http://dx.doi.org/10.1590/1678-4162-12669

Arq. Bras. Med. Vet. Zootec., v.75, n.1, p.117-121, 2023

Occurrence of intersexuality in *Mugil curema* from an estuary of the North coast of Santa Catarina, Brazil – case report

[*Ocorrência de intersexualidade em* Mugil curema *em estuário do litoral norte catarinense, Brasil – relato de caso*]

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ABSTRACT

This study describes the occurrence of reproductive changes in a mullet (*Mugil curema*) from the Babibtonga Bay, Santa Catarina. Gross and microscopic findings indicated changes in the reproductive system that were characterized by the presence of both male and female gonads, nearing sexual maturity, which was compatible with the diagnosis of intersex. It was not possible to identify predisposing factors that may have contributed to the development of this condition. However, as this species of fish may have their reproductive development affected by anthropogenic influence, it is important to permanently monitor this kind of environment. Considering the number of fish belonging to this species that was examined (n=433), the estimated prevalence for intersexuality was 0.23% (confidence interval: 0.00 to 0.68%, with confidence level of 95%). The findings in this study support the diagnosis of intersexuality in *M. curema* from the Babitonga Bay, which is the first documented case of this condition in this species on the coast of Santa Catarina, Brazil.

Keywords: Babitonga Bay, ichthyopathology, mugilids, parati, aquaculture breeding

RESUMO

Este estudo descreve a ocorrência de alteração reprodutiva em peixe da espécie Mugil curema, *procedente da Baía da Babitonga, Santa Catarina. Macro e microscopicamente, foi identificada alteração no sistema reprodutivo, caracterizada pela presença de gônadas masculina e feminina, próximas da maturidade sexual, caracterizando um caso de intersexo. Não foi possível determinar os fatores que possam ter contribuído para o desenvolvimento dessa alteração reprodutiva, porém, como a espécie animal pode ter suas características de vida e reprodutiva influenciadas pela ação antrópica, é importante um estudo contínuo desses peixes nesse ambiente. Considerando o número de peixes dessa espécie que foram examinados (n=433), a prevalência estimada de intersexualidade foi de 0,23% (intervalo de confiança: 0,00 a 0,68%, com nível de confiança de 95%). Os achados deste estudo suportam o diagnóstico de intersexualidade em M. curema proveniente da Baía da Babitonga, sendo o primeiro caso documentado dessa condição nessa espécie na costa de Santa Catarina, Brasil.*

Palavras-chave: Baía da Babitonga, ictiopatologia, mugilídeos, parati, reprodução aquícola

INTRODUCTION

Aquaculture is the world's fastest growing food sector, and Brazil has a coastline of approximately ten thousand kilometers that is intensively exploited economically, including the fishing industry, which generates jobs, income, and sources of food and has the potential for expansion. The fishing industry is relevant to four of the five regions of the country, including the southern region, where there are many bays, estuaries, inlets, beaches, and coastal lagoons. There are many species of fish of economic interest in these areas, including: sardines,

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Submitted: January 20, 2022. Accepted: September 1, 2022.

skipjack tunas and croakers. In addition, two commercially exploited species belonging to the Mugilidae family are abundant in those areas, namely, the white mullet and the silver mullets (Castello, 2010; Menezes *et al*., 2015; The State…, 2020; Nascimento *et al*., 2022).

Mugil curema Valenciennes, 1836 (Osteichthyes: Mugilidae), commonly known as white mullet in English, or as "parati" in the Southern and Southeastern Brazilian coast or as "tainha" in the Northeastern coast, is broadly distributed in estuaries in those regions. The large populations of this fish are compatible with its biological features. It is highly adaptable to various aquatic environments, it is detritivore/iliophagous, feeding on diatom algae, decomposing plants, and microorganisms. This species is mostly abundant from October through April, a period that overlaps with the spawning season, which is from August through January (Pinheiro and Goitein, 2014).

Sexual dimorphism between males and females is not evident externally so sex identification requires examination of the gonads. However, as most animal species males and females have a pair of gonads characterized as testes and ovaries, respectively. The gonads are located bilaterally in the coelomic cavity ventrally to the swim bladder. The gonads are spindle-shaped, elongated, extending caudally where they are connected, with the right gonad usually larger than the left (Albieri *et al*., 2010).

Considering the relevance of this species and the need to expand our knowledge on reproductive aspects, the goal of this report is to describe a case of intersex in a silver mullet (*M. curema*) from the Babitonga Bay, in the State of Santa Catarina, Brazil.

CASE REPORT

From 2015 to 2019, a total of 433 specimens of *M. curema* were examined. These fish were captured by gillnet with a five to seven centimeters net between knots, two meters in height and 150m in lengthin the Babitonga Bay and its tributaries, located in the Southern region of Brazil, in the State of Santa Catarina. This study was approved by the institutional animal ethics committee (Comitê de Ética no Uso de Animais - CEUA) of the Instituto Federal Catarinense, Campus Araquari, under protocol number 285/2018. This study was also authorized by the Instituto Chico Mendes de Conservação e Biodiversidade – ICMBio, under authorization number SISBIO 67155-1.

Soon after capture, fishes were transported and subjected to necropsy at the Laboratório de Ensino e Diagnóstico Veterinário (LEDVET), Instituto Federal Catarinense, Campus Araquari.

Grossly, there were gonadal changes in one of the 433 specimens examined. This fish had two morphologically distinct gonads, with a whitish color and a milky appearance on the cut surface, which is morphologically compatible with a testicle on the left side. The right gonad had a yellow to red color with an granular appearance on cut surface, which is morphologically compatible with an ovary (Fig. 1). Samples of both gonads were fixed by immersion in 10% buffered formalin and processed for paraffin embedding and staining with hematoxylin and eosin (HE).

Histologically, the ovary had follicles at various stages of development, with immature oocytes or oocytes undergoing vitelogenesis (Fig. 2A). In the testicle there were parallel testicular lobules, with tubules layered by germinative epithelium with large numbers of spermatozoa in the lumen (Fig. 2B). Based on these morphologic features, the fish was classified as a true hermaphrodite.

The remainder 432 specimens of *M. curema* examined had either testicles or ovaries, but not both. Therefore, the estimated prevalence of rue hermaphrodite in this population was 0.23% with a confidence interval between 0.00 and 0.68% at 95% confidence level.

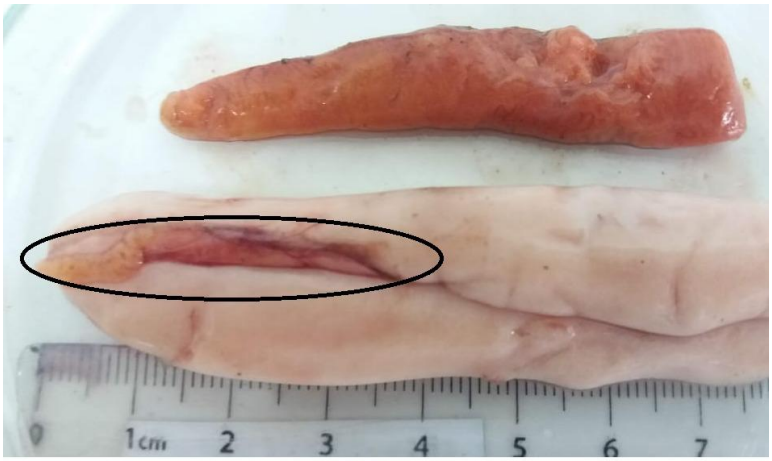

Figure 1. Gonads from an intersex *Mugil curema*. The ovary is on the top with a yellow to red color. The testicle is in the bottom with a whitish color. The insertion site of the ovary is indicated within the circle.

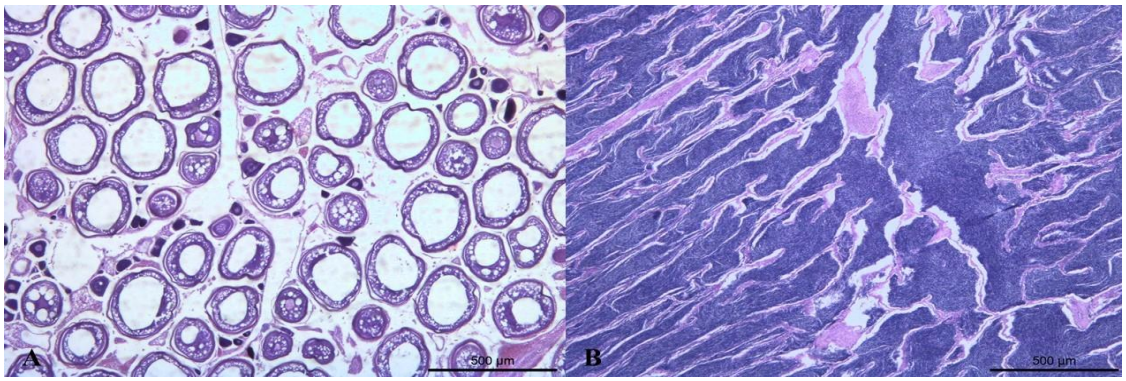

Figure 2. Gonads from an intersex *Mugil curema.* A. ovary with follicles at various stages of development. B. testicle with parallel testicular lobules, with tubules layered by germinative epithelium with large numbers of spermatozoa in the lumen. Hematoxylin and eosin (HE).

DISCUSSION

The occurrence of intersex in *M. curema* is relevant since it is considered a gonochoric species. There is one previous report of intersex in this species in Mexico (Garcia-Casca *et al.*, 2016), but to the best of our knowledge this is the first report of this condition in Brazil. Furthermore, intersexes have been identified in other species of this genus, namely *M. cephalus* (Franks *et al.*, 2001; Ferreira, 2006), *M. liza* (Andrade-Talmelli *et al*., 1994), and *M. cephalus* (Franks *et al*., 1998; Dhanasekar *et al*., 2018).

Similar to our findings in this case, in which the fish had an ovary with vitelogenic oocytes and a testicle with free spermatozoa, other studies describing intersexuality in fish of the genus *Mugil* (*M. cephalus* and *M. liza*), demonstrated fully developed and individualized gonads. In contrast, other reports described intersexes with gonads that were classified as mosaic, which is the equivalent to ovotestes as described in mammalian intersexes (Santos *et al.*, 2016), with multifocal distribution of oocytes at various stages of development among seminiferous tubules with absence of division between testicular and ovarian tissues, and poorly developed gametes (García-Gasca *et al.*, 2016; Dhanasekar *et al.*, 2018).

Intersexuality may occur as a natural event. However, there is a higher risk of development of this condition because of exposure to substances that interfere with the endocrine regulation during the process of gonadal differentiation (Leatherland *et al.*, 1998).

Most estuaries and bays are deeply impacted by environmental contaminants, which is the case of

Babitotnga Bay that receives residues from the port of São Francisco do Sul as well as industrial and domestic sewage from the urban area of Joinville (Barros *et al.*, 2010; Vaz *et al.*, 2010). Environmental contamination in estuaries has been assessed by studying selected fish species such as *M. curema* as biological indicators, with reports of gonadal malformation and intersexuality of natural origin or attributable to anthropogenic influence (García-Gasca *et al.*, 2016). Although it is very challenging to establish a cause-and-effect relationship, gross pathologic changes in sweet water, estuarine or marine fishes have been associated to environmental contamination (Matsusato, 1973; Cooley and Davies, 2001; Bashirullah *et al*., 2008). Therefore, the frequency of anomalies in fish related to environmental contamination has been accepted as a quality indicator in aquatic environments (Cooley and Davies, 2001; Dhanasekar *et al*., 2018).

In conclusion, our findings fully support the diagnosis of intersex in a *M. curema* from the Babitonga Bay, which is the first documented case of this condition in this species in the coast of Santa Catarina, Brazil.

REFERENCES

ALBIERI, R.J.; ARAÚJO, F.G.; UEHARA, W. Differences in reproductive strategies between two co-occurring mullets *Mugil curema* Valenciennes 1836 and *Mugil liza* Valenciennes 1836 (Mugilidae) in a tropical bay. *Trop. Zool.*, v.23, p.51-62, 2010.

ANDRADE-TALMELLI, E.F.; ROMAGOSA, E.; NARAHARA, M.Y.; GODINHO, H.M. Ocorrência de hermafroditismo em tainha *Mugil platanus* (Pisces, Mugilidae) na região estuarino-lagunar de Cananéia, SP, Brasil. *Bol. Inst. Pesca*, n.21, p.111-116, 1994.

BARROS, G.V.; MARTINELLI, L.A.; OLIVEIRA, N.T.M. *et al.* Stable isotopes of bulk organic matter to trace carbon and nitrogen dynamics in an estuarine ecosystem in Babitonga Bay (Santa Catarina, Brazil). *Sci. Total Environ.*, v.408, p.2226-2232, 2010.

BASHIRULLAH, A.K.; WILLIAMS Jr, E.H.; BUNKLEY-WILLIAMS, L. An anomalous White Mullet, *Mugil curema* (Perciformes: Mugilidae), with three ovarian lobes found in the Gulf of Cariaco, Venezuela. *Rev. Biol. Trop*., v.56, p.285-288, 2008.

CASTELLO, J.P. O futuro da pesca da aquicultura marinha no Brasil: a pesca costeira. *Cienc. Cult.*, v.62, p.32-35, 2010.

COOLEY, M.; DAVIES S. *Phase 2 technical memorandum for red and assiniboine ammonia criteria study*. Winnipeg: City of Winnipeg Project Management Committee Study Team Members, 2001. 386p.

DHANASEKAR, K.; SELVAKUMAR, N.; NATESAN MUNUSWAMY, N. Occurrence of intersex in grey mullet, *Mugil cephalus* L. from Kovalam Coast, Tamil Nadu. *Turk. J. Fish Aquat. Sci*., v.18, p.603-609, 2018.

FERREIRA, M.S.S. *Endocrine and enzymatic changes in flounder (Platichthys flesus) and in mullet (Mugil cephalus) chronically exposed to organic contaminants in River Douro Estuary*. 2006. 149f. Thesis (Doctoral) - Instituto de Ciências Biomédicas Abel Salazar, Universidade do Porto, Porto, POR.

FRANKS, J.S.; BROWN-PETERSON, N.J.; WILSON, D.P. *et al*. Occurrence of a synchronous hermaphroditic striped mullet, *Mugil cephalus*, from the Northern Gulf of Mexico. *Gulf Res. Rep.*, v.10, p.33-39, 1998.

FRANKS, J.S.; BROWN-PETERSON, N.J.; WILSON, D.P. R *et al*. Occurrence of a synchronous hermaphroditic striped mullet, *Mugil cephalus*, from the Northern Gulf of Mexico. *Gulf Res. Rep. Abstr*., v.10, p.33-39, 2001.

GARCIA-GASCA, A.; RÍOS-SICAIROS, J.; HERNÁNDEZ-CORNEJO, R. *et al*. The white mullet (*Mugil curema*) as biological indicator to assess environmental stress in tropical coastal lagoons. *Environ. Monit. Assess*., v.188, p.1-15, 2016.

LEATHERLAND, J.F.; BALLANTYNE, J.S.; VAN DER KRAAK, G. Diagnostic assessment of non-infectious disorders of captive and wild fish populations and the use of fish as sentinel organisms for environmental studies. In: LEATHERLAND, J.F.; WOO P.T.K. (Eds.). *Fish diseases and disorders*: non-infectious disorders. Canada: University of Guelph, 1998. v.2, p.335-366.

MATSUSATO, T. On the skeletal abnormalities in marine fishes. The abnormal marine fishes collected along the coast of Hiroshima prefecture. *Bull. Nansei. Reg. Fish Res. Lab*., v.6, p.17-58, 1973.

MENEZES, N.A.; NIRCHIO, M.; OLIVEIRA, C.; SICCHARAMIREZ, R. Taxonomic review of the species of *Mugil* (Teleostei: Perciformes: Mugilidae) from the Atlantic South Caribbean and South America, with integration of morphological, cytogenetic and molecular data. *Zootaxa*, v.3918, p.1-38, 2015.

NASCIMENTO, M.S.; CARVALHO, C.V.A.; PASSINI, G.; SOARES, M.; EVANGELISTA, D.K.R.; SOUZA, D.N. *Panorama da piscicultura marinha no Brasil*: desafios e perspectivas. Palmas,TO: Embrapa Pesca e Aquicultura, 2022. 40 p. (Documento 51).

PINHEIRO, M.S.S.; GOITEIN, R. Estrutura de uma população e aspectos biológicos de *Mugil curema* valenciennes, 1836 (Pisces, Mugilidae), em um Manguezal da Raposa, Brasil. *Rev. Bras. Ciênc. Saúde*, v.16, p.58-65, 2014.

SANTOS, R.L.; NASCIMENTO, E.F.; EDWARDS, J.F. Sistema reprodutivo feminino. In: SANTOS, R.L.; ALESSI, A.C. (Eds.). *Patologia Veterinária*. 2.ed. São Paulo: Roca, 2016. p.751-804.

THE STATE of world fisheries and aquaculture (SOFIA). Roma: FAO. 2020. 244p. (Fisheries and Aquaculture Department.).

VAZ, C.; OLIVEIRA, T.M.N.; BÖHM, R.F.S. *et al*. Use of *Artemia salina* to identify sites with risk of contamination in the waters of Babitonga Bay. *Toxicol. Lett.* v.196, p.S120, 2010.