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# BRAZILIAN MARINE FISH FARMING: CHALLENGES AND PROSPECTS FOR ITS DEVELOPMENT IN THE STATE OF CEARÁ

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## ABSTRACT

Fishing is still the largest provider of marine fish for human consumption. However, given the notorious threat to fish stocks and the growing demand for the product, this scenario needs to change and marine fish farming continues to be pointed out worldwide as a viable measure to remedy this situation. Thus, the objective of this article is to discuss marine fish farming in Brazil, focusing on the challenges and perspective of its development in the state of Ceará. During the six-month period, the methodology of the work consisted of three tools: bibliographic survey, interviews and technical visits. The results obtained show that, despite all the public and private initiatives, marine fish farming in Brazil remains incipient and with obstacles to overcome. As far as Ceará is concerned, the state, through a development agency, has been carrying out actions with the purpose of opportunizing the development of marine fish farming. Among the actions planned, the elaboration of a laboratory project to provide fish fry of marine species is being carried out initially, simultaneously with its analysis of the financial economic viability, and the prospection of profitable species for production in the state, whose preliminary conjecture has pointed out to *Lutjanus synagris* (ariacó) and, above all, *Lutjanus analis* (cioba).

**Descriptors:** Aquaculture; Mariculture; Fish farming; Marine.

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## 1. INTRODUCTION

According to Brazilian legislation, aquaculture is the activity of cultivating organisms whose life cycle under natural conditions takes place totally or partially in an aquatic environment, implying the ownership of the stock under cultivation, equated to the agricultural activity (Brazil, 2009). Among the categories of aquaculture we have mariculture, which consists of the production of aquatic organisms specifically in salt or brackish water, with a general emphasis on marine algiculture (seaweed farming), echinoderms (echinoderms farming), marine malacoculture (molluscs farming), marine *carcinicultura* (crustaceans farming) and marine fish farming (sea fish farming).

Of the world fish production in 2018, corresponding to 178.5 million tons, 96.4 million were supplied by fisheries and 82.1 million by aquaculture. Of the 82.1 million tons coming from aquaculture, 30.8 million were produced by mariculture, of which 7.3 million tons are specifically from marine fish production (FAO, 2020).

Despite the 84.4 million tons of fish produced by fisheries, specifically marine fisheries, it is clear that fishing grounds of commercial interest have already been threatened with over-exploitation, or were over-exploited, and in contrast to preservation, the demand for this type of product is growing (FAO, 2020). This problem reinforces the need to implement effective and sustainable alternatives to provide this source of high biological value protein, which is fish (Camargo; Pouey, 2005; Gonçalves, 2011). Since marine fish farming is pointed out worldwide for this purpose, this article seeks to conduct a discussion on marine fish farming in Brazil, focusing on the challenges and perspective for its development in the state of Ceará.

## 2. METHODOLOGY

For this proposal, the methodology used consisted of three data collection techniques, performed over a period of six months, with two months spent at each stage: bibliographic survey, interviews and technical visits.

The bibliographic review was carried out in scientific journals holding Qualis Capes, specialized technical journals and official electronic portals of companies (i.e. Embrapa, Epagri), which develop actions in the area of Mariculture. Terms such as “Mariculture”, “Marine Fish Culture” and “Production of Marine Fish” were used to conduct the bibliographic survey. During the literature review, terms related to the scientific and common names of marine fish species (i.e. *bijupirá*, *Rachycentron*, *goldfish*, *Lutjanídeos*) were also used, pointed out for captive production in the topics covered (i.e. reproduction, larviculture and nutrition) in the main public and private actions, carried out and in progress, and in the current status of the activity. The interviews were conducted with the five main researchers who play and played active roles in the scenario of marine fish farming in Ceará and Brazil, with the two current, and only, commercial producers of marine fish fattening, with the current, and only, commercial company supplying marine fish fry, with a former producer of marine fish fattening, with the former main supplier of inputs for the production of live food and marine fish larviculture, and with the commercial representatives of the two current companies supplying marine fish feed. The interviewees (researchers, producers, former producers and commercial representatives) were questioned about their history of performance in the marine fish farming scenario, what are the main obstacles faced and perspectives, or not, for the sector. The technical visits in turn were directed to four reference laboratories in marine fish farming research, two active in Brazil (Rio Grande do Sul and Santa Catarina), one in Ceará (currently inoperative specifically in the marine fish farming line), and one in Colombia.

## 3. RESULTS

### Overview of marine fish farming in Brazil

Worldwide, the origin of marine fish farming is unknown. The Classical Work of Fish Farming, considered the first record, seems to have been written in the year 500 B.C. by a Chinese politician called Fan Lei (Pillay, 1993). The development of marine fish farming on a commercial scale occurred in Japan in the 1960s with the discovery that the rotifer (a type of zooplankton) could be used as live food for marine fish larvae. (Hirata, 1979; Cerqueira, 2004; Côrtes; Tsuzuki, 2010). The most recent figures point to world production of 7.3 million tons of marine fish, with salmon (*Salmo salar*) being the main species, and Norway and Chile the main producers of salmon (FAO, 2020).

In Brazil, the breeding of marine fish through capture and confinement in nurseries began in the state of Pernambuco in the 17th century, when the Dutch occupied the region. During this period, the main species kept in extensive tidal nursery systems in the municipalities of Recife and Olinda were sea bass (*Centropomus*), mullets (*Mugil*) and carapebas (*Eugerres* and *Diapterus*) (Von Ihering, 1932; Cavalli; Hamilton, 2009). In the 1930s, Schubart (1936) estimated that there was an annual production of 25 tons in an area of 43 hectares of nursery in the region of Recife.

In general, the criteria used to select marine fish species with potential for production in captivity are: to have a market price, to breed in captivity (to supply fry), to adapt to

captivity and to the consumption of artificial diet (feed), to have potential for growth in captivity, and to be resistant (rustic species) and easy to manage (Sampaio *et al.*, 2001; Tutman *et al.*, 2004; Cavalli; Hamilton 2007; Cunha *et al.*, 2013; Cerqueira *et al.*, 2017).

Based on these criteria, mullets (*M. liza*), sole (*Paralichthys orbignyanus*), sea bass (*Centropomus parallelus* a *C. undecimalis*), bijupirás (*Rachycentron canadum*), goldfish (*Lutjanus spp.*), groupers (*Epinephelus marginatus*) and, more recently, sardines (*Sardinella brasiliensis*), were the outstanding species, in distinct periods, pointed out as potential for marine fish production in Brazil (Alvarez-Verde *et al.*, 2015; Baldisserotto; Gomes, 2010; Baloi *et al.*, 2014; 2017; Benetti *et al.*, 2002; 2008; Benetti; Fagundes, 1980; Boglione *et al.*, 2009; Bourque; Phelps, 2007; Boza-Abarca *et al.*, 2008; Cabrera *et al.*, 1998; Cabrita *et al.*, 2009; Carvalho *et al.*, 2010; 2019; Carvalho *et al.*, 2019; Cavalli *et al.*, 2011; Cavalli; Hamilton, 2009; Caylor *et al.*, 1994; Cerqueira; Tsuzuki, 2009; Clarke *et al.*, 1997; Cunha *et al.*, 2013; Emata, 2003; Gesteira; Rocha, 1976; Glamuzina *et al.*, 1998; Godinho *et al.*,1993; Guinle *et al.*, 2015; Hamilton *et al.*, 2013; Ibarra-Castro; Alvarez-Lajonchere, 2009; 2011; Kerber *et al.*, 2012; Lanes *et al.*, 2010; Leu *et al.*, 2003; Liebl *et al.*, 2016; Maltez *et al.*, 2019; Marino *et al.*, 2000; 2003; Muhlia-Melo *et al.*, 2003; Okamoto *et al.*, 2006; 2012; Papanikos *et al.*, 2008; Passini *et al.*, 2016; 2018; Pereira, 2010; Phelps *et al.*, 2009; Rocha *et al.*, 2008; Russo *et al.*, 2009; Sampaio *et al.*, 2007; 2016; Silva, 2013; Souza *et al.*, 2016; Sterzelecki *et al.*, 2017; Turano *et al.*, 2000; Watanabe *et al.* 1998). However, despite all the research and efforts conceived over the years, the commercial production of the Brazilian marine fish culture was effected for a very short period, specifically with the production of the species *Rachycentron canadum*.

According to the researchers interviewed, initially, given the economic losses related to the fall in production of sea shrimp (*Litopenaeus vannamei*) due to illness, some companies began to evaluate the opportunity of producing other species. In this context, bijupirá (*Rachycentron canadum*), or beijupirá or *cação de escama*, emerged as a target species in studies aimed at the development of marine fish farming in Brazil, because of its characteristics, in particular, its growth performance in captivity, the viability of fry production and the fact that it is a native species.

The first spawning of the species occurred in 2006, at the Marine Fish Reproduction Laboratory of the company Bahia Pesca, which can be considered a milestone in the history of Brazilian marine fish farming (Sampaio et al., 2010). However, it was the company Aqualíder that, at the end of 2009, marketed the first production of bijupirá in captivity in Brazil, which corresponded to the volume of 49 tons (MPA, 2011).

It was around the year 2008 that the company Aqualíder began to dedicate itself to the production of cobia in captivity, seeking, besides the concession of areas, a partnership with the Federal Rural University of Pernambuco (UFRPE). In fact, the company acquired the onerous permission to use, for 20 years, a total area of 169 hectares, of which 2.36 were specifically destined for cultivation, located 11 km from Boa Viagem beach, Pernambuco (Cavalli; Hamilton, 2009). For the cooperation with UFRPE, a Brazilian protocol for fry production was established and consolidated. Then, the company implemented a laboratory specifically for the production of fingerlings and proceeded with the installation of three offshore cages (of the 48 projected), where the first Brazilian production (fattening) occurred in marine fish farming. After this period, problems such as cage damage due to the collision of boats, the poor quality of feed available on the market, the development of diseases, the lack of insurance in Brazil for the activity and the lack of qualified labor caused the closure of the company in 2010 (Cavalli *et al.*, 2011).

In the private sector, Itapema, located in São Sebastião, São Paulo, also stood out. According to a former entrepreneur interviewed, Itapema began producing fry and fattening *Rachycentron canadum* in nearshore cages in 2011, but in 2016, mainly for nutritional reasons and environmental licensing issues, it closed its activities.

In the scenario of public promotion, in 2007, with the same impetus to develop sustainable technologies for the creation of cobia, the Research and Development Network in Marine Fish Culture (REPIMAR - *Rede de Pesquisa e Desenvolvimento em Piscicultura Marinha*) was created in Brazil, as well as two sub-networks. REPIMAR, with the project Development of sustainable technologies for the creation of cobia in Brazil, brought together Brazilian expertise in marine fish farming to develop studies on the themes of genetics, nutrition, health, production systems and fish processing throughout the Brazilian territory. This network was composed of several institutions, such as public universities, research foundations, and Embrapa, and ended its activities in 2012.

Likewise, in 2009, UFRPE counted on the financing of the then Ministry of Fisheries and Aquaculture (MPA) for the execution of the Cação-de-Escama Project: cultivation of cobia by artisanal fishermen of the coast of Pernambuco, from which there was the installation of a farm to create cobia. According to the researcher responsible, the project aimed to train fishermen in the metropolitan region of Recife, determine technical and economic parameters to make viable the sustainable creation of cobia in Brazilian conditions, and collaborate with a series of scientific studies linked to REPIMAR. This project ended its activities in December 2012.

S&G Journal
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This being said, it can be assumed that the main initiatives, public and private, and the imminent glimpse of the development of the productive chain of marine fish farming in Brazil, which, currently, based on research and interviews conducted with current and former members of this sector, is summarized in a private laboratory for the production of fry of bijupirá and grouper (*Epinephelus marginatus*), located in Ilha Bela - SP, and in four private companies of extensive fattening of bijupirá in cages: one on the island of Búzios, São Sebastião - SP; one in Ubatuba - SP; one in Angra dos Reis - RJ; and one in Vitória - ES. There is also a private partnership (Pousada Náutillus - RJ) and a public one (Rio de Janeiro City Hall and UERJ) for the production of fry and fattening of bijupirá in nearshore cages.

Two private companies commercialize specific feeds for marine species in granulometries for the different phases of development, one of which, according to its commercial representative, carries out the production and "beating" of the feed, from the minimum demand of 4,000kg or 160 bags of 25kg per millimeter. The products of enrichers, in turn, which are essential in the production of live food for marine fish larviculture, according to a former supplier, are no longer available on the local market due to the decline in demand. Thus, according to the entrepreneurs of the fry production sector, what remains is the import of these products, which raises production cost, or the elaboration of artisanal formulas, which, according to some technicians of the visited laboratories, has been a practice used by some research laboratories active in the field of marine fish farming.

The fact is that the finding made in 2003 by Roubach et al. (2003), that marine cut fish farming was not a commercial activity in Brazil, remains valid. The information available on Brazilian marine fish farming is basically from scientific research and, despite its relevance, is one of the parts of the effort needed to enable the development of the activity. Circumstances point to indications that past experiences have generated fear about the viability of the sector and the decline of investments, private and public, making the current scenario for the development of the marine fish production chain in Brazil even more challenging. Thus, despite the evident potential, large-scale marine fish farming production remains nonexistent.

**Challenges and prospects for marine fish farming in Ceará state**

According to Ostrensky and Boeger (2008), the absence of fry suppliers on a commercial scale, of adequate commercial feed, of the determination of areas for crops, and of market support infrastructure and the difficulty of environmental licensing are the main challenges for the establishment of the marine fish production chain. The lack of local supply of other inputs (live food enrichers), acquired via imports and skilled labor are other factors that should also be considered, given the significant contribution of these factors in increasing production costs. Therefore, as it is a high cost activity and a potential for long-term production increase (Ostrensky et al., 2008), the investment of resources in the sector should be advocated and weighted by economic feasibility and execution studies.

Until the present moment there are no records of marine fish production for cutting (meat production) in the state of Ceará, and fishing is the great responsible for supplying this demand. However, equally to the global and Brazilian scenario, Ceará's fishing stocks of commercial interest are on the list of species threatened with overexploitation or being overexploited (MMA, 2005), reiterating the need for effective and sustainable alternatives to promote the supply of marine fish (Camargo; Pouey, 2005; Gonçalves, 2011). Aware that fishing is increasingly ineffective at meeting growing demand, the government of the state of Ceará is seeking to identify these alternatives.

The potential of Ceará for the development of marine fish farming is notorious. The state possesses 573 km of coast with characteristics that make possible the development of the marine pisciculture, in addition to the absence of significant oscillations in the temperature and to possess in its native fauna species appreciated by the consumers of market value, as the "goldfish". The term "goldfish" refers to those belonging to the Lutjanidae family, which are prominent worldwide, nationally and regionally (Popma; Masser, 1999; Benetti et al., 2002; Velarde et al., 2012), and they are usually marketed in the "whole", "fresh" or "frozen" fashion, with an average price in Ceará ranging, according to the species, between 14.00 and 25.00 Reais per kilo (Allen, 1985; Ceasa-CE, 2020).

Ceará emerges in this scenario, adding to its Aquaculture Development Plan of the State of Ceará actions aimed at promoting the sustainable development of marine fish farming in the state. These measures have been promoted and implemented through the Ceará Foundation for Scientific and Technological Development Support (FUNCAP), through the Chief Scientist Program, associated with the Coordination of Development of Family Fisheries and Aquaculture (COPEA) of the Secretariat of Agricultural Development (SDA - *Secretaria do Desenvolvimento Agrário*). According to the head scientist of the program's aquaculture nucleus, the actions are initially directed towards the supply of fingerlings of marine fish species and the analysis of species suitable for this purpose. As a measure for the supply of fingerlings, a laboratory project for the production of marine fish fingerlings is being developed together with the execution of an economic and financial feasibility study.

On the other hand, the prospecting for species suitable for captive production in the state of Ceará has verified that, among the species of marine fish pointed out as propitious to production in captivity, are two Lutjanids: *Lutjanus synagris* and *Lutjanus analis* (Watanabe *et al.*, 1998; Benetti *et al.*, 2002; Botero; Ospina, 2002; Vettorazzi *et al*., 2010; Cerqueira *et al*., 2017). The commercial production of Lutjanids is already a reality in many countries, such as Costa Rica (*L. guttatus*), Hong Kong (*L. russelli*), Taiwan (*L. bohar*), Singapore (*L. goldiei*), Filipinas (*L. spp*.) and Malaysia (*L. argentimaculatus*) (Lucas; Southgate, 2012). In due course, *Lutjanus synagris* and *Lutjanus analis* are part of the group of native species highlighted previously by the appreciation by consumers and their market price.

The species *Lutjanus synagris* (ariacó) is distributed in the Western Atlantic Ocean, from the state of North Carolina (USA) to the state of São Paulo (Brazil) (Souza et al., 2016). They can reach up to 60 cm, presenting sexual maturity between 15 and 18 cm and can reach 3.8 kg (Sanches; Cerqueira, 2010). The *Lutjanus analis* (cioba), considered one of the tastiest marine fish species (Watanabe et al., 1998), occurs in the Western Atlantic, from New England to the southeast of Brazil, but it has been showing a drastic reduction in its abundance and distribution (Menezes; Figueiredo, 1980; Anderson, 2002; Menezes *et al*., 2003; Ávila-da-Silva *et al*., 2007; Froese; Pauly, 2008). They can reach 80 cm and weigh 11 kg, reaching sexual maturity at the age of four, when they are longer than 50 cm (Claro; Lindeman, 2008). Both species have a carnivorous feeding habit and feed mainly on fish and crustaceans (Randall, 1967; Menezes; Figueiredo, 1980; Bohlke; Chaplin, 1993; Anderson, 2002; Menezes *et al*., 2003; Ávila-da-Silva *et al*., 2007; Froese; Pauly, 2008).

The species prospecting actions verified that several studies in Brazil and Ceará found that *Lutjanus synagris* and *Lutjanus analis* adapt to captivity and consumption of inert food (feed), and are rustic species, resistant to management and with growth potential in captivity (Watanabe *et al.*, 1998; Benetti *et al.*, 2002; Botero; Ospina, 2002; Vettorazzi *et al*., 2010, Freitas *et al.*, 2011). However, it is observed that while the bibliography related to the ariacó (*Lutjanus synagris*) presents data referring to its spawning in captivity and registration of larviculture punctually until the 30th day after hatching (Facundo, 2016; Souza, 2012; Souza *et al*., 2016), the data on the cioba (*L. analis*) portray spawning, larviculture and production of successful juveniles, besides pointing it as one of the best perspectives for commercial production (Clarke *et al.*, 1997; Watanabe *et al.*, 1998; Feeley; Benetti, 1999; Feeley et al., 2000; Watanabe *et al.*, 2001; Benetti *et al.*, 2002; Botero-Arango; Castano-Rivera, 2005). In view of this, the prospection of species has been focused especially on *Lutjanus synagris* (ariacó) and, above all, *Lutjanus analis* (cioba).

Through the continuity of initiatives and actions of fomentation, researches, as well as public and private investments, the scenario points to a promising possibility for the commercial production of marine fish farming for cutting in the state of Ceará.

## CONCLUSION

Over the years, scientific research has been carried out, public and private initiatives have been implemented and, to a lesser extent, enterprises have been implemented. However, the development of marine fish farming in Brazil remains incipient and with obstacles to overcome. Despite past experiences and the details that hinder and hamper its evolution in Brazil, marine fish farming is a reality in other countries and continues to be pointed out worldwide as a viable option, especially in relation to maintaining the supply of fish as a source of high quality protein, through population growth, reducing the exploitation of commercial fish stocks, and regional development. These purposes are the foundations to persist in the improvement and in the search for innovations and strategies to boost the sector and finally convert the Brazilian circumstance from potential to effective.

Regarding Ceará, some actions to promote marine fish farming have been carried out. The partial results of these measures have provided the elaboration of a laboratory project to supply fry of marine species to the state, together with the execution of an economic and financial feasibility study, and the prospecting of species for captive production have been focused on *Lutjanus synagris* (ariacó) and, above all, *Lutjanus analis* (cioba).

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S&G Journal
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