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INTERESPAÇO
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Water quality as a parameter of sanity of the hybrid Tambacu (*Colossoma macropomum* × *Piaractus mesopotamicus*) from the west of the state of Maranhão, Brazil

Qualidade da água como parâmetro de avaliação da sanidade de Tambacu (*Colossoma macropomum* × *Piaractus mesopotamicus*) do oeste maranhense, Brasil

Calidad del agua como parámetro de evaluación de la sanidad del Tambacu (*Colossoma macropomum x Piaractus mesopotamicus*) del oeste maranhense, Brasil

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Abstract

Poor microbiological quality of pond water may interfere with the microbiological quality of fish and their by-products. This paper evaluates water quality as a parameter of sanity of the hybrid tambacu (*Colossoma macropomum* × *Piaractus mesopotamicus*) from the West of the Maranhão state (MA), Brazil. Specimens of tambacu were captured in excavated ponds in the municipality of Governador Edison Lobão, Western Region of Maranhão state, and microbiological analyses of the water, feed, and fillet were carried out, as well as parasitological analyses of the gills and intestines. The analyses found parasites in the gills and the intestines and showed microbiological contamination in the pond waters, fish food, fish fillets, and fish gills over the limit legally allowed. The conclusion is that fishpond water quality influences the microbiological quality of the fish. Therefore, the fish produced in the Western Region of Maranhão need inspection and monitoring to be considered safe for human consumption.

Keywords: Water; Microbiology; Tambacu.

Resumo

A água dos viveiros, se de má qualidade microbiológica, pode interferir na qualidade microbiológica do peixe e de seus subprodutos. Com o objetivo avaliar a qualidade da água como parâmetro de sanidade de tambacu (*Colossoma macropomum* × *Piaractus mesopotamicus*) do Oeste Maranhense produziu-se este trabalho. Espécimes de tambacu foram capturados em tanques escavados do município de Governador Edison Lobão, região Oeste do estado do Maranhão (MA) e feitas análises microbiológicas da água, da ração e do filé, bem como análises parasitológicas das brânquias e dos intestinos. Além de parasitas nas brânquias e nos intestinos, foi encontrada contaminação microbiológica nas águas dos reservatórios, na ração, no filé e nas brânquias acima do padrão estabelecido pela legislação. Conclui-se, portanto, que a qualidade da água dos tanques de cultivo exerce influência sobre a qualidade microbiológica dos peixes. Logo, os peixes produzidos na região Oeste do Maranhão necessitam de fiscalização e acompanhamento para que possam ser considerados alimentos seguros para a população.

Palavras-chave: Água; Microbiologia; Tambacu.

Resumen

La mala calidad microbiológica del agua del estanque puede interferir con la calidad microbiológica de los peces y sus subproductos. El presente estudo se realizo con el objetivo de evaluar la calidad del agua como parámetro sanitario para el híbrido Tambacu (*Colossoma macropomum* × *Piaractus mesopotamicus*) en el oeste de Maranhão. Se capturaron ejemplares de Tambacu en tanques excavados en el municipio de Governador Edison Lobão, región occidental del estado de Maranhão (MA) y se realizaron análisis microbiológicos del agua, alimento y filete, así como análisis parasitológicos de branquias e intestinos. Además de parásitos en las branquias y los intestinos, se encontró contaminación microbiológica en el agua de los embalses, alimento, filete y branquias, por encima de los niveles estándar establecidos por la legislación. Se concluye que la calidad del agua de los tanques de cultivo influyen en la calidad microbiológica de los peces. El pescado producido en la región occidental de Maranhão requiere inspección y seguimiento para que pueda ser considerado alimento seguro para la población.

Palabras clave: Agua; Microbiologia; Tambacu.

Introduction

Being responsible for a significant portion of fish used for human consumption, fish farming stands out as the most prominent production chain in aquaculture (Souza;

Viana, 2020; FAO, 2022). Aquaculture encompasses various practices, including cultivating of fish, crustaceans, mollusks, and aquatic plants in controlled environments. It plays a crucial role in fish production for human consumption and is one of the most significant forms of aquaculture in the context of global food production. To meet the growing demand, it has been expanding by developing of new techniques to produce more in less time and sustainably (Calixto *et al.*, 2020). Given the importance of fish farming in Brazil and the state of Maranhão, conducting biomonitoring studies is becoming increasingly relevant (Santos *et al.*, 2013; Araujo *et al.*, 2024).

Aquatic health is the part of animal health defense focused on protecting the health of aquatic animals. Normative Instruction MPA No. 04/2015, updated by Normative Instruction Mapa No. 04/2019, provides tools for the Official Veterinary Service to quickly respond to the emergence of diseases in aquaculture. However, the state of Maranhão, especially in the Western region, requires more supervision (Brasil, 2020). If of poor microbiological quality, water from fish ponds can interfere with the microbiological quality of fish and its by-products. Morphological lesions likely originate from pollutants accumulated in the aquatic environment (Lorenzon et al., 2010; Bezerra et al., 2020). In this context, freshwaters intended for the protection of aquatic communities and the natural and/or intensive breeding of species intended for human consumption have a control classification determined by Resolution Conama No. 357, of March 17, 2005 (BRASIL, 2005). However, sanitary control in Western Maranhão is still precarious, leaving the entire basin susceptible to contaminations that can cause damage to the fish in this aquatic environment (Barroso; Sousa, 2007; Acioly *et al.*, 2024).

Analyzing changes in the intestine can contribute to a broader evaluation of the conditions influenced by management as a cause of stress in fish. The intestinal mucosa plays a vital role in efficiently absorbing nutrients such as proteins, lipids, vitamins, and minerals, which are essential for the growth and development of fish. Changes in intestinal morphology, such as an increase in villus length, may indicate physiological adaptations in response to environmental stressors, such as changes in water quality, inadequate diet, presence of pathogens, and other stress factors. Therefore, histological and morphological analysis of the intestine is a valuable tool for assessing the health status of fish and understanding how management can influence their well-being (Ferreira *et al.*, 2014).

Due to its direct contact with the external environment and its role as a barrier between the external and internal environment, the gill tissue is highly susceptible to alterations. In this context, the microbiological analysis of tambacu gills is a study that can assist in evaluating the influence of water quality in breeding environments and animal health (Bezerra *et al.*, 2020). Gill investigations based on responses at molecular and cellular levels as environmental biomarkers are increasingly common worldwide (Fonseca *et al.*, 2016). However, this type of study in fish from breeding facilities in Western Maranhão is nonexistent, making this work unprecedented.

Studying the morphology of the fish digestive tract can provide information about specific structures involved in digestibility and, from the understanding of possible adaptations found in the digestive system, can be linked to behavior and feeding habits (Ferreira et al., 2014). In aquaculture, the balance of beneficial and pathogenic bacteria can be disrupted by inappropriate management practices, leading to the proliferation of pathogenic bacteria. Analyzing water quality in breeding facilities, especially within microbiological parameters, is relevant in Western Maranhão due to high production (Russo *et al.*, 2021).

In this context, the work directly addresses the Sustainable Development Goals: Goal 12, which refers to Responsible Consumption and Production, aiming to ensure sustainable production and consumption standards, is considered a fundamental step for each country to establish its goals and priorities for Sustainable Production and Consumption. Goal 3, which refers to Good Health and Well-being, aims to ensure a healthy life and promote well-being for all, at all ages, through the fight against hepatitis, waterborne diseases, and other communicable diseases.

Such diseases can also be transmitted by fish raised in contaminated water. The tambacu (*Colossoma macropomum* × *Piaractus mesopotamicus*) is one of the most produced fish in the country and demonstrates rapid growth, adaptability to various breeding systems, and good acceptance in the consumer market. Western Maranhão stands out for tambacu production (BRASIL, 2020). In addition, aquaculture practiced in breeding facilities in the Legal Amazon region, in Western Maranhão, is the second largest among the state's regions, behind only the North. The production of tambacu/tambatinga in Western Maranhão (MA) shows constant growth, with 2,320,211 kg produced in 2019. However, the municipality of Governador Edson Lobão experienced a decrease in production: from 232,270 kg in 2015 to 188,695 kg in 2019 (IBGE, 2020; Viana *et al.*, 2022).

The biomarkers identified in the research could help fish farmers reduce the negative impacts of aquaculture on the environment and increase productivity. Recognizing the region's production prominence, understanding the producers' situation, and noting the scarce scientific production aimed at evaluating and improving fish production conditions in the Western Maranhão region motivated the production of this work

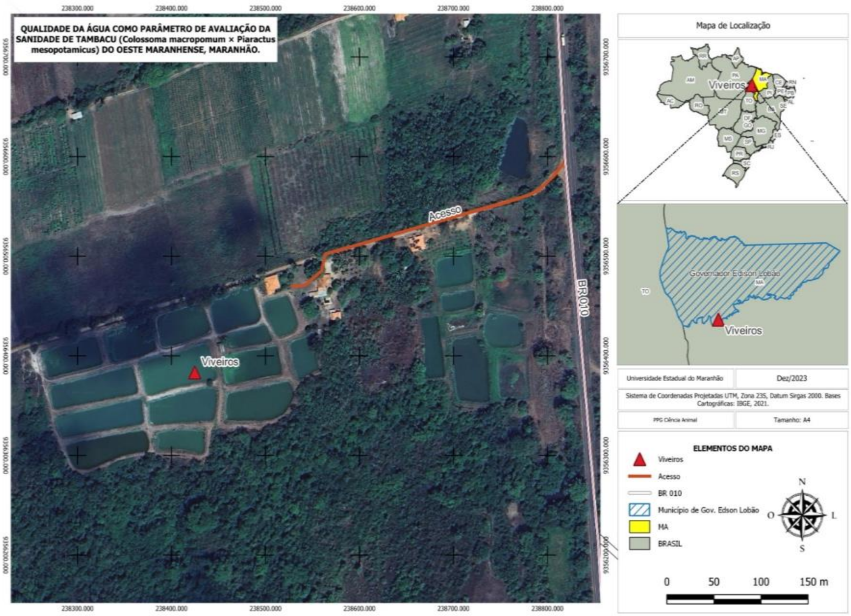
Recognizing the importance of monitoring water and fish quality in tambacu farming and the commercial value of this fish for the state of Maranhão, this study aimed to assess water quality as a health parameter for tambacu (*Colossoma macropomum* × *Piaractus mesopotamicus*) in Western Maranhão through microbiological analysis, physicochemical water analysis, and parasitological analysis of gills and intestines.

Material and methods

Study área

The research was conducted in the municipality of Governador Edison Lobão, Western region of the state of Maranhão (5°44'56" S 47°21'39" W) and approved for the Ethics Committee for the use of animals in scientific research at the State University of Maranhão, Protocol No. 31/2021 of the Animal Ethics and Experimentation Committee, by the Animal Welfare standards of Federal Council of Veterinary Medicine Resolution No. 1000/2012, Law 11.794/2008, and Concea/MCTI. Collections were made in the rainy and dry seasons, between 2021 and 2023. Below is the location map of the collection point created in the QGIS 2023 software (Figure 1).

Figure 1 – Geographical location of the tambacu (*Colossoma macropomum* × *Piaractus mesopotamicus*) collection site obtained in Western Maranhão, Maranhão, 2023.



Source: IBGE, 2021.

The property has 15 excavated tambacu cultivation ponds in the dam system with natural water flow from a tributary of the Tocantins River (Ribeirão stream), with water entering the system through gravity and interconnected ponds (Figure 2).

Figure 2 – Image of the tambacu (*Colossoma macropomum* × *Piaractus mesopotamicus*) collection pond obtained in Western Maranhão, Maranhão, 2023.

Source: Author, 2023.

Fish and water collection

Tambacu specimens (*Colossoma macropomum* × *Piaractus mesopotamicus*) were captured in nets and immediately placed in plastic bags with water from the reservoirs, which received oxygen and were sent to the Anatomy Laboratory and Ecology and Limnology Laboratory, as well as to the Microbiology Laboratory of the State University of the Tocantina Region of Maranhão for analysis. The fish were anesthetized with eugenol solution (20ml of clove oil diluted in 92.8° ethyl alcohol, followed by dilution of 30 ml of this stock solution in 15 liters of water), weighed, and euthanized through brain section. A total of 57 specimens were collected from ponds with fish ready for consumption (Figure 3). Water samples for microbiological analysis, a total of 18, were collected in sterilized bottles (500 mL) in the surface water column, stored in an isothermal material box with ice cubes, and transported to the Microbiology Laboratory. Three collections were made: the first occurred in the dry period of 2021; the second in the rainy period of 2022, and the third in the dry period of 2023.

Figure 3 – Tambacu specimen (*Colossoma macropomum* × *Piaractus mesopotamicus*) obtained in Western Maranhão, Maranhão, 2023.

Source: Author, 2021.

Physical-chemical water analyses

Measurements were taken for the following physical-chemical parameters of pond water: water temperature (°C) and dissolved oxygen (portable digital with data logger - MO-900) with temperature and hydrogen potential meter (pH) (portable digital pH meter MOD. PH-1900).

Microbiological analyses of water, feed, and tambacu fillet

Microbiological evaluations of water, feed, and fillet consist of counts of total coliforms (most probable number - MPN/100 ml) and *Escherichia coli* (most probable number - MPN/100 ml) according to the methodology described by Silva *et al.* (2017). This methodology was initially applied with the presumptive test, in which a series of three tubes of Lactose Broth with Sulfate Lauril (LST) per dilution were inoculated (one series of 3 dilutions), and 1.0 mL of the dilution was added per tube with 10 mL of Broth incubated at 35 ºC for 24-48 hours. Then, growth with gas production was observed. In case of a positive result, subsequent steps were taken: the confirmatory test for total coliforms, in which, from each positive tube from the previous step, a well-loaded loop of the culture was transferred to tubes with Brilliant Green Bile Broth (VB) and incubated at 35 ºC for 24-48 hours, observing growth with gas production, and then the calculations were performed. In case of a positive result, subsequent steps were taken: the confirmatory test for thermotolerant coliforms, in which, from each positive tube from the previous step, a loaded loop of the culture was transferred to tubes of *E. coli* Broth (EC) and the tubes were incubated at 44.5 ºC for 24 hours, observing growth with gas production, and calculations were performed. For the *E. coli* Count, a loop of each culture obtained in each EC tube with gas production was taken and streaked on plates of Eosin Methylene Blue Agar (EMB), incubated at 35 ºC for 24 hours to observe if there was development of typical *E. coli* colonies (nucleated with a black center, with or without metallic shine).

Microbiological evaluations of water also included counts of total coliforms (most probable number - MPN/100 ml) and *Escherichia coli* (most probable number - MPN/100 ml) using the Quanti-tray2000 kit, which employs the chromogenic substrate technique. Water samples were placed in glass bottles with Colilert® reagent, and the diluted solution was evenly distributed in cups and incubated at 35 °C in the oven for 24 hours. Colilert® includes a proprietary indicator that changes color in the presence of coliform bacteria and *E. coli*. Therefore, the color change was a visual indication of the presence and concentration of these bacteria in the water sample, and the degree of color change was used to estimate the concentration of bacteria in the sample. The reading took place with the aid of an ultraviolet lamp and was evaluated according to the current resolution (Brasil, 2005).

In the microbiological evaluation of the gills, the adopted methodology, according to Silva *et al.* (2017) for the total count of mesophilic aerobes (CFU/g), consists of weighing 10 g of the gills and adding 90 mL of 0.1% peptone water. From the initial dilution, the other dilutions (10-2 and 10-3) will be prepared. Then, an aliquot of 1 mL from each dilution was poured into a sterilized Petri dish, and standard agar for counting (PCA) was added. The plates were then incubated in a bacteriological incubator at 35 °C, and after 24-48 hours, the colonies were counted, and a Gram stain was performed to characterize the microbiota.

Parasitological analysis of tambacu

Parasitological assessments were conducted on the gills and intestines of tambacu specimens. The intestines were placed in Petri dishes with saline solution, and after opening them with the aid of scissors and a scalpel, thorough examinations were conducted under a magnifying glass to identify acanthocephalans detached from the intestinal walls. Identification was carried out with the help of specific keys for the group (Yamaguti, 1963; Petrochenko, 1971) and through comparisons with descriptions published in scientific articles. As the gills were removed, they were placed in a Falcon tube with water heated to 70 ºC (3 parts) for relaxation, and the flask was vigorously shaken to detach the parasites from the gill lamellae. Next, fixation of the parasites was performed by adding absolute alcohol to achieve an approximate concentration of 70% (Boeger; Viana, 2006). For collecting the parasites, each gill arch, along with the resulting fixing liquid, was transferred to Petri dishes and scraped with the help of a fine-bristle brush or scalpel to release the helminths that remained attached to the gill lamellae. Subsequently, they were observed under a stereoscopic microscope for collection (Boeger; Viana, 2006). The helminths were stored in vials with 70% alcohol for further study, and some were mounted in Hoyer's medium between slide and coverslip to allow for the study of sclerotized parts such as hooks, anchors, haptor bars, and copulatory complex (Boeger; Viana, 2006). To study the internal organs, the parasites were stained with Gomori's trichrome, dehydrated in a graded alcohol series ending with absolute alcohol, cleared with clove oil, and mounted between a slide and coverslip in Canada balsam. The identification of monogenetic parasites was based on identification keys and reference guides (Kritsky; Thatcher; Kayton, 1979; Cohen; Kohn, 2005).

Statistical analysis

For morphometric analysis and physiological indices in tambacus, ANOVA and Tukey's Test were performed, with $P<0.05$ considered significant. The results were presented as means ± standard error or standard deviation, and all analyses were performed using the Bioestat program, version 5.0, and Excel 2019.

Results and discussion

The readings of pH determinations of the pond waters (Table 1) were inconsistent with the legislation, as Conama Resolution 357 establishes that, for the protection of aquatic life, pH should be between 6 and 9 (Brasil, 2005). However, the chemical parameter dissolved oxygen (mg/L) showed favorable conditions for survival rates, as the legislation requires it not to be less than 4 mg/L for Class 2 waters, since dissolved oxygen is a limiting factor for maintaining aquatic life. Waters classified as belonging to Class 2 receive this classification due to the required quality for their use. The water from the studied ponds originates from an affluent of the Tocantins River, and aquaculture and fishing activities fall under Section 2, Article 6 of this Resolution (Brasil, 2005).

The physicochemical quality of the water in the two lakes in Kenya, as observed by Onjong *et al.* (2018), was within the tolerance limits for Nile tilapia growth. According to Bambi *et al.* (2008), in lakes and reservoirs, such as dams and excavated tanks, due to thermal stratification and other factors, such as high organic load, the concentration of dissolved oxygen varies with depth: higher at the surface and lower at the bottom. It is known that water temperature in the ponds is a physical parameter that directly influences fish growth. Low temperatures in the ponds are considered inadequate, as the ideal temperature is between 24 ºC and 28 ºC. In this temperature range, the fish can achieve a good increase in production and, consequently, a better immune system. The temperature measurements obtained in this study align with those considered ideal for achieving better performance of tambacu raised in Western Maranhão.

Table 1 – Average and standard deviation of the physicochemical parameters from 18 water samples of tambacu (Colossoma macropomum × Piaractus mesopotamicus) ponds obtained in Western Maranhão, Brazil, 2023.

Physicochemical parameters	Average ± Standard deviation
T(°C)	27.35 ± 0.96
D.O. (mg/L)	67.74 ± 41.75
pH	10.01 ± 2.45

Legend: O.D.: Dissolved Oxygen

According to Resolution Conama 357, 2005, for waters classified as Class 2, in this case, reservoir water, the level of thermotolerant coliforms should not exceed a limit of 2.500 per 100 milliliters. *E. coli* can be determined as a substitute for thermotolerant coliform indicators according to the limits established by the competent environmental agency (Brasil, 2005). It is observed that in more than 80% of the samples analyzed, thermotolerant coliforms and *E. coli* (traditional methodology) exceed the limits allowed by legislation. However, through the chromogenic and fluorogenic substrate method (Colilert®), the results comply (Table 2).

Table 2 - Mean Most Probable Number (MPN) of thermotolerant total coliforms and *E. coli* in water, feed, and tambacu (*Colossoma macropomum* × *Piaractus mesopotamicus*) fillet samples obtained from a pond in Western Maranhão, Brazil, 2023.

	Water from reservoirs (MPN/100 mL)		Feed (MPN/g)	Fillet (MPN/g)	Gills (CFU/mL)
	Silva *et al.* (2017)	Colilert®			
Total coliforms	2.2 a 4800	1011.2	8.9	3.0 a 1.100	Countless
Thermotolerant coliforms	2.2 a 4800	-	8.9	8.9 a 4.800	
Escherichia coli	2.2 a 4800	19.3 a 436.0	8.9	9.0 a 4.800	

Legend: MPN: Most Probable Numbe; CFU: Colony Forming Units

Studies have associated higher coliform density in water, especially fecal coliforms, with a higher density of these bacteria in fish bodies (Mandal *et al.*, 2009). This association may be responsible for the higher bacterial count in fish sampled in ponds in the Western Maranhão. The higher bacterial count in fish sampled by Onjong *et al.* (2018) and in water samples, especially in the capture phase of the value chain, reveals direct relationships between water quality and fish quality. Such studies align with the results found in this research in Western Maranhão.

It is noteworthy that after capture, fish from the ponds will go through several stages that can exert a direct influence on their microbial load, such as secondary contamination due to poor handling and terrestrial environment, airborne, water, and lack of hygiene, with particular deficiencies or lack of handwashing (Kirby; Bartram; Carr, 2003; Gomez-Duarte *et al.*, 2009). This raises significant concerns about food safety and points to inadequate conditions and insufficient control measures, as well as the lack of management systems throughout the fish value chain. The absence or deficiency of measures and systems can contribute to poor processing and hygiene conditions, increasing the likelihood of fish contamination by microorganisms. The establishment and implementation of such measures and systems can effectively reduce microbial contamination of fish. However, this requires a multifaceted approach and, primarily, the involvement of various regulatory bodies (Onjong *et al.*, 2018).

Compared to traditional methodology and Colilert®, it is believed that the pros and cons of each should be observed. Some articles, for example, confirm the superiority of the safety of the Quanti-tray 2000 kit over traditional methodology. As for the microbiological analyses of tambacu fillet, according to the standard established in legislation, which is Escherichia coli or thermotolerant coliforms in 100 mL, the result should be absence; for total coliforms in 100 mL, the result should be <1.1 MPN or absence (Brasil, 2005). It is noteworthy that tambacu fillet samples were contaminated.

Coliform counts were higher than those reported by Ligia *et al.* (2008) for fresh fish and by Hernandez et al. (2009) for muscle. These results differed from those of Aubourg *et al.* (2007), who obtained values below 3 log CFU/g. Coliform counts can indicate water contamination (Boulares *et al.*, 2011). The biological quality of freshwater is a constant concern in fish farming because, if it is of poor quality, it can cause a drop in productive performance and fish mortality. Some factors cause a reduction in production and profitability (Sant'ana *et al.*, 2012).

Microbiological contamination of tambacu gills in Western Maranhão was very high in more than 80% of the samples analyzed. The fish analyzed by Santos *et al.* (2009) showed contamination in the gills by fecal coliforms at 45 °C and Salmonella, and, on the skin, by *Staphylococcus*. These two tissues were considered unsuitable for human consumption.

Regarding the parasitological evaluation, over 1.000 specimens of Monogenoidea were found, identified as *Anacanthorus spathulatus* Kritsky, Thatcher, and Kayton (1979) and

Mymarothecium boegeri Cohen and Kohn (2005); and Yamaguti (1963), Petrochenko (1971) in 45% of the samples. Additionally, acanthocephalans were also found in the intestines. These findings are consistent with recent research by Araujo *et al.* (2024).

The presence of monogeneans in the fish gills can lead to cellular hyperplasia, mucous hypersecretion, and, in some cases, fusion of gill filament. In cases of excessive mucus production, it can lead to gill impermeability and difficulty in breathing (Yamada et al., 2018). According to Pavanelli, Takemoto, and Eiras (2013), the damage determined in fish is related to the parasite species, the occurrence site, the intensity of infestation, and the type of feeding, as it can feed on mucus, epithelial cells, and blood. In this study, monogenean organisms were found lodged in the gill filaments of tambacus. Differences in management and the quality of cultivation environments, especially regarding fishing, stocking density, nutrition, and host age, influence the different levels of parasitism among fish farms (Negreiros; Tavares-Dias; Pereira, 2019).

Monogenea and Acanthocephala, among others, are taxa commonly found parasitizing fish in Latin American waters (Luque *et al.*, 2016). Among these groups, endoparasites, especially acanthocephalans, nematodes, and cestodes, are potential bioindicators of pollution, especially for trace metals (Sures *et al.*, 2017; Vidal-Martínez; Wunderlich, 2017). On the other hand, ectoparasites, mainly monogeneans, despite not being an ideal group for use in studies with bioindication of accumulation, can be very useful for another type of approach: the bioindication of effect (Leite *et al.*, 2023).

Effect bioindication considers the physiological, behavioral, or numerical responses of parasites to a stressor (Vidal-Martínez *et al.*, 2009). In this case, Monogenea class parasites can be used as bioindicators since they tend to respond numerically, that is, increase or decrease their populations according to the increase in chemical pollution in the environment. They are even capable of responding to eutrophication, organic pollution, pollution from residual metals, and pollution caused by effluent discharge (Gilbert; Avenant-Oldewage, 2017; Leite *et al.*, 2023).

The Monogenoidea infestation found in tambacu hybrids (C. macropomum × P. mesopotamicus) in Western Maranhão corroborates with the results of Santos et al. (2013), who described moderate parasitism caused by Mymarothecium boegeri, Anacanthorus spathulatus, and other species in tambaqui raised in net pens in the state of Amapá. Parasites with a direct life cycle, such as monogeneans, are more frequently found in lentic environments, as this type of environment favors the transmission of these parasites (Pavanelli; Takemoto; Eiras, 2013). Naturally, excavated tank farms represented suitable conditions for monogeneans.

Studies on fish parasites are more relevant due to the understanding of their roles in ecosystems and the regulation of host populations' abundance and density. In the case of aquaculture, it becomes even more important due to the damage they can cause to the production chain. Regarding acanthocephalans, South America has low recorded numbers compared to other helminths: there are more than 80 species reported in different countries (Luque *et al*., 2016). As for tambaquis (*Colossoma macropomum*, Cuvier, 1818), there are reports of the consequences that high parasitological indices can cause. When researching infections by acanthocephalans, Malta *et al*. (2001) found a high incidence of Neoechinorhynchus buttnerae species, Golvan (1956), parasitizing pyloric caeca and the intestine, which resulted in partial or total occlusion of the intestinal tract, causing impairment of food absorption and, consequently, the death of the host.

Conclusions

The different methodologies applied for water analysis revealed that the chromogenic and fluorogenic substrate method (Colilert®) can be a quickly applicable tool for obtaining accurate results. However, despite being within the limits established by current legislation, the contamination found in the pond water may be directly responsible for the level of microbiological contamination in the fillets and gills of tambacus in Western Maranhão. The physicochemical analysis of water from the region's ponds can provide very relevant complementary standards in the overall assessment of the safety of the produced food. The occurrence of parasites in the gills and intestines of tambacus indicates the need to adopt preventive measures to reduce economic losses and avoid harm to consumers, as well as to control the presence of parasites in fish farming in the Western region of Maranhão, known as the Tocantina do Maranhão region. Therefore, fish produced in Western Maranhão should be tested and monitored to be considered safe food for consumers.

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