

THE CULTIVATION OF *Epinephelus marginatus* (Iowe, 1834) IN BRAZIL: A SCIENTOMETRIC APPROACH AND STUDY PROSPECTS

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ABSTRACT

This production aimed to carry out a scientometric approach to research involving the cultivation of *Epinephelus marginatus* in Brazil from 2002 to 2022, using different virtual databases. Based on scientometrics, the data was analyzed qualitatively and quantitatively to generate perspectives on the subject. We found 20 academic-scientific productions developed by authors in different parts of the country, with a predominance of dissertations, theses, and articles. The time distribution of the publications listed was sparse during the period analyzed, predominantly from the first decade of the period studied. All the manuscripts used in this research are freely accessible to the public, and the articles are the most cited. The published papers were categorized into six broad areas: Growth, Reproduction and Larviculture, Genetics, Economics, and others. The two most studied categories were Growth and Reproduction and Larviculture.

Keywords: Aquaculture; Groupers; Scientometrics; Brazil.

INTRODUCTION

The serranids (Serranidae family, Epinephelinae subfamily) comprise 159 species distributed in 15 genera (Heemstra and Randall, 1993). They are widely distributed in tropical regions and subtropical coastal waters. Generally referred to as groupers, chernes, groupers, and whiting, they are generally fast-growing and resistant to handling, making them suitable for intensive farming systems. In addition, they have excellent characteristics for post-harvest processing, adding more value to the final product (Randall, 1987; Kohno *et al.*, 1990; Heemstra, 1991; Heemstra and Randall, 1993; APEC/SEAFDEC, 2001).

Epinephelus marginatus (Lowe, 1834) has been widely studied from a scientific perspective. Many scientific approaches exist to understanding this species' biology, ecology, and behavior. Study of reproductive biology, including sexual maturation, spawning, fecundity, fertilization, and analysis of diets and feeding behavior, are among the most widely used approaches (Chua and Teng, 1977; Chen and Chen, 1987; Chauvet, 1988; Tseng and Ho, 1988; Yen, 1988; Yen and Lim, 1988b; Skaramuca *et al.*, 1989; Castello *et al.*, 1992; Leong, 1993; Ruangpanit and Yashiro, 1995; Spedicato *et al.*, 1995; Chao and Chow, 1996; Gracia, 1996; Zabala *et al.*, 1997a; Zabala *et al.*, 1997b; Glamuzina *et al.*, 1998a; Glamuzina *et al.*, 1998b; Glamuzina *et al.*, 1998c). According to Main and Rosenfeld (1995), most of the studies conducted on serranids are from a biological standpoint rather than a cultivation one.

Groupers can have different growth rates depending on the environmental conditions of their habitat. Wild grouper reaches 400 g in approximately two years (Manooch and Haimovici, 1978; Bruslé, 1985; Salazar and Sanchez, 1992). Therefore, the growth of wild grouper can be considered slow for aquaculture purposes, but the right farming conditions and management of physical parameters, together with knowledge of nutritional needs, can be the key to achieving faster growth.

Its cultivation began in Asia, more precisely in the countries of Singapore, Malaysia, Hong Kong, Thailand, and Taiwan in the early 1970s, where cultivation has been performed in small and medium-sized net tanks ranging from 8m³ to 18m³, usually in sheltered coastal regions, in areas where there are fishing villages, and is traditionally carried out by small and medium-sized producers (APEC/SEAFDEC, 2001).

In Brazil, the cultivation of the *Epinephelus marginatus* species has been boosted by several factors, such as the reduction in its supply through capture fishing and its economic importance, as it is a noble and highly prized fish with high market prices. Another factor worth mentioning is that *Epinephelus marginatus* is a species on the list of threatened

fish species (Bern Convention, Annex 3 - Protocol for Mediterranean Biodiversity) and has been on the Red List of the International Union for Nature Conservation and Natural Resources since 1995 (Marino *et al.*, 2003). The Brazilian Ministry of the Environment Ordinance No. 445/2014 (IBAMA, 2014) prohibits fishing for grouper because it is on the list of overexploited species of threatened marine fish (Rodrigues *et al.*, 2009). As such, the cultivation of *Epinephelus marginatus*, in addition to being identified as a potential candidate for leading marine fish farming in Brazil, also appears to be a promising alternative for protecting the natural stocks of this already threatened fish.

This study aims to review and survey the main studies involving the cultivation of *Epinephelus marginatus* and to analyze the lines of study of the leading publications over the last 20 years in Brazil.

METHOD

In the scientometric study, this research aimed to evaluate various types of academic production (dissertations, theses, articles, and papers published in the proceedings of national and international events) from 2002 to 2022. The bibliographic survey was carried out via the World Wide Web, using the Science Direct, Scientific Electronic Library Online (SciELO), and Google Scholar databases. The descriptors used were "*Cultivation of Epinephelus marginatus*" in Portuguese, English, and Spanish.

The selection criteria were those that directly explained the related topic and/or words linked to the stages of crop management in the descriptor in the title, abstract, and/or keywords in the three languages mentioned above. As for the exclusion criteria, dossiers, scientific notes, review articles, book chapters, and books were not considered. The latter was disregarded mainly because of the difficulty of accessing printed versions.

After selecting the works that fit the pre-established criteria, a screening was carried out to exclude repeated material. The following information was analyzed: a) production type; b) region to which the research site belongs; c) academic-scientific institution and the region where it is located (considering the link of the first author of the manuscript); d) year of publication; e) number of citations of each work listed, using the "cited by" option of Google Scholar; f) scientific journals; g) type of access of the manuscript to the public (open or closed); and h) research areas.

The quantitative data was analyzed descriptively and represented in charts, graphs, and tables. For the study's perspectives, information from the literature was analyzed qualitatively to generate a theoretical framework related to

future academic, scientific, and political approaches in this field of research.

RESULTS

Regarding the academic-scientific institution and region in which the publication was generated

From 2002 to 2022, 20 national academic-scientific productions, including 2 short notes, 1 abstract, 3 master's dissertations, 4 doctoral theses, and 10 scientific articles, were analyzed. In the scenario examined based on **Figure 1**, it was found that studies on this approach are still not very significant in number, with the Southeast region of Brazil receiving the most attention from research institutions (6) and having the highest number of bibliographic productions (13), with the Fishing Institute standing out with seven productions, and the state of São Paulo concentrating all the research institutions focused on the area of *E. marginatus* cultivation in the region. In the northern region of the country, three institutions have published on the study topic, including an international partnership (IFAM x the University of Messina, Italy). In the south of the country, only the Federal University of Santa Catarina has published on the cultivation of *E. marginatus* (**Table 1**). Despite the great coastal potential and the large number of research institutions, until this study, the northeastern region had no publications on the cultivation of *E. marginatus*.

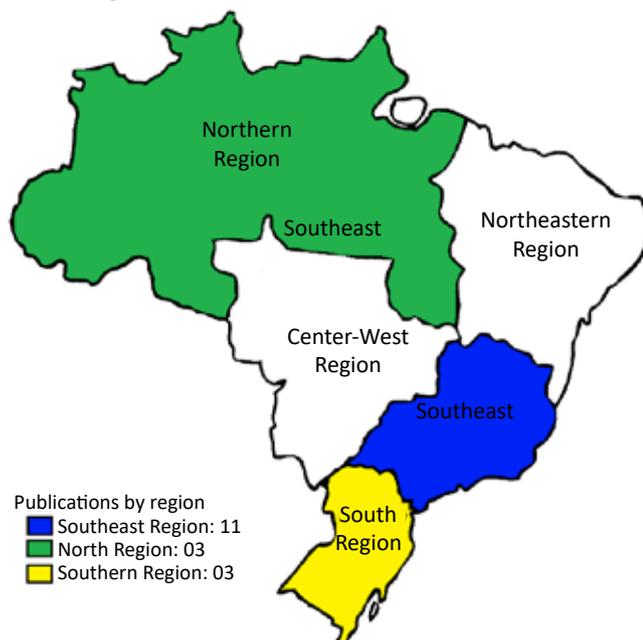


Figure 1. Distribution of publications by region of Brazil, where research was carried out on the cultivation of *E. marginatus* between 2002 and 2022

Source: The authors.

Regarding the period of publication

During the stipulated period, it was found that the time distribution (in years) of the manuscripts found on the subject was sparse, with a predominance in the first decade of the period, in which 11 manuscripts were carried out, with the year 2008 standing out with four works, while between one and two works were found in the other years (**Figure 2**). In this regard, it can be inferred that research has some circumstances that can be considered essential for generating the intended knowledge, which can influence the number of publications over the years, such as the time taken to develop such studies (Zago, 2018), including the publication of such research in scientific journals.

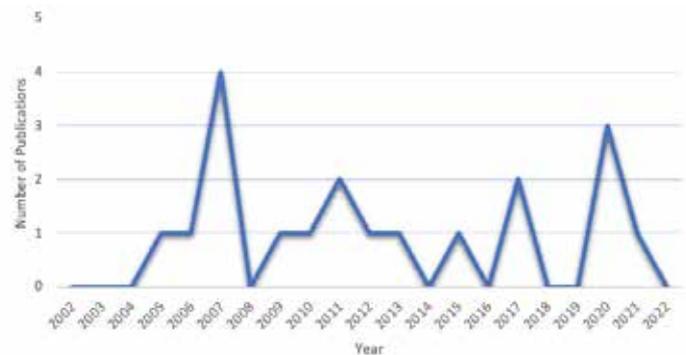


Figure 2. Distribution of the number of publications on *Epinephelus marginatus* cultivation in Brazil from 2002 to 2022

Source: The authors.

Regarding the number of citations of each work

Articles were the most cited among the citations, possibly because this type of production is more credible than TCCs (undergraduate final project), dissertations, theses, and papers published in event proceedings (**Table 1**).

The works by Sanches *et al.* (2006) and Roubedakis *et al.* (2013) had the highest number of citations (35 and 24, respectively), while the others ranged from none to just under two dozen citations, as shown in **Table 1**.

It is worth reiterating that all the publications analyzed were open to the public. In this context, we highlight that the most cited work (Sanches *et al.*, 2006) was the pioneer in the country, thus opening up a series of possibilities and questions for further studies in Brazil.

Regarding authorship and main keywords

Regarding the authorship composition of the papers, there were between one and eight authors in the articles,

Chart 1. List of academic-scientific institutions, their respective Brazilian regions, and the corresponding production published on the cultivation of *E. marginatus* between 2002 and 2022.

Region	Name of the Institution	Published works
South East	Fishing Institute	Sanches et al., 2006; Sanches et al., 2007; Sanches, 2008a; Sanches, 2008b; Sanches et al., 2008; Sanches et al., 2014; Silva et al., 2018
	University of São Paulo (USP)	Coelho, 2021; Garcia, 2012
	São Paulo State University (UNESP)	Rodrigues Filho, 2016; Engrácia Filho et al., 2018
	Redemar Alevinos Inc,	Kerber et al., 2012
	University of Mogi das Cruzes (UMC)	Mota et al., 2018
	Federal University of Lavras (UFLA)	Tarôco, 2021
South	Federal University of Santa Catarina (UFSC)	Ramos, 2011; Souza, 2012; Roubbedakis et al., 2013
North	Federal Institute of Education, Science, and Technology of Amazonas (IFAM)	Arde et al., 2021
	Federal University of Pará (UFPA)	Ramos et al., 2012
	Embrapa Fisheries and Aquaculture	Soares et al., 2022

Source: The authors.

Table 1. List of publications found on the cultivation of *Epinephelus marginatus* in Brazil from 2002 to 2022, categorized by type of production, number of citations, and title of the journal of publication.

Production Type	Works found	Number of citations	Journal Title
Abstract	Mota et al., 2018	0	Revista Científica UMC
Short Note	Sanches et al., 2007	12	Atlântica
Dissertation	Ramos, 2011	0	-
Dissertation	Sanches, 2008b	0	-
Dissertation	Souza, 2012	1	-
Thesis	Coelho, 2021	0	-
Thesis	Rodrigues Filho, 2016	0	-
Thesis	Garcia, 2012	0	-
Thesis	Torôco, 2021	0	-
Article	Sanches et al., 2006	35	Informações Econômicas
Article	Kerber et al., 2012	17	Journal of Agricultural Science and Technology
Short note	Arde et al., 2021	4	Fishes
Article	Sanches, 2008a	17	Revista Brasileira de Parasitologia Veterinária
Article	Ramos et al., 2012	12	Boletim do Instituto de Pesca
Article	Sanches et al., 2014	14	Boletim do Instituto de Pesca
Article	Roubbedakis et al., 2013	24	Brazilian Journal of Biology
Article	Sanches et al., 2008	15	Boletim do Instituto de Pesca
Article	Silva et al., 2018	2	Arquivo Brasileiro de Medicina Veterinária e Zootecnia
Article	Engrácia Filho et al., 2018	2	Arquivo Brasileiro de Medicina Veterinária e Zootecnia
Article	Soares et al., 2022	0	Research, Society and Development

Source: The authors.

unlike the dissertations and theses, in which one author typically predominates (Table 2). On the other hand, articles usually require a higher number of authors because, in addition to the main author, there is usually the collaboration of the supervisor(s) and members of a research group, among others. The productions analyzed included only one (1) paper with only one author in a direct count analysis (contribution only by the main authors); this is called a transient producer, i.e., an author who publishes once or twice a year on the topic analyzed, according to the Sciencimetrics perspective (Urbizagastegui, 2009). In this respect, it can be inferred that although a small number of authors have collaborated in this line of research, they are predominantly beginners in the subject (Alvarado, 2009). Among all the productions analyzed, one (1) paper had 13 authors, and it was a short communication, which, under analysis, may be due to the large number of undergraduate students involved in the authorship.

Regarding the areas surveyed

The publications were analyzed and divided into six groups according to the type of research related to the cultivation of *E. marginatus*: economics, growth, diseases, reproduction and larviculture, genetics, and others (Figure 3). The most representative groups were growth and reproduction and larviculture, with 30% of the publications each, followed by diseases, with 20%, and genetics, with 10%.

Figure 3. Classification by research area of publications on the cultivation of *Epinephelus marginatus* in Brazil from 2002 to 2022

Legend: Economy; Growth; Diseases; Reproduction and larviculture; Genetics; Other.

Source: The authors.

Table 2. Composition of authorship of each type of production on the cultivation of *Epinephelus marginatus* in Brazil between 2002 and 2022

	Article	Short Note	Abstract	Dissertation	Thesis
1 Author	1	-	-	3	3
2 Authors	-	-	-	-	-
3 Authors	3	1	1	-	-
4 Authors	2	-	-	-	-
5 Authors	1	-	-	-	-
>5 Authors	3	1	-	-	-

Source: The authors

Prospects for studies related to the cultivation of *Epinephelus marginatus* in Brazil

The main prospects for rearing *Epinephelus marginatus* in Brazil include studies on nutrition, reproduction, and larviculture. Despite being a new species in the Brazilian aquaculture species chart and with a technological cultivation package that is still under development, cultivation experiences in Brazil have shown great promise (Manooch and Haimovici, 1978; Bruslé, 1985; Salazar and Sanchez, 1992; APEC/SEAFDEC, 2001), not to mention its natural occurrence, which extends from practically the entire Brazilian coast to Argentine Patagonia (Figueiredo and Menezes, 1980; Iriyoyen *et al.*, 2005; Condini *et al.*, 2013).

In the north of Brazil, there are reports of *Epinephelus marginatus* during the Amazonian dry season, when salinity increases in estuarine waters, which is already a reason to study the cultivation of the species in Amazonian waters. It is worth noting that *Epinephelus marginatus* is a species that has been on the International Union for Nature Conservation's Red List of Threatened Animals since 1995 (Marino *et al.*, 2003). Encouraging its cultivation, which is much more than stimulating marine fish farming in the country, is a way to mitigate these impacts on natural populations. Thus, breeding the goliath grouper needs to be boosted by reducing the supply of capture fishing and its economic relevance since it is considered a noble and highly prized fish with high market values.

Brazilian marine fish farming has yet to play a prominent role in the national aquaculture scene, and *Epinephelus marginatus* could be a major player in this role. In this sense, more research is needed to develop effective farming techniques as well as more accurate information on nutrition, reproduction, and nursery.

CONCLUSION

Few studies on the cultivation of *Epinephelus marginatus* in Brazil between 2002 and 2022 were published on the internet. Those found had a very sparse publication frequency during the search period, ranging from abstracts published in event proceedings to theses. The articles were the most published and cited by other authors, perhaps due to the greater degree of scientific credibility and free access to the manuscript. In general, research was primarily concentrated in the first decade of the 21st century, focused on the Southeast region, reaffirming it as a major hub of information on the cultivation of *E. marginatus*. However, regions in the south and north of the country have also published on the subject.

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