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CAN THE WOOD-BORING MOLLUSC TEREDO SP. BE A SUITABLE SPECIES FOR FAMILIAR AQUACULTURE IN THE AMAZON REGION?

O MOLUSCO PERFURADOR DE MADEIRA TEREDO SP. PODE SER UMA ESPÉCIE ADEQUADA PARA A AQUICULTURA FAMILIAR NA REGIÃO AMAZÔNICA?

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Resumo
O molusco bivalve perfurador de madeira Turu (*Teredo* sp.), tradicionalmente pescado e consumido por comunidades ribeirinhas da Amazônia, apresenta características biológicas e ecológicas desejáveis para a aquicultura moderna. O objetivo deste estudo foi fornecer as primeiras evidências do potencial aquícola do Turu no estuário do rio Panacuéra, Abaetetuba, Pará, Brasil. Um sistema experimental de cultivo de baixo custo foi implementado submergindo intencionalmente toras de madeira padronizadas. Durante o período, a qualidade da água no estuário apresentou temperaturas variando de 26 a 31 °C, oxigênio dissolvido entre 5,5 e 7,5 mg L^{-1}, salinidade entre 5 e 10 ‰, pH entre 6,5 e 8,0, turbidez superior a 100 NTU e alcalinidade entre 40 e 120 mg $CaCO_3$ L^{-1}. A colonização ocorreu em 45 dias, com densidades variando de 25 a 60 indivíduos por metro linear de madeira. Os animais atingiram comprimentos corporais médios de 15 a 25 cm após 90 dias. O Turu destaca-se pela ausência de exigências alimentares, manejo simplificado, rápida colonização do substrato e forte relevância sociocultural. Esses resultados oferecem suporte biológico e socioeconômico inicial para o potencial da aquicultura de Turu em estuários amazônicos.

Palavras-chaves: Estuários amazônicos; Diversificação alimentar; Espécies de baixo nível trófico; Sustentabilidade.

Abstract

The wood-boring bivalve mollusc Turu (*Teredo* sp.), traditionally harvested and consumed by Amazonian riverside communities, exhibits desirable biological and ecological characteristics for modern aquaculture. The aim of this study was to provide the first evidence of the aquaculture potential of Turu in the Panacuéra River estuary, Abaetetuba, Pará, Brazil. A low-cost experimental cultivation system was implemented by submerging standardised wooden logs intentionally. During the period, the water quality in the estuary showed temperatures ranging from 26 to 31 °C, dissolved oxygen ranging from 5.5 to 7.5 mg L^{-1}, salinity ranging from 5 to 10 ‰, pH between 6.5 and 8.0, turbidity exceeding 100 NTU, and alkalinity ranging from 40 to 120 mg $CaCO_3$ L^{-1}. Colonisation occurred within 45 days, with densities ranging from 25 to 60 individuals per linear metre of wood. The animals reached average body lengths of 15 to 25 cm after 90 days. The Turu is notable for its lack of feeding requirements, simplified management, rapid substrate colonisation, and strong sociocultural relevance. These findings offer initial biological and socioeconomic support for the potential of Turu aquaculture in Amazonian estuaries.

Keywords: Amazonian estuaries; Food diversification; Low-trophic-level species; Sustainability.

Introdution

Species of the genus *Teredo* play a vital ecological role in mangrove ecosystems by contributing to wood decomposition and nutrient recycling, while also holding cultural significance as a traditional food source for Amazonian riverside communities (Leiwakabessy et al., 2022; Carmo-Santos et al., 2023; Batista et al., 2025). According to Batista et al. (2025), Turu (*Teredo* sp.) is traditionally collected and consumed by these communities, most frequently during the Amazonian dry season, and plays a fundamental role as part of their cultural and nutritional heritage. With regard to its nutritional value, Turu has a profile comparable to that of other bivalve molluscs commonly consumed worldwide. It is recognised for its high protein and omega-3 fatty acid content, low lipid levels, and significant concentrations of essential minerals, making it a reliable and well-balanced food source with potential applications beyond its traditional use (Almeida et al., 2020; Willer and Aldridge, 2020; Batista et al., 2025).

In Brazil, including the state of Pará, species of the family Teredinidae, such as *Neoteredo reynei* and *Teredo bartschi*, have been recorded in estuarine mangrove environments, with their distribution influenced by salinity variation and habitat diversity (Leonel et al., 2002; Carmo-Santos et al., 2023). The Abaetetuba region, with its favourable estuarine conditions, such as tidal influence, mangrove ecosystems, abundant organic matter and the availability of woody substrates, provides an ideal setting for the management and controlled cultivation of Turu, enabling its incorporation into small-scale aquaculture systems (Almeida et al., 2020).

Turu also exhibits distinctive physiological traits, including rapid growth and the capacity to feed on decaying wood or microalgae, further underscoring its potential for sustainable aquaculture and the diversification of food production (Willer and Aldridge, 2020). Although these molluscs represent a valuable nutritional resource, further advances in research, industrial development, food processing and consumer engagement are required to support their large-scale production and commercialisation (Willer and Aldridge, 2020; Batista et al., 2025).

The potential for aquaculture is generally assessed based on a range of factors, including biological, ecological, technical, and economic considerations, to determine the feasibility of cultivating a species efficiently, safely, and sustainably (Gul et al., 2024; Carlino-Costa and Belo, 2025, Ohia, 2025). According to the classical framework proposed by Webber and Riordan (1976), candidate species for aquaculture should possess favourable biological traits such as high adaptability to environmental conditions, tolerance of physicochemical fluctuations, rapid growth, efficient utilisation of available resources, and low susceptibility to stress and mortality. Furthermore, species suitable for aquaculture should respond positively to simple and controllable cultivation techniques, require minimal external inputs, and allow for predictable production cycles. Economic and social factors, including low production costs, compatibility with local infrastructure, cultural acceptance, and potential market demand, are also crucial considerations in evaluating aquaculture viability. These criteria remain widely applicable, especially in the assessment of nonconventional or emerging species intended for low-intensity, family-or community-based aquaculture systems.

Aquaculture is widely recognised as a promising solution for global food security, and the cultivation of unconventional species such as Turu (*Teredo* sp.) could enhance the sustainability and diversification of the sector (Little et al., 2016). Although direct studies on the genus *Teredo* remain limited, research on other Amazonian species highlights the importance of farming approaches that promote growth and survival with minimal external inputs, an approach that may also be applicable to Turu cultivation (Costa et al., 2025). Consequently, Turu shows considerable potential for aquaculture development, particularly in regions with favourable environmental conditions such as Abaetetuba (Little et al., 2016; Almeida et al., 2020; Willer and Aldridge, 2020; Batista et al., 2025).

Based on this context, the present study aims to gather information and demonstrate the aquaculture potential of the wood-boring mollusc Turu (*Teredo* sp.) in the Panacuéra Estuary, located in the Amazon region of the state of Pará, Brazil. The study addresses bioecological, sociocultural, and production-related aspects, as well as the prospects and challenges associated with integrating Turu into aquaculture systems. This may have various positive effects on these communities, including enhanced food security, income generation, and reduced physical exertion and risk, while maintaining a focus on environmental sustainability.

Material and Methods

Location and data collection

The study was conducted on the Panacuéra River, located in the municipality of Abaetetuba, in the state of Pará, Brazil, within the Amazon estuary and under the direct influence of the Tocantins River fluvial–marine system. Abaetetuba forms part of the Northeast Pará mesoregion and is located approximately 124 km from Belém (1°48'10.3"S and 49°04'44.6"W). The municipality has an estimated population of 172,344 inhabitants, of whom approximately 8,000 live along the banks of the Panacuéra River (IBGE, 2025). These traditional riverside communities maintain a strong socio-economic and environmental relationship with the river (figure 1).

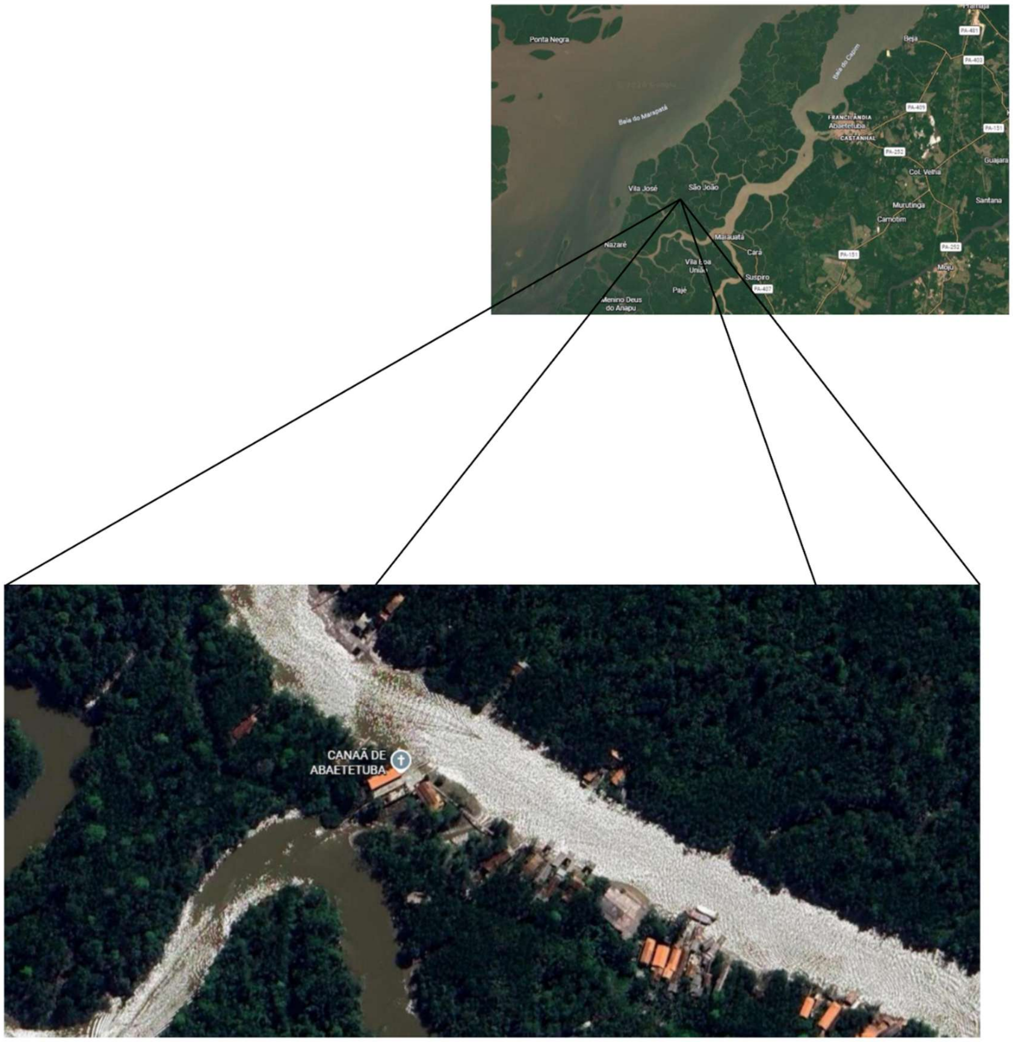

Figure 1. Geolocation of the site where the study was conducted on the banks of the Panacuéra River, located in the municipality of Abaetetuba, in the state of Pará, Brazil, within the Amazon estuary and under the direct influence of the Tocantins River fluvial–marine system.

The region is characterised by semi-diurnal tides, high biological productivity and extensive mangrove ecosystems, together with an abundance of natural woody substrates, environmental conditions that favour the occurrence and development of bivalve molluscs of the family Teredinidae (Batista et al., 2025). Information obtained from participants was limited to the documentation of traditional knowledge in the public domain related to practices of collection, consumption and environmental perception of the organism, without the collection of sensitive data, interventions or experiments, or the exposure of participants to any form of physical, psychological, social or economic risk (Marques et al., 2025). The research adopted a qualitative approach, using semi-structured interviews to document traditional knowledge and cultural practices related to the consumption of *Teredo* sp. Data collection was carried out with the free and informed consent of all participants, ensuring confidentiality and respect for individual and collective values, customs, and rights. As the study involved a low-risk public opinion survey with anonymous participants, no invasive procedures were performed, nor were any personal identities disclosed.

Experimental cultivation system and environmental conditions

The experimental cultivation system for the wood-boring bivalve (*Teredo* sp.) was designed to simulate the natural colonisation conditions of the species in an Amazonian estuarine environment. The experiment was conducted over a 12-month period, allowing for the evaluation of substrate colonisation, persistence and growth under realistic environmental conditions.

Ninety-five submerged woody substrates were used, as wood constitutes the primary natural habitat of teredinid bivalves. Logs of native hardwood species commonly found in the region's riparian vegetation (*Rhizophora mangle*) were obtained locally. The logs were cut into standardised sections approximately 1.0 m in length, with diameters ranging from 10 to 15 cm, ensuring uniformity among experimental units.

The wooden substrates were arranged horizontally and secured to simple support structures anchored to the riverbed. Fixation was achieved using nylon ropes and wooden stakes, providing stability while accommodating tidal water movement. The logs were positioned at depths ranging from 0.5 to 1.5 m, according to local bathymetry and tidal amplitude. Adjacent logs were spaced approximately 0.5 m apart, minimising physical interference while maintaining comparable exposure conditions.

The experimental substrates were exposed to the natural estuarine environment and subjected to daily tidal cycles, being fully submerged twice per day during high tides, with immersion periods lasting approximately 4 to 6 h per tidal cycle, depending on tidal amplitude. During low tide, the substrates remained partially submerged or were briefly exposed to air, reflecting the natural conditions experienced by woody substrates in the estuary.

No artificial induction or larval seeding was performed. Colonisation of the substrates occurred exclusively through the natural settlement of planktonic larvae present in the water at the study site. The substrates were inspected periodically to document colonisation intensity, the presence of burrows and structural degradation associated with *Teredo* sp. activity.

Water quality conditions in the Panacuéra River estuary were monitored continuously over the 12-month period, with weekly assessments, in order to characterise the environmental conditions under which colonisation and growth of *Teredo* sp. occurred. Water temperature, dissolved oxygen, pH and salinity were measured in situ using a portable multiparameter probe (Horiba U-50 Series, HORIBA Ltd., Japan). Turbidity was determined using the optical sensor attached to the instrument. Total alkalinity was determined in the laboratory following standard analytical methods and expressed as mg $CaCO_3$ L^{-1}. All measurements were taken during substrate immersion periods, thereby reflecting the environmental conditions actually experienced by the organisms.

Growth and colonization assessment

Colonisation was assessed through monthly inspections of the woody substrates. During these inspections, the logs were partially opened to allow the enumeration of individuals per unit of wood and the measurement of body length using a precision digital calliper. Individual growth was estimated based on the mean increase in body length over the period of substrate exposure in the environment, enabling a descriptive analysis of the dynamics of colonisation and development of Turu under natural environmental conditions.

Ethnobiological and socioeconomic perception

Ethnobiological and socio-economic data concerning the traditional use of Turu by riverside communities along the Panacuéra River, in the municipality of Abaetetuba, Pará, were collected between November 2024 and November 2025. The data collection aimed to document traditional knowledge related to the harvesting, consumption and cultural perception of the organism, as well as to characterise the socio-demographic profile of the riverside residents and their perceptions regarding cultural, sensory and environmental factors.

Information was obtained from 60 riverside residents, including artisanal fishermen and local extractivists, based on their empirical knowledge and practical experience with the harvesting and consumption of Turu. Participants included fishermen, shellfish gatherers, elderly individuals and young adults. The interviews addressed aspects such as seasonal occurrence, harvesting techniques, preparation and consumption methods, perceived abundance, food taboos, and the cultural significance of the organism for the local community, in accordance with Guazi (2021), Ruslin et al. (2022) and Batista et al. (2025).

Data analysis

The data were analysed using descriptive statistics, taking into account biological, productive and socio-environmental variables related to the experimental cultivation of *Teredo* sp. Quantitative variables included total biomass per log (kg), individual wet weight (g), body length (cm) and settlement density (number of individuals per linear metre of wood). These variables were expressed as mean values and observed ranges, as the primary objective of the study was the initial characterisation of the species' productive potential under natural cultivation conditions.

Settlement density was estimated from the direct count of individuals present on each woody substrate, while total biomass was determined by weighing all organisms removed from each log. Average individual weight was calculated as the ratio between total biomass and the number of individuals sampled. Qualitative information obtained from interviews with local extractivists was organised into thematic categories and analysed in an integrated manner alongside the biological and productive data, adopting a holistic approach to assess the cultivation potential of *Teredo* sp. within the context of family-based aquaculture and the sustainable utilisation of estuarine resources.

Results

Environmental conditions

During the monitoring period, water temperature ranged from 26 to 31 °C, while dissolved oxygen concentrations varied between 5.5 and 7.5 mg L^{-1}. Salinity exhibited pronounced fluctuations associated with tidal cycles and seasonal rainfall, predominantly ranging from 5 to 10 ppt. pH values generally remained between 6.5 and 8.0. Turbidity was consistently high throughout the sampling period, often exceeding 100 NTU, particularly during phases of increased sediment resuspension induced by tidal dynamics. Total alkalinity ranged from 40 to 120 mg $CaCO_3$ L^{-1}. All measurements were taken during periods of substrate immersion, thereby accurately reflecting the environmental conditions experienced by the organisms. These conditions are typical of Amazonian estuaries and are considered compatible with the biological requirements of bivalves in the family Teredinidae, providing a suitable environmental framework for evaluating the potential of Teredo sp. in low-intensity, low-input aquaculture systems.

Growth and colonization assessment

Visible colonisation of woody substrates by Turu (*Teredo* sp.) was observed after approximately 30–45 days of submersion, indicating rapid larval settlement under natural estuarine conditions. Settlement density ranged from 25 to 60 individuals per linear metre of wood, depending on the duration of substrate exposure and its location within the estuary. After 90 days of cultivation, individuals reached average lengths of 15–25 cm, demonstrating continuous growth.

At the end of the cultivation period, the total biomass removed per log ranged from 3 to 5 kg, depending on the intensity of colonisation and the characteristics of the substrate. Mean individual wet weight during intermediate growth stages varied between 5 and 15 g; this variation was influenced by organism size and the amount of residual wood present in the digestive tract at the time of collection. Individuals sampled 30–45 days after initial colonisation were classified as juveniles and generally weighed between 1 and 5 g.

After up to one year in the estuarine environment, individuals reached lengths of 40–50 cm, with individual weights ranging from 150 to 300 g, demonstrating high growth potential under natural conditions. These results highlight the ability of Turu to rapidly colonise woody substrates, exhibit substantial growth over time, and generate significant biomass, reinforcing its potential for low-intensity cultivation systems in Amazonian estuarine environments.

Overall, the proposed cultivation system performs well, being characterised by operational simplicity, low implementation costs, and the absence of a need for external inputs or food management, owing to the filter-feeding habits of the shipworm. Mortality was low and was mainly associated with the deterioration of the woody substrates, indicating that material quality and durability are the primary limiting factors of the system. The structure adopted allowed for straightforward management and demonstrated strong potential for adaptation to family- or community-based production systems (table 1).

Table 1. Evidence supporting the aquaculture potential of the wood-boring bivalve Turu (*Teredo* sp.) in an Amazonian estuary. Occurrence, local perception, colonization and growth parameters of Turu in the Panacuéra River.

Grouping	Variant	Outcome
① **Occurrence and habitat**	Distribution within the environment:	● Common in the Panacuéra River
	Preferred environment:	● Areas with the highest density of submerged logs near mangroves
② **Local use and perception**	Consumption:	● Traditional practices linked to regional culinary preparations
	Cultural value:	● Elevated with intensified taste and rich cultural significance
	Harvesting period:	● Preferably during periods of reduced rainfall
	Associated environmental conditions:	● Increased estuarine salinity
③ **Colonisation of woody substrates**	Start of colonisation:	● 30-45 days after log submersion
	Average density:	● 25-60 individuals per meter of wood length
	Factors that have a major influence:	● Exposure duration and estuary location
④ **Growth**	Average length after 90 days:	● 15-25 cm
	Growing conditions:	● Natural environment, without feed inputs

The set of productive characteristics of Turu, including high tolerance to environmental variations typical of estuarine ecosystems, relatively rapid growth, and adaptation to simple cultivation systems, reinforces its potential for alternative aquaculture with low environmental impact. In addition, prospects for its use in the context of the Panacuéra River indicate the feasibility of implementing systems based on the controlled introduction of woody substrates, with the potential for integration with other aquaculture activities or community-based management initiatives. The performance of the cultivation system, the productive advantages of the species, and the prospects for regional application highlight the potential of Turu as a strategic resource for productive diversification, income generation, and the strengthening of the Amazonian bioeconomy, in line with the principles of environmental and sociocultural sustainability (table 2).

Table 2. Evidence supporting the aquaculture potential of the wood-boring bivalve Turu (*Teredo* sp.) in an Amazonian estuary. Performance of the cultivation system, productive benefits, and potential for utilizing turu in the Panacuéra River.

Grouping	Aspect assessed	Elucidation
① Cultivation system performance	Operational complexity:	● Straightforward system, simple to deploy and oversee
	Implementation cost:	● Low, no external inputs required
	Feed management:	● Not required (filtering habit)
	Mortality:	● Very low
	Main limiting factor:	● Excessive deterioration of the woody substrate
	Scalability:	● High potential for family and community-based aquaculture
② Productive advantages	Environmental tolerance:	● High tolerance to the physical and chemical fluctuations of the estuaries
	Eating habits:	● Filter-feeding habits, with no associated feed costs
	Growth rate:	● Relatively quick under natural conditions
	System type:	● Extensive aquaculture, carried out using basic wooden structures
	Environmental impact:	● Potentially low
③ Cultivation prospects	Implementation strategy:	● Controlled introduction of submerged logs or wooden structures
	Productive integration:	● Strong potential for integrated multitrophic aquaculture (IMTA)
	Production scale:	● Suitable for family and community-based aquaculture
	Socioeconomic benefits:	● Production diversification and income generation
	Sustainability contribution:	● Valuing native species and traditional knowledge, a pillar for sustainability
	Integration into the bioeconomy:	● Alignment with Amazonian bioeconomy principles

Intense colonisation of the wooden logs was evidenced by the presence of multiple galleries drilled along the longitudinal axis of the substrates. After the logs were opened, numerous Turu individuals were identified within the galleries, exhibiting elongated bodies, whitish coloration, and a gelatinous texture, typical characteristics of teredinids. The distribution of individuals along the substrate indicates dense and continuous colonisation, with different developmental stages coexisting within the same log (figure 2).

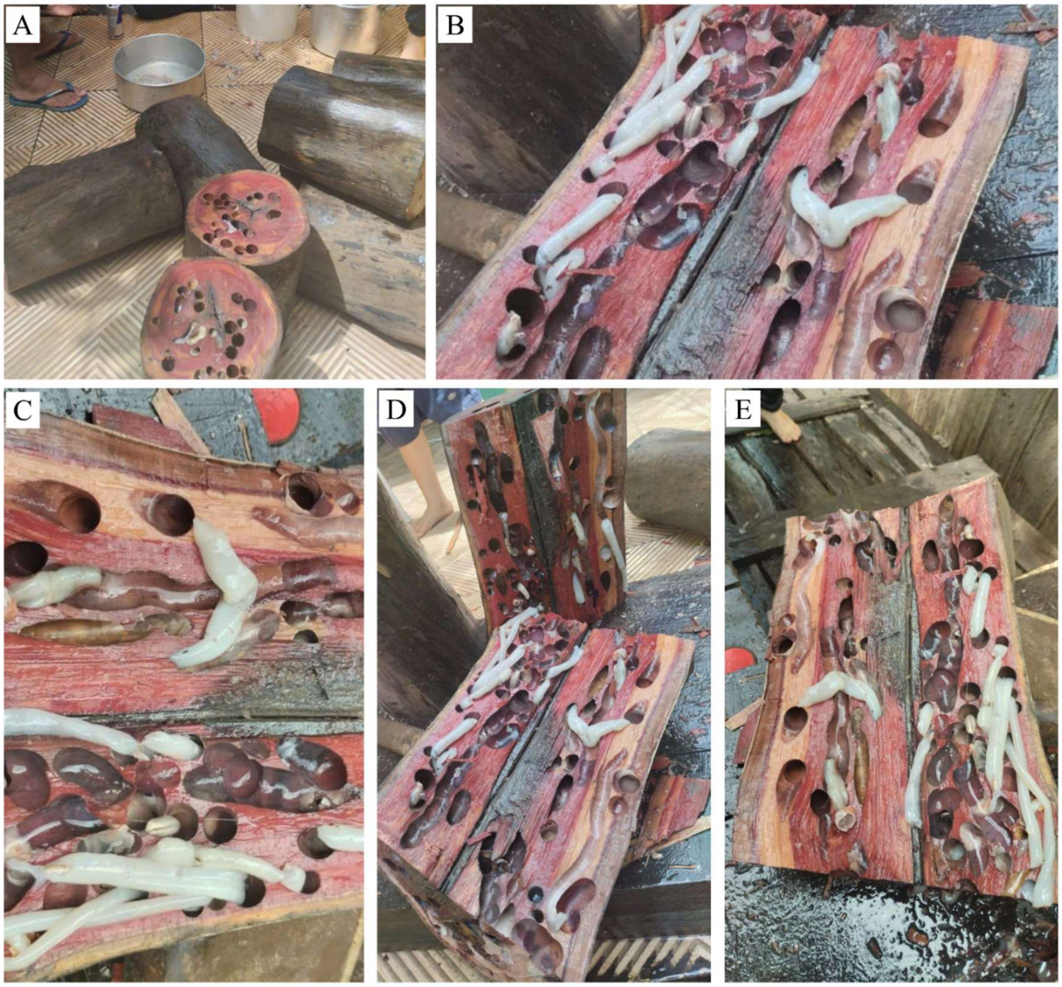

Figure 2. Wood substrates of (*Rhizophora mangle*) used for experimental cultivation of Turu (*Teredo* sp.) in the Panacuéra River, Abaetetuba, Pará. (A) Logs of *R. mangle* cut to verify Turu colonization. (B to D) Logs of R. mangle opened with various species colonizing the experimental substrate, evidence supporting the aquaculture potential of the wood-boring bivalve in an Amazonian estuary.

The logs were highly degraded and fragmented in the estuarine environment, reflecting the continuous activity of wood-boring molluscs. This pattern is consistent with the biological activity of teredinids and reinforces the ecological role of Turu in the degradation of woody substrates and the cycling of organic matter. Turu possesses small, whitish calcareous valves with pigmented bands, which are used to bore into wood. The observed morphology is consistent with the family Teredinidae and confirms the identity of the collected organism. Natural colonisation of submerged wooden structures, such as stakes and pillars, was also observed, with visible clusters of Turu adhered to the surface and base of these structures, indicating the feasibility of using such materials in experimental cultivation systems (Figure 3).

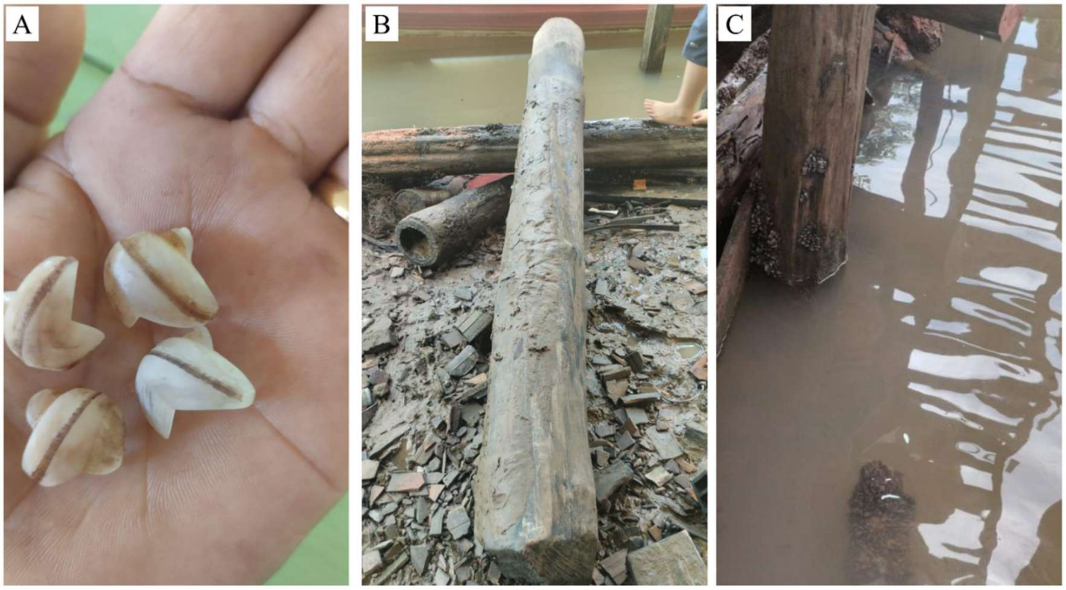

Figure 3. (A) Turu (*Teredo* sp.) has a small, calcareous shell that is split into two parts at the end of its head, featuring serrated grooves. The animal uses this structure as a drilling tool to scrape wood, forming calcareous galleries for its habitat. (B) Wood substrates of (*Rhizophora mangle*) used for experimental cultivation of Turu (*Teredo* sp.) in the Panacuéra River, Abaetetuba, Pará. (C) Logs of *R. mangle* fixed in the estuary.

Overall, the photographic records confirm the high availability of Turu in the studied environment, its strong association with submerged woody substrates, and its intense colonisation capacity, as well as the persistence of traditional collection and consumption practices. These findings underscore the biological, ecological, and sociocultural potential of Turu for application in community-based aquaculture systems.

Ethnobiological and socioeconomic perception

Respondents reported a widespread occurrence of Turu in the Panacuéra River, particularly in areas with a higher concentration of submerged logs and in close proximity to mangrove vegetation. The consumption of turu was described as a traditional practice strongly associated with regional cuisine, valued both for its flavour and its cultural symbolism. Collection occurs predominantly during periods of lower rainfall, when estuarine salinity tends to be higher.

Discussion

Turu (*Teredo* sp.) plays an important role in the food systems of Amazonian riverside communities beyond its direct production and consumption, contributing significantly to food security, diet, and local value chains (Leiwakabessy et al., 2022; Carmo-Santos et al., 2023; Batista et al., 2025). As an accessible resource in floodplain environments and submerged wood habitats, it serves as a complementary source of protein in contexts where other food sources may be scarce, strengthening the food resilience of these populations. From a dietary perspective, Turu complements a carbohydrate-based diet by providing protein and essential minerals and is associated with traditional cultural practices that reinforce local identities and the transmission of knowledge. In economic terms, its harvesting and sale in local markets integrate the product into short and informal value chains, generating supplementary income with low production costs (Batista et al, 2025). Thus, the cultivation of Turu could transform a currently opportunistic resource into a more stable, predictable, and sustainable component of riverside food systems, with positive impacts on food security, income generation, and environmental management.

The results of the present study provide initial experimental evidence of the aquaculture potential of the wood-boring bivalve mollusc Turu in the Amazon estuary. The study employed a passive, cost-effective cultivation system that relies on natural processes. Although preliminary, these data constitute an important foundation for assessing the technical and ecological feasibility of this species within the framework of sustainable Brazilian aquaculture. The findings on Turu cultivation are particularly relevant to the Brazilian aquaculture sector, as they promote sustainability, technical viability and socio-environmental considerations, especially in the Amazon region.

Historically, the development of mollusc, fish and crustacean aquaculture has followed a systematic progression, beginning with observational knowledge, low-cost extensive methods and a strong dependence on natural environmental factors. For example, marine fish farming originated in a rudimentary form in Indonesia around the year 1400. During this initial phase, juvenile milkfish (*Chanos chanos*) were captured from the natural environment and transferred to artificial ponds, where they were reared until reaching a suitable size for consumption (Shepherd and Bromage, 1988). In Brazil, fish-farming practices are believed to have originated in the state of Pernambuco during the Dutch occupation of the north-eastern region of the country between 1630 and 1654. These early systems focused primarily on the production of estuarine fish in tidal ponds, relying exclusively on tidal dynamics for water renewal and the recruitment of juvenile estuarine species such as mojarras (*Eugerres* sp. and *Diapterus* sp.), mullet (*Mugil* sp.) and snook (*Centropomus* spp.) (Valenti et al., 2021). This aquaculture approach remains in use today. In various regions of the world, marine fish farming continues to involve the capture and transfer of juvenile fish to ponds for fattening, allowing them to increase in size and weight before being marketed (Owatari et al., 2024).

An additional example of the importance of early-stage cultivation can be found in the farming of the mussel (*Perna perna*), which was first explored experimentally in the state of Santa Catarina in the late 1980s through mariculture trials conducted in different coastal areas, particularly in sheltered bays (Macedo et al., 2012). Today, Santa Catarina is the leading mollusc-producing state in Brazil. The history of aquaculture demonstrates that the successful establishment of a species is rarely immediate; rather, it is a gradual process that involves the accumulation of knowledge, technological refinement and adaptation to local ecological and social conditions. Therefore, Turu should not be regarded as a direct substitute for existing aquaculture species, but rather as a potential addition to a diversified portfolio of native species, especially in regions such as the Amazon, where sustainable and socially valuable production systems are prioritised.

The high levels of natural colonisation observed in the Panacuéra River further reinforce the environmental suitability of this estuary for the development of productive systems based on turu, a species of recognised importance to artisanal fisheries. Moreover, Amazonian macrotidal estuaries associated with extensive mangrove systems receive substantial inputs of sediments, organic matter and woody debris, creating conditions that sustain complex food webs and favour the integration of cultivation systems grounded in natural ecological processes and the use of local resources (Gomes et al., 2021). Although specific studies on the application of Turu in family-based aquaculture systems remain limited, evidence from analogous systems supports its potential as a complementary component capable of diversifying production, reducing economic risks, and enhancing the social and productive sustainability of these units (Saint-Paul, 2006; Checon et al., 2023).

The cultivation of Turu in Amazonian estuaries is emerging as an innovative and environmentally sustainable aquaculture practice that integrates the use of native biodiversity, traditional knowledge, and the principles of the regional bioeconomy (Almeida et al., 2020; Marques et al., 2025). Ecological and conceptual evidence supports its environmental viability and productive potential, particularly within low-intensity integrated systems (Varotto and Barreto, 1998). However, its establishment as a stable aquaculture activity requires the development of standardised management and health protocols, the assessment of estuarine carrying capacity, and the creation of governance instruments and public policies grounded in scientific evidence (Silva et al., 2020). If it is properly structured, Turu farming can significantly diversify production, strengthen local economies, and contribute to the conservation of Amazonian estuarine ecosystems (Delgado-Ramírez et al., 2023). Although direct studies on Turu cultivation remain limited, research on integrated aquaculture systems in the Amazon indicates enhanced productive performance and environmental benefits when multiple species are combined, suggesting similar potential for turu-based systems (Costa et al., 2025). Further research is needed to optimise cultivation methods and ensure sustainable expansion within the Amazonian estuarine context.

The findings of the present study emphasise the integration of Turu into the customary practices of riverside communities, particularly in relation to food gathering and consumption, as well as from an ecological perspective. This traditional use has been observed in Amazonian societies, where Turu serves as an important supplementary food source and cultural component, contributing to socio-ecological food systems that are interconnected with cultural, nutritional, and environmental dimensions (Almeida et al., 2020; Batista et al., 2025).

Nutritionally, Turu serves as a supplementary source of protein and micronutrients, contributing to the diversification of diets that are primarily carbohydrate-based, such as cassava, and helping to improve nutritional balance in settings with limited food variety (Almeida et al., 2020; Willer and Aldridge, 2020). In terms of food security, its consistent availability for direct consumption could serve as a valuable resource in remote areas, acting as a fallback food source during periods of protein scarcity and strengthening the food resilience of riverside communities (Leiwakabessy et al., 2022; Carmo-Santos et al., 2023; Batista et al., 2025). By promoting the cultivation of Turu, these benefits could potentially be enhanced and expanded, transforming a resource currently dependent on sporadic harvesting into a more reliable and locally managed asset. Furthermore, its filter-feeding habit and the absence of a requirement for food supplementation underscore its potential for low-intensity, community-based aquaculture systems, as proposed for teredinids in sustainable production approaches (Willer and Aldridge, 2020; Little et al., 2016). However, the pronounced degradation of the wood observed in the images indicates that substrate durability constitutes a limiting factor and should be considered in the development of management strategies and the planning of cultivation systems.

Conclusion

The experimental cultivation of Turu (*Teredo* sp.) was successful. Turu cultivation can therefore contribute to the diversification of regional aquaculture and the strengthening of the Amazonian bioeconomy. The species represents a biological resource of considerable socio-economic and cultural value, which remains largely unexplored in Amazonian aquaculture. As with other aquaculture activities, the consolidation of Turu cultivation depends on investment in scientific research, technical training, and sanitary regulation to ensure food safety, economic viability, and environmental conservation.

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References

ALMEIDA, A. M. F. DE, SANTOS, L. P., MORAES, J. L., SILVA, F. E. R., BICHARA, C. M. G., & ROSA, R. M. S. S. (2020). Avaliação físico-química de turus (Bivalvia: teredinidae) de Curuçá, Pará, Brasil/ Physical and chemical evaluation of turus (Bivalvia: teredinidae) of Curuçá, Pará, Brazil. Brazilian Journal of Development, 6(11), 87766–87776. https://doi.org/10.34117/bjdv6n11-266

BATISTA, D. V. V., CASTRO, L. A. M., BARROS, A. F., FARIAS, C. F. S., SOUZA, A. P., SILVA, A. V., DITTRICH, C. C. L., LOPES, E. M., BRASIL, E. M., OWATARI, M. S., MOURIÑO, J. L. P., & MARTINS, M. L. (2025). Food use, behavioral and cultural significance of the wood-boring mollusc Turu (Teredo sp.) in the Brazilian Amazon. Food and Humanity, 6, 100961. https://doi.org/10.1016/j.foohum.2025.100961

CARLINO-COSTA, C., & BELO, M. A. D. A. (2025). Ensuring fish safety through sustainable aquaculture practices. Hygiene, 5(4), 51. https://doi.org/10.3390/hygiene5040051

CARMO-SANTOS, E., SANTOS, M. R., ROCHA-BARREIRA, C. D. A., & MAIA, R. C. (2023). Characterization and distribution of Teredinidae assemblage in an estuary in Ceará, Brazil's Northeast. Brazilian Journal of Biology, 83, e272066. https://doi.org/10.1590/1519-6984.272066

CHECON, H. H., CORTE, G. N., CUNHA, B. P., SHAH ESMAEILI, Y. M., FONSECA, G., & AMARAL, A. C. Z. (2023). Macro-and meiofaunal communities in brazilian mangroves and Salt Marshes. In Brazilian Mangroves and Salt Marshes (pp. 155-178). Cham: Springer International Publishing. https://doi.org/10.1007/978-3-031-13486-9_9

COSTA, J. I., DE FREITAS, R. A., NETO, M. P. N., DE SENA, A. P. N., BEZERRA, D. B., NASCIMENTO, C. F., NATIVIDADE, J. A. S., & DA SILVA, T. B. A. (2025). Integrated multitrophic aquaculture improves the production performance of Amazonian fishes in nursery phase. Aquaculture, 600, 742240. https://doi.org/10.1016/j.aquaculture.2025.742240

Delgado-Ramírez, C. E., Ota, Y., & Cisneros-Montemayor, A. M. (2023). FISHING AS A LIVELIHOOD, A WAY OF LIFE, OR JUST A JOB: CONSIDERING THE COMPLEXITY OF "FISHING COMMUNITIES" IN RESEARCH AND POLICY. REVIEWS IN FISH BIOLOGY AND FISHERIES, 33(1), 265-280. HTTPS://DOI.ORG/10.1007/S11160-022-09721-Y

FLORES-IWASAKI, M., MARCIAL-RAMOS, R., DEL ÁGUILA-PANDURO, E., SILVA-ZUTA, M. Z., CAYO-COLCA, I. S., & CHÁVEZ, S. G. (2025). Enhancing Aquaculture Productivity via Polyculture with Colossoma macropomum: A Focus on Two Native Amazon Species. Fishes, 10(11), 563. https://doi.org/10.3390/fishes10110563

GOMES, V. J., ASP, N. E., SIEGLE, E., GOMES, J. D., SILVA, A. M., OGSTON, A. S., & NITTROUER, C. A. (2021). Suspended-sediment distribution patterns in tide-dominated estuaries on the eastern Amazon coast: geomorphic controls of turbidity-maxima formation. Water, 13(11), 1568. https://doi.org/10.3390/w13111568

GUAZI, T. S. (2021). Diretrizes para o uso de entrevistas semiestruturadas em investigações científicas. Revista Educação, Pesquisa e Inclusão, 2. https://doi.org/10.18227/2675-3294repi.v2i0.7131

GUL, S., SHAFIQ, U., MIR, S. A., IQBAL, G., & LONE, H. Q. (2024). Enhancing global food security through sustainable fisheries and aquaculture: a comprehensive review. Asian Journal of Agricultural Extension, Economics & Sociology, 42(10), 60-70. https://doi.org/10.9734/ajaees/2024/v42i102563

HILSDORF, A. W. S., HALLERMAN, E., VALLADÃO, G. M. R., ZAMINHAN-HASSEMER, M., HASHIMOTO, D. T., DAIRIKI, J. K., TAKAHASHI, L. S., ALBERGARIA, F. C., GOMES, M. E. S., VENTURIERI, R. L. L., MOREIRA, R. G., & CYRINO, J. E. P. (2022). The farming and husbandry of Colossoma macropomum: From Amazonian waters to sustainable production. Reviews in Aquaculture, 14(2), 993-1027. https://doi.org/10.1111/raq.12638

IBGE (2025) Instituto Brasileiro de Geografia e Estatística. Disponível em: https://cidades.ibge.gov.br/brasil/pa/abaetetuba/panorama Acesso em: 26 de janeiro de 2026.

LEIWAKABESSY, J., YAHYA, Y., FADJAR, M., & SUPRAYITNO, E. (2022). Identification of Tambelo (Bactronophorus thoracites) in Wamesa Waters, Manokwari, West Papua, Indonesia. Biodiversitas Journal of Biological Diversity, 23(11). https://doi.org/10.13057/biodiv/d231157

LEONEL, R. M. V., LOPES, S. G. B., & AVERSARI, M. (2002). Distribution of wood-boring bivalves in the Mamanguape River estuary, Paraíba, Brazil. Journal of the Marine Biological Association of the United Kingdom, 82(6), 1039-1040. https://doi.org/10.1017/S002531540200663X

LITTLE, D. C., NEWTON, R. W., & BEVERIDGE, M. C. M. (2016). Aquaculture: a rapidly growing and significant source of sustainable food? Status, transitions and potential. Proceedings of the Nutrition Society, 75(3), 274-286. https://doi.org/10.1017/S0029665116000665

MACEDO, P. P. B. D., MASUNARI, S., & CORBETTA, R. (2012). Crustáceos decápodos associados às cordas de cultivo do mexilhão Perna perna (Linnaeus, 1758) (Mollusca, Bivalvia, Mytilidae) na Enseada da Armação do Itapocoroy, Penha-SC. Biota Neotropica, 12, 185-195. https://doi.org/10.1590/S1676-06032012000200018

MARQUES, A.R., BATISTA, D.V. V., FARIAS, C.F. S., CASTRO, L.A. M., BRASIL, E.M., FERREIRA, M.B., SOUZA, A.P., SAMPAIO, D.S., LOPES, E.M., MOURIÑO, J.L. P., MARTINS, M.L. (2025). Chapter 1: Commercialization dynamics of turu Teredo sp.: Tradition and economy in the Atlantic Amazon. In: Batista, D.V. V.; Silva, A.V.; Mouriño, J.L. P. & Martins, M.L. (Eds.), Commercial dynamics of Amazonian species (Vol. 1, pp. 11-22). https://repositorio.ufsc.br/handle/123456789/265449

MIKKOLA, H. (2024). Aquaculture and Fisheries as a Food Source in the Amazon Region-A Review. Food & Nutrition Journal, 9(286), 1-26. https://www.doi.org/10.29011/2575-7091.100186

OHIA, C. M. D. (2025). Aquaculture Technologies and Practices: Balancing Innovation, Environment and Economy for Sustainability. In Food Security, Nutrition and Sustainability Through Aquaculture Technologies (pp. 417-424). Cham: Springer Nature Switzerland. https://doi.org/10.1007/978-3-031-75830-0_23

OLIVA, P. A. C., REIS, J. A. D., GOMES, K. P., PENA, R. T., NUNES, I. S., SANTOS, S. D. C. D., & CORREIA, K. A. (2024). Subsurface evaluation for aquaculture ponds in the Amazon Region. Revista Brasileira de Ciência do Solo, 48, e0230101. https://doi.org/10.36783/18069657rbcs20230101

OLIVA, P. A. C., TEXEIRA, F. D. A. D. S., DOS REIS JUNIOR, J. A., PENA, R. W. T., & SANTOS, A. D. S. (2025). Selection of Sustainable Locations for Fish Farms in the Amazon Region of Northern Brazil Using Geophysical and Sedimentological Data. IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, 18, 25204-25220. https://doi.org/10.1109/JSTARS.2025.3612299

OWATARI, M. S., CERQUEIRA, V. R., BALOI, M. F., CIPRIANO, F. D. S., MANZONI, G. C., STERZELECKI, F. C., & MAGNOTTI, C. (2024). Low-Trophic-Level Species Sardinella brasiliensis in Aquaculture: Crosstalk Between Aquaculture and Fisheries. Reviews in Fisheries Science& Aquaculture, 32(4), 679-697. https://doi.org/10.1080/23308249.2024.2362236

PACHECO, F. S., HEILPERN, S. A., DILEO, C., ALMEIDA, R. M., SETHI, S. A., MIRANDA, M., RAY, N., BARROS, N. O., CAVALI, J., COSTA, C. R., DORIA, C. R., FAN, J., FIORELLA, K. J., FORSBERG, B. R., GOMES, M., GREENSTREET, L., HOLGERSON, M., MCGRATH, D., MCINTYRE, P. B., MORAES-VALENTI, P., OLIVEIRA, I., OMETTO, J. P. H. B., ROLAND, F., TRINDADE, A., UMMUS, M. E., VALENTI, W. C., XU, X., GOMES, C. P., & FLECKER, A. S. (2025). Towards sustainable aquaculture in the Amazon. Nature Sustainability, 8(3), 234-244. https://doi.org/10.1038/s41893-024-01500-w

PALHETA, G. D. A., JESUS, A. M. B. S. D., LIMA, L. M., GUERREIRO, S. L. D. M., MELO, N. F. A. C. D., LUZ, R. K., STERZELECKI, F. C., & GALVÃO, J. R. (2025). Evaluating the Productivity of Jambu (Acmella oleracea) with Effluent from Tambaqui Culture: An Integrated Aquaculture-Agriculture Approach for the Amazon. Agriculture, 15(22), 2332. https://doi.org/10.3390/agriculture15222332

PENA, R. W. T., OLIVA, P. A. C., & ABRUNHOSA, F. A. (2023). Application of the Ground Penetrating Radar (GPR) and Electromagnetic (EM34-3) Geophysical Tools and Sedimentology for the Evaluation of the Subsurface of Sites Earmarked for Aquaculture Ponds in the Amazon Region of Northern Brazil. Applied Sciences, 13(19), 11107. https://doi.org/10.3390/app131911107

RUSLIN, R., MASHURI, S., RASAK, M. S. A., ALHABSYI, F., & SYAM, H. (2022). Semi-structured Interview: A methodological reflection on the development of a qualitative research instrument in educational studies. IOSR Journal of Research & Method in Education (IOSR-JRME), 12(1), 22-29. https://doi.org/10.9790/7388-1201052229

SAINT-PAUL, U. (2006). 12 Interrelations among Mangroves, the. Environment and Livelihoods in Tropical Coastal Zones: Managing Agriculture-fishery-aquaculture Conflicts, 2, 154.https://doi.org/10.1079/9781845931070.01

Shepherd J, Bromage NR. 1988. Intensive fish farming. Oxford: BSP Professional Books.

SILVA, F. N. L., MENDONÇA, R. C., DE QUADROS, M. L. A., DE OLIVEIRA, L. C., MACEDO, A. R. G., SILVA, O. L. L., & DE ARAUJO OLIVEIRA, L. A. (2020). Students as promoters of rural extension in aquaculture in the Marajó archipelago, Pará, Brazil. Revista Brasileira de Educação do Campo, 5, e8936-e8936. https://doi.org/10.20873/uft.rbec.e8936

VALENTI, W. C., BARROS, H. P., MORAES-VALENTI, P., BUENO, G. W., & CAVALLI, R. O. (2021). Aquaculture in Brazil: past, present and future. Aquaculture Reports, 19, 100611. https://doi.org/10.1016/j.aqrep.2021.100611

VAROTTO, R. S., & BARRETO, C. C. (1998). Colonization of artificial substrata by teredinid larvae released from a previously infested focus at Ilha Grande Bay, RJ. Brazilian Archives of Biology and Technology, 41, 391-400. https://doi.org/10.1590/S1516-89131998000400002

WEBBER, H. H., & RIORDAN, P. F. (1976). Criteria for candidate species for aquaculture. Aquaculture, 7(2), 107-123. https://doi.org/10.1016/0044-8486(76)90001-6

WILLER, D. F., & ALDRIDGE, D. C. (2020). From pest to profit-The potential of shipworms for sustainable aquaculture. Frontiers in Sustainable Food Systems, 4, 575416. https://doi.org/10.3389/fsufs.2020.575416