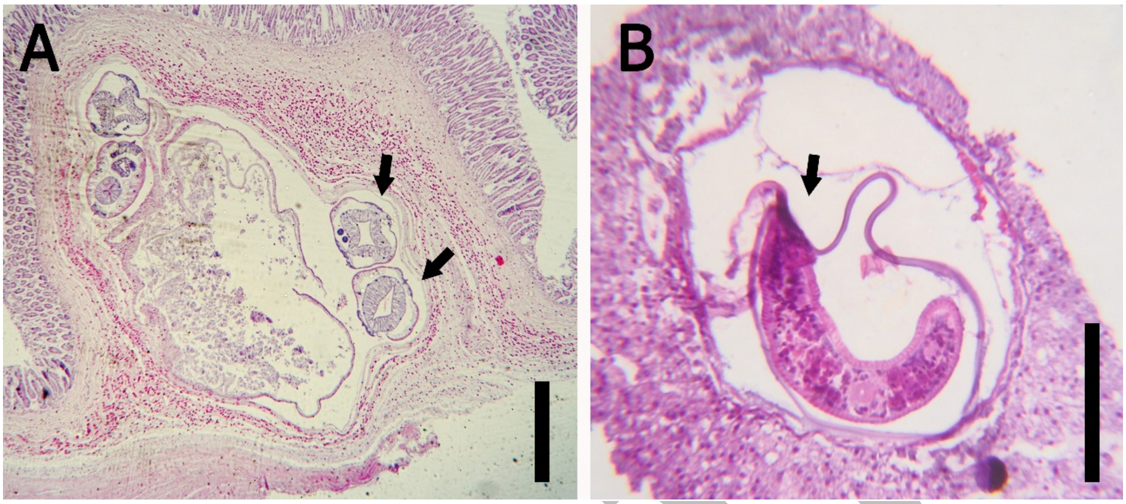

Figure 3. Histopathological images of the *M. curema*'s liver and intestine. **A -** Cross section of the intestinal muscle. **B -** Cross section of the liver parenchyma. Black arrows show the endoparasite. All images in HE stains. Scale bar: 200 µm.