

MARINE RECORD

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Elacatinus figaro Sazima, Moura & Rosa, 1997 (Gobiiformes: Gobiidae): Distribution extension of a Brazilian endangered endemic reef fish with comments on south-western Atlantic Ocean biogeography

Daniel Fernando Almeida¹, Gabriel Soares Araujo^{1*}, Marcelo R. Britto¹ and Cláudio Luis Santos Sampaio²

Abstract

Background: A new record for *Elacatinus figaro*, an endangered Brazilian species, is documented for Pedra do Sal, Piauí coast. We present new data about its distribution, discussing on the limits of the Brazilian Province and commenting on the IUCN criteria for evaluation on threatening status.

Results: Five specimens of *E. figaro* were collected about 550 km northward from its previously known boundary, overtaking the expectations around its real distribution as presented in the original description.

Conclusions: Results from *E. figaro* range expansion and new records of species in Brazilian coast fit the hypothesis presented in Floeter et al. (*J Biogeogr* 35: 22-47, 2008) of a Brazilian Zoogeographic Province, also assigned by Briggs & Bowen (*J Biogeogr* 39: 12-30, 2012) on a review of Marine Zoogeographic Provinces.

Keywords: Brazilian Province, Conservation status, Endemism, Zoogeography

Background

The genus *Elacatinus* Jordan 1904 has currently 25 valid species (Eschmeyer et al., 2016), all but *Elacatinus punctulatus* (Ginsburg, 1938), from eastern Pacific, occurring on western Atlantic (Van Tassell, 2011) and three of which endemic to Brazilian waters. Generally, *Elacatinus* species are small brightly coloured reef inhabitants that feed mainly on parasites by engaging in cleaning symbiosis with larger fishes and invertebrates (Pezold, 1993; Sazima & Moura, 2000; Sazima et al., 2000; Sazima et al., 2004), being recently used as models for speciation studies on large versus small geographic scales (Colin, 2003;

Palumbi & Warner, 2003; Warner & Palumbi, 2003; Taylor & Hellberg, 2005), and connectivity (Colin, 2010), presenting so high speciation rates that yielded a comparison with Tolkien's Hobbits (Palumbi & Warner, 2003) due to its low mobility and phylopatric behaviour.

One of the Brazilian species, the Barber Goby *Elacatinus figaro* Sazima, Moura & Rosa, 1997 was originally described as occurring in "Brazilian Coast", with its distribution from Paraíba State - northern boundary - to Santa Catarina State - southern boundary (Sazima et al., 1997), but with an addendum to its potential occurrence up to Ceará State.

Briggs (1974, 1995), following previous innuendos (Ekman, 1953), recognized Cabo Frio (22° 54' S) as the southern limit of both the Brazilian Province and western Atlantic Tropics, followed by several other authors (Vermeij, 1978; Absalão, 1989; Boschi, 2000;

* Correspondence: gabrielsoaraujo@gmail.com

¹Departamento de Vertebrados, Universidade Federal do Rio de Janeiro/ Museu Nacional, Setor de Ictiologia, Quinta da Boa Vista s/n, CEP 20940-040 Rio de Janeiro, RJ, Brazil

Full list of author information is available at the end of the article



Di Dario et al., 2011) with very similar arrangements based on distinct taxonomic groups. On the other hand, Floeter et al. (2008), studying the distribution of a great variety of coastal fish families, recognized an arrangement where the Brazilian Province extends its limits from the mouth of the Amazon River south to Santa Catarina, including the offshore islands of Atol das Rocas, Fernando de Noronha, St Paul's Rocks and Trindade - all of them in Brazilian jurisdictional waters. This arrangement was recently followed by Briggs & Bowen (2012) in a recent reappraisal of marine biogeographic provinces with particular reference to fish distributions.

Herein, a new record for *E. figaro* (Fig. 1) is documented for Piauí coast, increasing the knowledge about the species distribution. The Barber Goby, *E. figaro*, is endangered due to degradation of reef environments and the illegal collection to supply the ornamental marine trade (Gasparini et al., 2005). Herein, we present new data about its distribution, discussing on the limits of the Brazilian Province and conservation status.

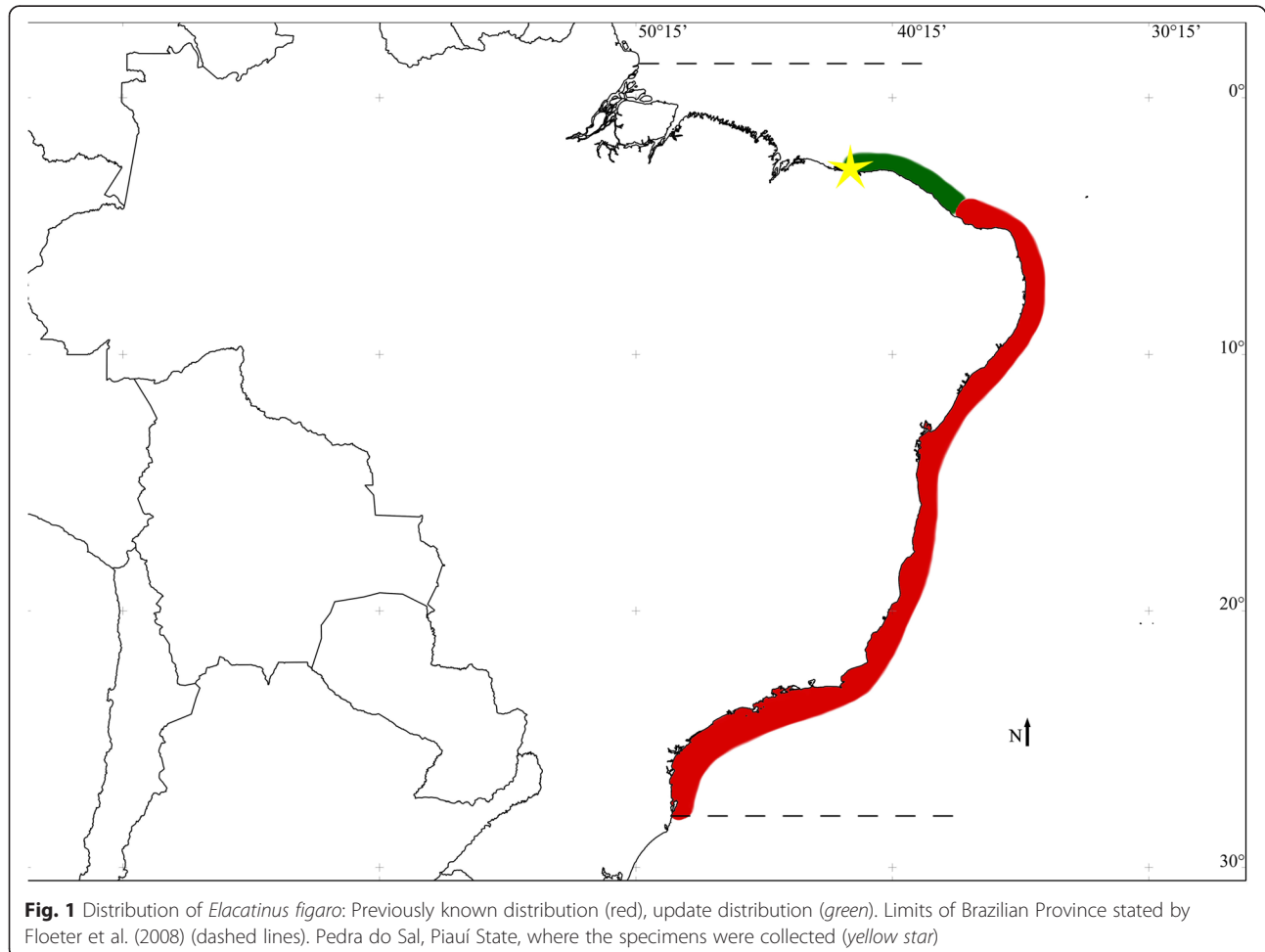
Methods

Field work took place at Pedra do Sal, Piauí State, Brazil (03°32' S, 38°16' W). Specimens were collected through hand-nets during SCUBA dives, between 2-3 m depth, on March 2015 under license number 10488-1 - from Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis (IBAMA) and Instituto Chico Mendes de Conservação da Biodiversidade (ICMbio).

The specimens were fixed in 99,6 GL ethanol. Five vouchers are deposited at Museu Nacional Ichthyological Collection, Rio de Janeiro, Brazil, under catalogue number MNRJ 43599 (Fig. 2).

All major ichthyological collections were examined using speciesLink project (<http://www.splink.org.br/index>) tools in order to look for *E. figaro* records beyond its original distribution. There, two southern records of *E. figaro* were found for Ceará State, Brazil, collected in 2000 and deposited at Museu de Zoologia da USP, São Paulo, Brazil, under catalogue numbers MZUSP 65161 and MZUSP 65178, but none for Piauí State.

Besides that, to verify the endemicity of the Brazilian Province *sensu* Floeter et al. (2008), all new marine fish



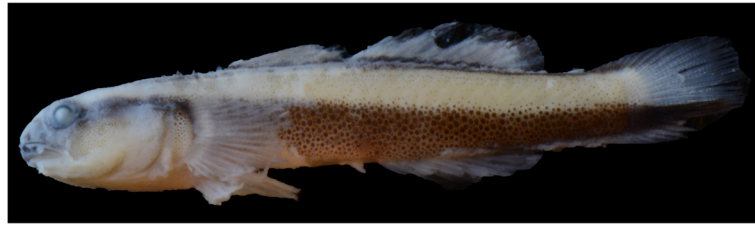


Fig. 2 *Elacatinus figaro*, MNRJ 43599, 22,8 mm SL

descriptions and records after 2008 for the speciose families stated by those authors were examined, as well as an extensive literature search on studies discussing on Brazilian Province. Ten new species (Table 1) were found, all of which corroborate Floeter et al. (2008) and Briggs & Bowen (2012).

Morphological identification was made taking the original description of *Elacatinus figaro* (Sazima et al., 1997) and Van Tassell (2011) as the base (Fig. 2). Besides, molecular identification was conducted with two markers, a mitochondrial (CytB) and a nuclear (Rho), both reaching a score of 100 % on the blast tool of NCBI GenBank.

Results

Five specimens of *E. figaro* were collected about 550 km northward from its previously known boundary, overtaking the expectations around its real distribution as presented in the original description.

The specimens were collected at a rocky bottom with depths ranging from 0,5 m to 2,0 m. The visibility was around 0,8 m due to the proximity of Parnaíba river outfall. Probably as a product of the small input of light, many benthic organisms were not detected on the rocks, but only a very thick layer of green algae.

Discussion

Despite the radiations in small geographic scales presented by most Caribbean *Elacatinus* species (Palumbi & Warner, 2003; Taylor & Hellberg, 2005), the endemic Brazilian coast *E. figaro* is the most widespread species of the genus since it occurs throughout most part of its coastal reefs.

As an endemic and endangered species, knowledge of the Barber Goby distribution is essential for conservation purposes (Tyre et al., 2001; Rondinini et al. 2006). The most recent Red List of Brazilian Fauna (Ministério do Meio Ambiente, 2014) lists *Elacatinus figaro* as a threatened species, and recommends that it fits the Vulnerable (VU) category of IUCN based on A2bcd criteria (population reduction observed, estimated, inferred, or suspected in the past where the causes of reduction may not have ceased, or may not be understood, or may not be reversible, based on (b) an index of abundance appropriate to the taxon, (c) a decline in area of occupancy (AOO), extent of occurrence (EOO) and/or habitat quality, and (d) actual or potential levels of exploitation) (IUCN, 2011). Accordingly, estimates infer that populations of *E. figaro* decline in nearly 30 % in the last ten years, numbers associated with threats like over capture due to aquarist activity, and large decline of Brazilian coral reefs (ICMBio 2015).

Table 1 Marine species described after 2008 to the speciose families stated by Floeter et al. (2008), and their distribution. Only species occurring in Brazilian waters were included

Family	Species	Distribution
Bleniidae	<i>Scartella itajobi</i> Rangel & Mendes, 2009	Fernando de Noronha Archipelago and São Pedro e São Paulo Archipelago
	<i>Hypleurochilus brasil</i> Pinheiro, Gasparini & Rangel, 2013	Trindade Island and Martin Vaz Archipelago
Gobiidae	<i>Elacatinus phthiophagus</i> Sazima, Carvalho-Filho & Sazima, 2008	Fernando de Noronha Archipelago
	<i>Barbulifer enigmaticus</i> Joyeux, Van Tassell & Macieira, 2009	From Espírito Santo to São Paulo States
Labridae	<i>Halichoeres rubrovirens</i> Rocha, Pinheiro & Gasparini, 2010	Trindade and Martin Vaz Archipelago
	<i>Halichoeres sazimai</i> Luiz, Ferreira & Rocha, 2009	From Espírito Santo to Santa Catarina States
Labrisomidae	<i>Malacoctenus bruno</i> Guimarães, Nunan & Gasparini, 2010	Trindade and Martin Vaz Archipelago
	<i>Labrisomus conditus</i> Sazima, Carvalho-Filho, Gasparini & Sazima, 2009	Fernando de Noronha Archipelago
Scaridae	<i>Sparisoma rocha</i> Pinheiro, Gasparini & Sazima, 2010	Trindade Archipelago
Serranidae	<i>Serranus alicae</i> Carvalho-Filho & Ferreira, 2013	Southeastern Brazil

New occurrence records constitute important information that improves evaluation of conservation status. Some of the plausible threats listed to *Elacatinus figaro* concerns those acting in its geographic range, which also fits at IUCN's "B" criteria (Geographic range in the form of either extent of occurrence and/or area of occupancy). Therefore, we use the georeferenced localities of *E. figaro* from the records available at SpeciesLink plus the new data presented herein in the Geospatial Conservation Assessment Tool (geocat.kew.org) to calculate its extent of occurrence (EOO) and area of occupancy (AOO). Considering a cell width of 2 km, the calculated AOO was 340 km², which suggests an Endangered (EN) category based on B2 criteria (AOO < 500 km²). Since *E. figaro* occurs in specific habitats (coral or rocky reefs) in a distributional range with high pressure of human activities, it is possible to detect severe fragmentation of its distribution (IUCN's B(a) criteria), associated with the continuing decline in the quality of its habitat (IUCN's B(b iii) criteria), threats listed by Moura et al. (2008). However, the use of AOO for a taxon as *E. figaro* seems severely inaccurate, despite of several reef species admittedly display a low occupational range (Taylor & Hellberg, 2003). Nevertheless, according to Almeida (2011), populations of *E. figaro* shares haplotypes along larger areas than previously reported for the genera, having haplotypes common to the whole Brazilian northwestern coast and others common to the whole southern/southwestern coast.

The recent range expansion of *E. figaro*, herein recorded, fits within Floeter et al. (2008) and Briggs & Bowen (2012) arrangement of Brazilian Province (Fig. 1). Except by the Parcel Manuel Luiz, the northernmost coral reef communities in Brazil (Castro & Pires, 2001), the lack of *E. figaro* in most of the northern portion of the province, where the reefs are not well developed, is probably due the presence of a barrier between the Parcel and the rest of the Brazilian coastal reef (Rocha & Rosa, 2001).

It seems that organisms with putative great mobility and cryptical species, that can be easily misidentified by non-specialists, are not the best models for discussing areas of endemism (AoE) as they do not fit classical protocols to establish endemism areas (e.g. Müller, 1973; Linder, 2001). Accordingly, Giokas & Sfenthourakis (2008) critically discourage the use of widely distributed species for delineation of AoE, stating that they cannot provide enough evidence for it. Morrone (1994) encourages only the use of species with accurately known distributional limits for this purpose.

Some recent uses of fish from these two categories for delimitation of AoE, and hence the Brazilian Province delineation, can be observed. Menni et al. (2010) reviewed chondrichthyan distribution in southwest Atlantic, and besides the great mobility of sharks, skates and rays - that

extrapolates the requirements of Müller (1973) and Linder (2001) - authors stated that "disturbances in the southwestern Atlantic may affect large parts of, or even the whole chondrichthyan assemblages", a proposition that by itself points out the group as an unreliable source for AoE delimitation. On the other side, *Odontesthes argentinensis* (Valenciennes, 1835) had its northern limit originally established to Santos (23° 57' S, 46° 20' W). Later, Bemvenuti (2000) proposed Santa Catarina State (28° S) as its limit, and recently Di Dario et al. (2011) increased it to northern Rio de Janeiro State, based in a large discussion about the limits of Brazilian Province on such boundary. However, subsequently those same authors collected *O. argentinensis* northwards at Marataizes, Espírito Santo state, Brazil (catalogue number NPM 71). This entry not only extrapolates the limits of the provinces under discussion on that paper, but opens for the great probability of a subsequent range expansion of *O. argentinensis* due to misidentification of previously collected material northward Marataizes.

Elacatinus species seem to be good models to study geographic barriers due to its quick speciation and low dispersion (Taylor & Hellberg, 2005). The genus speciation is sensible to invisible barriers, occurring even though populations reside only within 23 km of each other in Caribbean waters (Palumbi & Warner, 2003), therefore *E. figaro* was the chosen model to discuss onto the limits of Brazilian Province. Furthermore, the requirements of *E. figaro*, the ten new species descriptions for the Brazilian coast (Table 1), as well as most of the members of the families used by Floeter et al. (2008) are in accordance with Müller (1973) and Linder (2001) protocols to establish AoE.

Conclusions

Results from *E. figaro* range expansion and new records of species in Brazilian coast (Table 1) fit the hypothesis of a Brazilian Zoogeographic Province extending from its north portion on the mouth of Amazon River basin to its southern limit at Santa Catarina, Brazil, including its offshore islands (Fig. 1) as proposed by Floeter et al. (2008) and used by Briggs & Bowen (2012) on a review of Marine Zoogeographic Provinces.

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Authors' contributions

Conceived and designed the experiments: DFA GSA. Performed the experiments: DFA GSA MRB. Analyzed the data: DFA GSA MRB CLSS. Contributed materials/analysis tools: DFA GSA MRB CLSS. Wrote the paper: DFA GSA MRB CLSS. All authors have read and approved the final manuscript.

Competing interests

The authors declare that they have no competing interests.

Author details

¹Departamento de Vertebrados, Universidade Federal do Rio de Janeiro/ Museu Nacional, Setor de Ictiologia, Quinta da Boa Vista s/n, CEP 20940-040 Rio de Janeiro, RJ, Brazil. ²Universidade Federal de Alagoas, Campus Arapiraca, Unidade de Ensino Penedo, Av. Beira Rio s/n, CEP 57200-000 Penedo, AL, Brazil.

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