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A EXPLOTAÇÃO DE ESPÉCIES ORNAMENTAIS MARINHAS NO BRASIL, COM ÊNFASE NO ESTADO DO CEARÁ

LÍVIO MOREIRA DE GURJÃO

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“A cura para tudo é sempre água salgada: o suor, as lágrimas ou o mar”

Isak Dinesen - pseudônimo de Karen von Blixen-Finecke (1885 -1962)

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Resumo

O Brasil tem um papel importante no comércio ornamental marinho mundial e o Ceará é o estado exportador mais relevante. Entretanto, faltam informações relativas às espécies explotadas, inexistem normas especificamente voltadas para a proteção de muitos organismos e é desconhecida a eficiência das ferramentas de manejo disponíveis. Além disso, dados de exportação precisavam ser atualizados e o transporte ilícito de espécies através dos correios necessitava ser investigado.

Diferentes fontes de informação foram pesquisadas e os dados relativos à exportação e ao envio de espécies pelos correios foram analisados. Os resultados revelaram a participação de muitas espécies nativas brasileiras na indústria ornamental, incluindo aquelas ameaçadas de extinção. Existem falhas nas ferramentas de manejo usadas para controlar a utilização de espécies no aquarismo marinho. A análise das autorizações de exportação corroborou a participação relevande do estado do Ceará no comércio brasileiro de peixes ornamentais marinhos, porém demonstrou um declínio substancial das exportações na última década. Os pomacantídeos foram os peixes mais comercializados, as menores exportações ocorreram nos verões do hemisfério norte e os países asiáticos são os principais importadores do Brasil. As espécies marinhas enviadas pelos correios foram menos representativas que as dulcícolas. No entanto, algumas daquelas estão presentes na lista brasileira de espécies ameaçadas. Muitas das espécies apreendidas não são nativas do Brasil ou do estado do Ceará – o que aumenta a preocupação acerca de potenciais bioinvasões. Portanto, para reduzir os impactos causados pelo comércio ornamental marinho, as autoridades brasileiras deveriam incentivar o desenvolvimento da aquicultura sustentável, além de estratégias de manejo "baseadas-no-ecossistema". Ainda, é necessária a elaboração de regras especificamente voltadas para o aquarismo marinho, ferramentas de manejo e fiscalizações de espécies enviadas pelos correios precisam ser aprimoradas e dados de exportação devem ser frequentemente atualizados.

Palavras-Chave: Comércio ornamental, espécies de aquarismo marinho, legislação, ferramentas de manejo, exportação de peixes ornamentais, serviços postais brasileiros.

Abstract

Brazil has an important role in marine ornamental trade worldwide and Ceará state is the most relevant exporter in the country. However, there is a paucity of data regarding the species currently traded, as well as a lack of rules specifically driven to the protection of many organisms and the efficiency of the available management tools is unknown. Additionally, export data had to be updated and the illicit transport of species via Brazilian postal services needed to be investigated.

Different sources of information were accessed, legislation was surveyed, Ibama's export data were analyzed and information concerning mailed ornamental species was gathered. Results revealed that a wide range of Brazilian native species are exploited by the ornamental industry, including those threatened with extinction. Flaws in the management tools adopted by Brazilian authorities to control utilization of marine aquarium ornamentals were detected. The analysis of authorizations of export corroborated the relevant participation of Ceará state in Brazilian marine ornamental fish trade, but showed a substantial decline of exports along the last decade. Pomacanthids were the most important fish group traded, lower export numbers occurred in the Northern Hemisphere summers and Asian countries are currently the main importers from Brazil. Mailed marine species were less representative than freshwater individuals, but some of the former organisms figure in the Brazilian list of threatened species. Most of the species confiscated neither are native from Brazil nor from Ceará state - raising concerns about potential risks of bioinvasions. Hence, in order to reduce environmental impacts caused by marine ornamental trade, Brazilian authorities should encourage the development of sustainable aquaculture initiatives and ecosystem-based management strategies. Additionally, specific rules oriented to marine ornamental trade have to be issued, management tools, as well as controlling the illegal mailing of species through Brazilian postal services, have to be improved and export data ought to be more often updated.

Key-words: ornamental trade, marine aquarium species, legislation, management tools, ornamental fish export, Brazilian postal services.

Introdução

Dados históricos apontam para o início do comércio de peixes ornamentais marinhos na década de 1930, no Sri Lanka, ainda em uma escala muito pequena, na qual os indivíduos eram capturados por barcos de cargas e passageiros e mantidos em tanques nos conveses dessas embarcações até o seu destino final (Wood, 2001). Segundo esta autora, esse mercado se expandiu gradualmente durante os anos 50, quando também se iniciaram as exportações aéreas, e vários outros locais, a exemplo do Havaí e das Filipinas, expediram as primeiras autorizações para captura desses recursos. A autora reporta ainda que nas décadas subsequentes a aquariofilia marinha se tornou cada vez mais popular, impactando diretamente a demanda por peixes – no Havaí, por exemplo, o número de autorizações comerciais para captura de peixes ornamentais marinhos saltou de apenas quatro, em 1968, para 274, ao final dos 30 anos que se seguiram.

Durante os anos 90, o comércio de peixes ornamentais marinhos era suprido por 45 países exportadores, os quais comercializaram cerca de 14 a 30 milhões de indivíduos, com valores de importação e varejo alcançando aproximadamente US$144 milhões e US$300 milhões (Bruckner et al., 2005). Entretanto, nesse mesmo período esse mercado passou a sofrer variações que podem ser parcialmente explicadas pelo crescente interesse de aquariofilistas marinhos pela manutenção de invertebrados, em detrimento de peixes (Wood, 2001). Corroborando essas informações, Bruckner (2005) relataram o crescimento de 20 a 50% por ano no comércio mundial de corais vivos, a partir de 1987, com mais de um milhão desses organismos e de mil e quinhentas toneladas de rochas vivas comercializadas em 2001.

No século XXI, a explotação de diversas espécies ornamentais marinhas continuou a crescer e tornou-se uma grande indústria de projeção mundial, cujos principais alvos são mais de 150 espécies de corais duros, além de centenas de outros invertebrados e de pelo menos 1.800 espécies de peixes recifais, pertencentes à 50 famílias distintas (Rhyne et al., 2014; Leal et al., 2015).

A tendência moderna da aquariofilia marinha em mudar de aquários voltados exclusivamente a peixes (*fish only*) para aqueles que se assemelham a miniaturas de ecossistemas recifais (contendo também invertebrados - conhecidos popularmente como *mini-reefs*), fez com que as coletas para suprir o mercado passassem a explorar mais recursos ambientais (Rhyne et al., 2012). Dessa forma, esses autores classificaram os coletores da indústria da aquariofilia marinha atual como predadores generalistas peculiares e sem precedentes, que visam à captura tanto de espécies abundantes quanto de raras, alcançando estas um maior valor de comercialização.

Diferentemente da aquariofilia dulcícola, na qual cerca de 90% das espécies são oriundas de cultivos, a grande maioria dos peixes e invertebrados marinhos que integram o comércio ornamental é extraída diretamente de recifes de corais ou de suas adjacências - apenas cerca de 5 a 10% das espécies são produzidas comercialmente em cativeiro (Wabnitz et al., 2003; Calado, 2006; Olivotto et al., 2011). Isso tem acarretado muitas controvérsias acerca da sustentabilidade da atividade de coleta de ornamentais marinhos, principalmente em virtude do grande valor ecológico dos ambientes recifais, que já vêm sofrendo com problemas relacionados à poluição, pesca destrutiva, sobrepesca, branqueamento de corais, além de vários outros danos causados pelo desenvolvimento desordenado do turismo e outras atividades (Bellwood et al., 2004). Neste contexto, existem duas linhas de pensamento que avaliam os efeitos positivos e negativos da aquariofilia marinha em relação a conservação dos ambientes recifais.

Sob o aspecto positivo, a manutenção de aquários marinhos em casa, como *hobby*, ou a visita à aquários públicos faz com que as pessoas desenvolvam afinidades com os ambientes recifais e, consequentemente, se sensibilizem e despertem o interesse pela conservação desses ecossistemas (Wood, 2001). Além disso, a aquariofilia marinha contribui para a valorização e incentiva a conservação dos locais de coleta, uma vez que a atividade é bastante seletiva e capaz de alcançar altos preços de mercado – favorecendo a sobrevivência de comunidades costeiras de baixa renda (Wabnitz et al., 2003; Rhyne et al., 2014).

A fim de exemplificar o que foi dito, Wabnitz et al. (2003) citam trabalhos realizados nas ilhas Maldivas, onde 1Kg de peixe ornamental era avaliado em quase US$500,00 enquanto a mesma quantidade de pescado usado para alimentação valia somente US$6,00. De maneira semelhante, o mercado de coral vivo para aquariofilia marinha rendia aproximadamente US$7 mil/tonelada, ao passo que a indústria de extração de calcário pagava apenas cerca de US$60,00/tonelada de coral coletado.

Por outro lado, existem vários aspectos negativos relacionados à atividade exploratória de ornamentais marinhos, como: a possível sobreexplotação de espécies e seus efeitos secundários nas comunidades recifais, métodos de coleta predatórios e altas taxas de mortalidade pós-captura (Wood, 2001).

Wabnitz et al. (2003) citam como exemplos de adversidades geradas pela coleta desordenada de peixes ornamentais: 1) o uso de técnicas de coleta predatórias e não seletivas, a exemplo da utilização de cianeto de sódio, que afeta a saúde de todo o recife de coral e atinge negativamente espécies que não alvo da coleta; 2) a sobreexplotação das espécies-alvo e 3) os altos níveis de mortalidade associados à alta intensidade das exportações. De acordo com esses autores, apesar de alguns países terem implementado medidas regulatórias para a atividade, outras mais precisam ser adotadas, especialmente quando se considera que mais de 2.2 bilhões de pessoas vive a menos de 100Km da costa e que os recifes de coral estão enfrentando problemas crescentes relacionados a poluição, sedimentação, branqueamento, sobrepesca e turismo.

Ainda em relação aos efeitos negativos da atividade, pode-se citar as alterações nas comunidades recifais provocadas pela remoção exagerada de espécies com papéis ecológicos críticos para o equilíbrio do ecossistema e a retirada de imaturos (Rhyne et al., 2012). É pertinente também reportar outros efeitos adversos potencialmente causados pela gestão desordenada da atividade, como a disseminação de doenças e de patógenos em decorrência de fragilidades de controle sanitário (Whittington e Chong, 2007), a introdução de espécies exóticas por solturas

inadequadas intencionais ou acidentais nos ambientes naturais (Semmens et al., 2004, Lasso-Alcalá e Posada, 2010) e o surgimento de conflitos sociais (Tissot et al., 2009).

Diante dos aspectos positivos e negativos da coleta de peixes ornamentais marinhos em ambientes naturais, muitos países resolveram adotar medidas que visam à sustentabilidade da aquariofilia marinha, conciliando interesses ambientais, sociais e econômicos. Pois, os aspectos positivos da atividade, anteriormente citados, quando associados a ações educacionais para valorização dos ambientes recifais e à utilização de práticas sustentáveis nos locais de coleta, além da conscientização dos consumidores finais, podem trazer muito mais benefícios conservacionistas do que a simples proibição da atividade (Rhyne, et al., 2012).

No início da década de 2000, o Brasil era apontado como um grande abastecedor do mercado mundial de peixes ornamentais marinhos (Wood, 2001; Bruckner, 2005). Entretanto, assim como nos outros países exportadores, a grande maioria das espécies comercializadas era proveniente de coletas na natureza, o que vinha acarretando preocupações acerca do desenvolvimento sustentável dessa atividade no país (Gasparini et al., 2005).

Assim, nesse mesmo período, as autoridades brasileiras passaram a ser mais exigentes e começaram a: (a) emitir as primeiras autorizações específicas para exportação de peixes ornamentais marinhos no Brasil, (b) licenciar as primeiras embarcações voltadas para a captura desses recursos, (c) realizar as primeiras reuniões técnicas para avaliação da atividade no país e (d) publicar as primeiras normatizações direcionadas exclusivamente para esse setor – todo esse histórico detalhado está presente no trabalho de Nottingham et al. (2005a).

Mesmo diante da reconhecida importância da explotação de espécies ornamentais marinhas no Brasil (Nottingham et al., 2005a; Sampaio e Nottingham, 2008), ainda existe uma carência de informações sobre diversos aspectos pertinentes a essa atividade, como por exemplo:

- A utilização de espécies – uma vez que grande maioria dos estudos já realizados no país

contemplam somente a utilização de peixes pelo aquarismo marinho (Nottingham et al., 2000; Monteiro-Neto et al., 2003; Araújo e Albuquerque-Filho, 2005; Nottingham et al., 2003; Nottingham et al., 2005a; Nottingham et al., 2005b, Sampaio e Rosa, 2005; Feitosa et al., 2009) e muito poucos são aqueles que reportam a utilização de outros organismos (Gasparini et al., 2005, Ibama 2008a);

- Avaliação das normatizações direcionadas à atividade no país – poucos são os trabalhos que abordam o tema e ainda existem outros aspectos a serem observados (Gasparini et al., 2005; Bender et al., 2012; Sampaio e Ostrensky, 2013; Sampaio et al., 2015);

- Obtenção de dados recentes relativos à exportação de espécies ornamentais – as informações atualmente disponíveis são relativas a diferentes períodos entre os anos de 1995 e 2007 (Nottingham et al., 2000; Monteiro-Neto et al., 2003; Nottingham et al., 2005a; Nottingham et al., 2005b; Ibama, 2008b), ou seja, existe uma defasagem de dados de quase uma década;

Deste modo, o presente estudo teve como objetivo principal a obtenção de dados atualizados relativos a distintos aspectos da aquariofilia marinha no Brasil, os quais formam discutidos por meio de quatro capítulos apresentados a seguir.

- Capítulo 1 – Levantamento dos organismos utilizadas na aquariofilia marinha brasileira, contemplando não somente peixes, mas também invertebrados, algas e plantas aquáticas. Nele são apresentados e discutidos aspectos da explotação e níveis de conservação das espécies.

- Capítulo 2 – Apresentação de normas regulamentadoras para as atividades de explotação de espécies usadas no aquarismo marinho, bem como avaliação das ferramentas de manejo atualmente utilizadas na gestão da utilização desses recursos.

- Capítulo 3 – Atualização de dados relativos à exportação de peixes ornamentais marinhos entre os anos de 2006 e 2015. Nele é feita uma comparação entre as exportações realizadas pelo Brasil e o estado do Ceará, além de uma análise da situação atual dessa atividade.

- Capítulo 4 – Identificação do comércio ilegal de espécies ornamentais através dos Correios. Nele são reportadas apreensões realizadas no Ceará, tanto de organismos marinhos quanto dulcícolas, e avaliações das espécies quanto à sua distribuição a participação nesse tipo de transporte.

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CAPÍTULO 1 – *Native species exploited by marine aquarium trade in Brazil*

Native species exploited by marine aquarium trade in Brazil

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Abstract

Brazil has an important role in marine ornamental trading, exploiting native species for both international and domestic market. A few works have previously assessed wild species exploited by the Brazilian marine aquarium industry, but most of them focused solely on fish. Hence, the present paper intends to fulfill a paucity of information regarding the species currently traded in the country, as well as concerning their conservation statuses. To accomplish with this goal, different sources of information were investigated and each species was categorized in accordance with existing lists of threatened species. A wide variety of native species was identified in Brazilian marine aquarium trading, which includes not only fish but also invertebrates, macroalgae and macrophytes. Some of these species could not be exploited, but are still commerced anyway. Such illegal exploitation of

native species causes increasing concerns about the sustainability of the activity. Therefore, in order to reduce environmental impacts caused by marine ornamental trade, Brazilian authorities should encourage the development of sustainable aquaculture and ecosystem-based management initiatives.

Key-words: Marine aquarium fish, marine invertebrates, marine macroalgae, marine macrophytes, ornamental species, threatened species.

Introduction

Marine ornamental trade is a global multi-million dollar industry (~ US$200-300 million annually), involving the collection of more than 50 million coral reef animals (e.g. fishes, corals and a wide variety of invertebrate species) to supply aquaria kept by 2 million hobbyists worldwide (Wabnitz et al., 2003; Rhyne et al., 2012a). It is estimated that the activity targets over 1,800 reef fish species from 125 families, over 150 species of stony corals and hundreds of species of non-coral invertebrates (Rhyne et al., 2012b; Rhyne et al., 2014; Leal et al., 2015).

Since both fish and invertebrates began to be exploited together in the mid 1980s, consumers gradually shifted their preference from fish-only tanks to miniature reef ecosystems (Bruckner, 2005; Rhyne et al., 2009; Rhyne et al., 2012a; Murray and Watson, 2014) and collectors for the aquarium trade started to act as a peculiar and unprecedented type of generalist predators, targeting both abundant and rare species, including those with critical ecological roles on the reefs (Rhyne et al., 2012b).

Unlike freshwater ornamental commerce, where about 90% of fish species are produced in captivity, the great majority of marine tank species is wild-caught, and, thus, had generated controversies regarding the sustainability of the activity (Wabnitz et al., 2003; Olivotto et al., 2011;

Rhyne et al., 2014), as over-harvesting is among the most serious causes of coral reef degradation worldwide (Bellwood et al., 2004; Rhyne et al., 2014).

Brazil supplies significant quantities of the global marine ornamental market (Wood, 2001; Bruckner, 2005; Rhyne et al., 2012b) and, like in the other exporting countries, most of the exported organisms are wild-harvested, which also has generated concern about the development of this activity (Gasparini et al., 2005; Nottingham et al., 2005a).

Despite the importance of a wide variety of native organisms for both international and domestic aquarium trade, the great majority of studies already performed in Brazil focused on the exploitation of marine fish only (Nottingham et al., 2000, Monteiro-Neto et al., 2003; Nottingham et al., 2005a; Nottingham et al., 2005b; Ibama, 2008a; Sampaio and Nottingham, 2008; Sampaio and Ostrensky, 2013) and very few included the ornamental use of other marine organisms (Gasparini et al., 2005; Ibama, 2008b). Thus, the goal of the present study was to list the Brazilian native species used in marine aquarium trade, providing information regarding their usage and conservation statuses.

Materials and methods

First, three different lists of species were compiled: (1) fish, (2) invertebrates and (3) seaweeds and aquatic macrophytes.

These inventories were based on the following sources of information: (1) scientific literature, (2) governmental lists, (3) demands of exportation sent to Brazilian authorities, (4) author's personal observation, (5) visits to online marine aquarium discussion forums (e.g. http://www.ipaq.org.br, http://www.reefcorner.org, http://www.reefforum.net and http://www.reefdeep.org/), (6) Brazilian pet shops websites – searching for “lojas de aquário marinho Brasil” and “lojas de peixes marinhos Brasil”–, and (7) auction websites

(http://www.mercadolivre.com.br, http://www.olx.com.br and http://www.bomnegocio.com).

Only species with explicit usage in aquaria were included in the inventories. Therefore, organisms exploited exclusively as handcrafts, souvenirs, curio, or for either medical or magic-religious purposes were not analyzed. The exploitation of species was analyzed concerning specific norms and the threatening statuses of each species were determined based on the Brazilian lists of threatened species and the International Union for Conservation of Nature – IUCN red list of threatened species.

Results

Exploitation and conservation statuses of all species inventoried were analyzed, respectively, regarding the norms that regulate their usage in Brazil, besides their presence or not in the Brazilian lists of threatened species. Two administrative rules are applicable to ordinate fish (IN Ibama 202/08) and algae (IN MMA 89/06) exploitation. As there is a paucity of administrative norms regulating the usage of invertebrates, the only applicable rule is federal law 9,605/98.

Concerning the species' conservation statuses, fish and invertebrate were evaluated according to their classification in the Brazilian list of threatened fish and aquatic invertebrate species (*Portaria* MMA 445/14) and the IUCN red list (version 3.1), both using the same threatening categories: (NE) Not Evaluated, (DD) Data Deficient, (LC) Least Concern, (NT) Near Threatened, (VU) Vulnerable, (EN) Endangered, (CR) Critically Endangered, (EW) Extinct in the Wild or (EX) Extinct - it must be highlighted that due to controversies after publication of *Portaria* 445/14, it had its effects temporarily suspended by the Brazilian judiciary, but was not yet canceled by governmental authorities. For the analysis of the conservation statuses of macroalgae and aquatic macrophytes, it was used the Brazilian list of threatened flora species (*Portaria* 443/14) and again the IUCN red list criteria.

In the present survey, more than 200 bone and cartilaginous fish species were identified by accessing 24 different sources of information (Table 1). From this total, only 136 species can be legally exploited according to IN Ibama 202/08. Some species whose collection is not allowed by this norm may be exploited by means of specific authorizations (those categorized as vulnerable – VU in accordance with *Portaria* MMA 445/14) and other may be only harvested for scientific research or conservation purposes (e.g. species classified as EN or CR also at *Portaria* MMA 445/14).

In addition, table 1 also reports the occurrence of five fish species endemic of Brazilian oceanic islands, two new species from different genera and four updated scientific names for species reported under other synonyms in previous works.

Table 1 – Marine fish species traded in Brazil for aquarium purposes and their conservation status.

Species	Harvesting in accordance with IN 202/08	Brazilian list of threatened fish species (*Portaria* MMA 445/14)	IUCN red list of threatened species	Observation
Osteichthyes				
Abudefduf saxatilis[1;4;9;11;18;19;22;21;23;24]	Allowed	NE	LC	-
Acanthostracion polygonius[4;9;11;18;19]	Allowed	NE	LC	-
Acanthostracion quadricornis[1;4;7;9;11;18;19;24]	Allowed	NE	LC	-
Acanthurus bahianus[1;2;6;9;11;18;19;22;23;24]	Allowed	NE	LC	-
Acanthurus chirurgus[1;2;7;9;11;18;19;22;24]	Allowed	NE	LC	-
Acanthurus coeruleus[1;2;4;6;9;11;18;19; 22;23;24]	Allowed	NE	LC	-
Achirus lineatus[11;18;19]	Allowed	NE	LC	-
Alphestes afer[9;11;18;19]	Allowed	DD	LC	-
Aluterus schoepfii[11;18;19]	Allowed	NE	LC	-
Aluterus scriptus[1;9;11;18;19]	Allowed	NE	LC	-
Amblycirrhitus pinos[1;4;9;11;18;19;22; 23;24]	Allowed	DD	LC	-
Anisotremus moricandi[4;9;21]	Prohibited	NE	LC	-
Anisotremus surinamensis[9;11;18;19]	Allowed	DD	NE	-

Anisotremus virginicus[1;4;6;8;9;11;18;19; 22;23]	Allowed	NE	LC	-
Antennarius multiocellatus[1;6;18;21]	Prohibited	DD	LC	-
Antennarius striatus[4;11;18;19;21]	Allowed	DD	LC	-
Apogon americanus[11;18;19;21;22;24]	Allowed	NE	NE	-
Apogon maculatus[1]	Prohibited	NE	LC	-
Apogon planifrons[4;11;21]	Prohibited	NE	LC	-
Apogon pseudomaculatus[1;11;18;19;21]	Allowed	NE	LC	-
Archosargus rhomboidalis[11;18;19]	Allowed	NE	LC	-
Astrapogon puncticulatus[18]	Prohibited	NE	LC	-
Aulostomus strigosus[9;11;18;19]	Allowed	NE	LC	-
Balistes vetula[1;2;4;6;9;18;21;23;24]	Prohibited	NT	NT	-
Bathygobius soporator[1;11;18;19]	Allowed	NE	LC	-
Batrachoides surinamensis[11;18;19;23]	Allowed	NE	LC	-
Bodianus insularis[12;18;20]	Prohibited	NE	LC	EI
Bodianus pulchellus[1;6;9;11;18;19;21;22; 23;24]	Allowed	NE	LC	-
Bodianus rufus[1;2;4;6;9;11;18;19;21;22;23;24]	Allowed	NE	LC	-
Bothus lunatus[4;9;11;18;19]	Allowed	NE	LC	-
Bothus ocellatus[7;9;11;18;19]	Allowed	NE	LC	-
Calamus spp.[9]	-	-	-	-
Calamus pennatula[11;18;19]	Allowed	NE	LC	-
Cantherhines macrocerus[1;4;11;18;19;21;23; 24]	Allowed	NE	LC	-
Cantherhines pullus[1;4;9;11;18;19;21]	Allowed	NE	LC	-
Canthigaster figueiredoi[1;4;9;11;18;19;21;24]	Allowed	NE	LC	-
Carangoides crysos[9]	Prohibited	NE	LC	-
Caranx latus[9]	Prohibited	NE	LC	-
Caranx lugubris[9]	Prohibited	NE	LC	-
Centropyge aurantonotus[1;2;4;6;7;9;11;18;19;21;22;23;24]	Allowed	DD	LC	-
Cephalopholis fulva[1;9;18;19]	Prohibited	NE	LC	-
Chaetodipterus faber[1;6;11;18;19;23]	Allowed	NE	LC	-
Chaetodon ocellatus[1;2;4;6;7;11; 18;19;21;22;23;24]	Allowed	DD	LC	-
Chaetodon sedentarius[1;2;4;6;9;11;18;19;21;22]	Allowed	NE	LC	-
Chaetodon striatus[1;2;4;6;7;9;11; 18;19;21;22;23;24]	Allowed	NE	LC	-
Chilomycterus antennatus[11;18;19;23]	Allowed	NE	LC	-
Chilomycterus antillarum[1;11;18;19]	Allowed	NE	LC	-
Chilomycterus schoepfii[6]	Prohibited	NE	LC	-
Choranthias salmopunctatus[13;18;20]	Prohibited	VU	LC	EI, DN*

Chromis flavicauda[1;4;9;21]	Prohibited	NE	DD	-
Chromis jubauna[4;9;21]	Prohibited	NE	NE	-
Chromis multilineata[1;4;9;11;18;19;21]	Allowed	NE	LC	-
Clepticus brasiliensis[9;11;18;19]	Allowed	NE	LC	-
Conodon nobilis[11;18;19]	Allowed	NE	LC	-
Coryphopterus spp.[9]	-	-	-	-
Coryphopterus glaucofraenum[11;18;19;23]	Allowed	NE	LC	-
Cosmocampus albirostris[10;11;18;19;23]	Allowed	NE	LC	-
Cryptotomus roseus[9]	Prohibited	NE	LC	-
Cychlichthys spinosus[4;11;18;19;21]	Allowed	NE	NE	-
Dactylopterus volitans[1;2;6;9;11;18;19]	Allowed	NE	LC	-
Dermatolepis inermis[9]	Prohibited	NE	NT	-
Diodon holacanthus[4;11;18;19]	Allowed	NE	LC	-
Diodon hystrix[1;6;9;11;18;19;24]	Allowed	NE	LC	-
Diplectrum formosum[11;18;19]	Allowed	NE	LC	-
Diplectrum radiale[9;11;18;19]	Allowed	NE	LC	-
Diplodus argenteus[9]	Prohibited	NE	LC	-
Doratonotus megalepis[9;11;18;19;23]	Allowed	NE	LC	-
Dules auriga[11;18;19]	Allowed	NE	NE	-
Echeneis naucrates[1;11;18;19;23]	Allowed	NE	LC	-
Elacatinus figaro[2;4;7;8;9;14;18;20;21;22;23]	Prohibited	VU	NE	-
Emblemariopsis signifer[9]	Prohibited	NE	LC	-
Epinephelus adscensionis[18]	Prohibited	DD	LC	-
Epinephelus itajara[4;20;21]	Prohibited	CR	CR	-
Epinephelus marginatus[9]	Prohibited	VU	EN	-
Epinephelus morio[9]	Prohibited	VU	NT	-
Equetus lanceolatus[1;4;21]	Prohibited	NE	LC	-
Fistularia tabacaria[9;11;18;19]	Allowed	NE	LC	-
Gnatholepis thompsoni[9]	Prohibited	NE	LC	-
Gobiesox strumosus[11;18;19]	Allowed	NE	LC	-
Gramma brasiliensis[2;3;4;7;8;9;15;18;20;21;23]	Prohibited	NT	NE	-
Gymnachirus nudus[11;18;19]	Allowed	NE	LC	-
Gymnothorax funebris[1;6;11;18;19;22]	Allowed	DD	LC	-
Gymnothorax miliaris[1;4;8;11;18;19;22;24]	Allowed	NE	LC	-
Gymnothorax moringa[9;11;18;19;24]	Allowed	DD	LC	-
Gymnothorax ocellatus[11;18;19]	Allowed	DD	LC	-

Gymnothorax vicinus[1;9;11;18;19]	Allowed	DD	LC	-
Haemulon aurolineatum[9]	Prohibited	NE	LC	-
Haemulon plumieri[1;9;22]	Prohibited	DD	NE	-
Haemulon steindachneri[9;11;18;19]	Allowed	NE	LC	-
Halichoeres bivittatus[1;4;11;18;19;21]	Allowed	NE	LC	-
Halichoeres brasiliensis[1;4;6;9;11;18;19;21;23]	Allowed	NE	DD	-
Halichoeres dimidiatus[1;2;4;6;8;9;11;18;19;21;22;23;24]	Allowed	NE	LC	DN**
Halichoeres penrosei[1;4;6;9;11;18;19;21]	Allowed	NE	LC	DN***
Halichoeres poeyi[1;4;9;11;18;19;21]	Allowed	NE	LC	-
Heteropriacanthus cruentatus[11;18;19]	Allowed	NE	LC	-
Hippocampus erectus[1;2;4;6;7;10;11;18;19;21]	Allowed	VU	VU	-
Hippocampus reidi[2;4;5;7;10;11;18;19; 20;21;22]	Allowed	VU	DD	-
Holacanthus ciliaris[1;2;4;6;7;8;9;11;18;19;21;22;23;24]	Allowed	DD	LC	-
Holacanthus tricolor[2;4;6;7;8;9;11; 18;19;21;22;23;24]	Allowed	DD	LC	-
Holocentrus adscensionis[7;9;11;18;19]	Allowed	NE	LC	-
Hypleurochilus fissicornis[9]	Prohibited	NE	LC	-
Kyphosus spp.[9]	-	-	-	-
Kyphosus incisor[11;18;19]	Allowed	NE	NE	-
Kyphosus sectatrix[11;18;19]	Allowed	NE	LC	-
Labrisomus cricota[4;21]	Prohibited	NE	LC	-
Labrisomus kalisherae[9]	Prohibited	NE	NE	-
Labrisomus nuchipinnis[9;11;18;19;21]	Allowed	NE	LC	-
Lactophrys spp.[1]	-	-	-	-
Lactophrys polygonia[6]	Prohibited	NE	NE	-
Lactophrys trigonus[11;18;19]	Allowed	NE	LC	-
Lagocephalus laevigatus[7;11;18;19]	Allowed	NE	LC	-
Liopropoma carmabi[4;21;23]	Prohibited	NE	LC	-
Lutjanus analis[1]	Prohibited	NT	VU	-
Lutjanus jocu[9]	Prohibited	NT	NE	-
Lutjanus synagris[9]	Prohibited	NT	NE	-
Malacanthus plumieri[1]	Prohibited	NE	LC	-
Malacoctenus sp. n.[9;18;21;22;23;24]	Prohibited	-	-	NS
Malacoctenus delalandei[9]	Prohibited	NE	LC	-
Melichthys niger[11;18]	Allowed	NE	LC	-
Menticirrhus americanus[11;18]	Allowed	DD	LC	-
Microgmathus sp.[10]	Prohibited	-	-	-

Microphis lineatus[4;21]	Prohibited	NE	NE	DN****
Micropogonias furnieri[19]	Prohibited	NE	LC	-
Microspathodon chrysurus[1;2;3;9;18;21]	Prohibited	VU	LC	-
Mugil curema[9]	Prohibited	DD	LC	-
Mulloidichthys martinicus[9;11;18;19]	Allowed	NE	LC	-
Mullus argentinae[11;18;19]	Allowed	NE	NE	-
Muraena pavonina[11;18;19]	Allowed	NE	LC	-
Mycteroperca bonaci[9]	Prohibited	VU	NT	-
Mycteroperca interstitialis[9]	Prohibited	VU	VU	-
Myrichthys breviceps[4;11;18;19]	Allowed	NE	LC	-
Myrichthys ocellatus[1;9;11;18;19;22]	Allowed	NE	LC	-
Myripristis jacobus[1;4;9;11;18;19]	Allowed	NE	LC	-
Ocyurus chrysurus[6;9]	Prohibited	NT	NE	-
Odontoscion dentex[9;11;18;19]	Allowed	NE	LC	-
Ogcocephalus spp.[1;6]	-	-	-	-
Ogcocephalus nasutus[1]	Prohibited	NE	LC	-
Ogcocephalus notatus[19]	Prohibited	NE	LC	-
Ogcocephalus vespertilio[1;4;9;11;18;19]	Allowed	NE	NE	-
Oligoplites saliens[11;18;19]	Allowed	NE	LC	-
Ophioblennius trinitatis[4;11;18;19;21;23; 24]	Allowed	NE	LC	-
Opistognathus sp. n.[1;4;18;21;23]	Prohibited	-	-	NS
Opistognathus lonchurus[4;21]	Prohibited	NE	LC	-
Orthopristis ruber[9;11;18;19]	Allowed	NE	LC	-
Parablennius marmoreus[4;9;11;18;19;21]	Allowed	NE	LC	-
Parablennius pilicornius[11;18;19]	Allowed	NE	LC	-
Paraclinus rubicundus[11;18;19]	Allowed	NE	LC	-
Paralonchurus brasiliensis[11;18]	Allowed	NE	LC	-
Paranthias furcifer[9;11;18;19]	Allowed	NE	LC	-
Pareques acuminatus[1;3;4;6;9;11; 18;19;22;23;24]	Allowed	DD	LC	-
Pempheris schomburgkii[11;18;19]	Allowed	NE	LC	-
Phaeoptyx pigmentaria[4;11;18;19;21]	Allowed	NE	LC	-
Plectrypops retrospinis[11;18;19]	Allowed	NE	LC	-
Pomacanthus arcuatus[1;2;4;6;7;9;11;18;19;21;22;23]	Allowed	DD	LC	-
Pomacanthus paru[1;2;4;6;7;9;11;18;19;21;22;23;24]	Allowed	DD	LC	-
Pomadasys corvinaeformis[11;18;19]	Allowed	NE	NE	-
Porichthys porosissimus[11;18;19]	Allowed	NE	NE	-

Priacanthus arenatus[9]	Prohibited	NE	LC	-
Prionotus nudigula[11;18;19]	Allowed	NE	NE	-
Prionotus punctatus[1;19]	Prohibited	NE	LC	-
Prognathodes brasiliensis[4;9;11;21]	Prohibited	NE	LC	-
Prognathodes guyanensis[4;11;21]	Prohibited	NE	LC	-
Prognathodes obliquus[4;11;16;18; 20;21]	Prohibited	VU	DD	EI
Pseudocaranxs dentex[9]	Prohibited	NE	LC	-
Pseudupeneus maculatus[1;9]	Prohibited	NE	LC	-
Ptereleotris randalli[11;21]	Prohibited	NE	LC	-
Rypticus bitrispinus[9;11;18;19]	Allowed	NE	LC	-
Rypticus saponaceus[9;11;18;19]	Allowed	NE	LC	-
Scartella cristata[4;8;11;18;21;22;23;24]	Allowed	NE	LC	-
Scarus spp.[1]	-	-	-	-
Scarus trispinosus[9;20]	Prohibited	EN	EN	-
Scarus zelindae[4;9;11;18;19;21]	Allowed	VU	DD	-
Scorpaena brasiliensis[1;9;11;18;19]	Allowed	NE	LC	-
Scorpaena isthmensis[11;18;19]	Allowed	NE	LC	-
Scorpaena plumieri[1;9;11;18;19]	Allowed	NE	LC	-
Selar crumenophthalmus[9]	Prohibited	NE	LC	-
Selene vomer[1;2;11;18;19;22]	Allowed	NE	LC	-
Seriola spp.[9]	Prohibited	-	-	-
Serranus baldwini[1;9;11;18;19;23]	Allowed	NE	LC	-
Serranus flaviventris[1;9;11;18;19]	Allowed	NE	LC	-
Serranus phoebe[9;11;18;19]	Allowed	NE	LC	-
Sparisoma spp.[7;9]	-	-	-	-
Sparisoma amplum[9;11;18;19]	Allowed	NT	LC	-
Sparisoma axillare[9;11;18;19]	Allowed	VU	DD	-
Sparisoma frondosum[9;11;18;19]	Allowed	VU	DD	-
Sparisoma radians[9;11;18;19]	Allowed	NE	LC	-
Sparisoma tuiupiranga[4;9;21]	Prohibited	NE	NE	-
Sphoeroides greeleyi[9;11;18;19]	Allowed	NE	LC	-
Sphoeroides spengleri[1;9;11;18;19;24]	Allowed	NE	LC	-
Sphoeroides testudineus[11;18;19]	Allowed	DD	LC	-
Stegastes spp.[1]	-	-	-	-
Stegastes fuscus[3;4;9;11;18;19;21;23]	Allowed	NE	LC	-
Stegastes pictus[1;4;9;11;18;19;21]	Allowed	NE	NE	-

Stegastes rocasensis[20]	Prohibited	VU	NE	EI
Stegastes sanctipauli[18;20]	Prohibited	VU	LC	EI
Stegastes uenfi[11;18;19]	Allowed	NE	NE	-
Stegastes variabilis[1;4;9;11;18;19;21;23;24]	Allowed	NE	NE	-
Stephanolepis spp.[7]	-	-	-	-
Stephanolepis hispidus[1;9;11;18;19]	Allowed	NE	LC	-
Stephanolepis setifer[11;18;19]	Allowed	NE	LC	-
Stygnobrotula latebricola[4;11;18;19;21]	Allowed	NE	LC	-
Syngnathus sp.[10]	Prohibited	-	-	-
Synodus foetens[11;18;19]	Allowed	NE	LC	-
Synodus intermedius[7;9;11;18;19]	Allowed	NE	LC	-
Synodus synodus[9;11;18;19]	Allowed	NE	LC	-
Thalassoma spp.[1]	-	-	-	-
Thalassoma noronhanum[4;6;9;11;18;19;21]	Allowed	NE	LC	-
Thalassophryne montevidensis[11;18;19]	Allowed	NE	NE	-
Thalassophryne nattereri[11;18;19]	Allowed	NE	LC	-
Trachinocephalus myops[11;18;19]	Allowed	NE	LC	-
Upeneus parvus[11;18;19]	Allowed	NE	LC	-
Xyrichthys novacula[1;4;11;18;19;21]	Allowed	NE	LC	-
Xyrichthys splendens[1;11;18;19]	Allowed	NE	LC	-
Chondrichthyes				
Aetobatus narinari[8]	Prohibited	DD	NT	-
Dasyatis spp.[8]	Prohibited	-	-	-
Dasyatis guttata[1]	Prohibited	NE	DD	-
Dasyatis marianae[8]	Prohibited	DD	DD	-
Ginglymostoma cirratum[1;4;20;21]	Prohibited	VU	DD	-
Narcine brasiliensis[1;4;21]	Prohibited	DD	DD	-
Pristis perotteti[17]	Prohibited	NE	NE	-
Rhinobatos spp.[1;4;21;23]	Prohibited	-	-	-
Rhinobatos percellens[1]	Prohibited	DD	NT	-
Rhinoptera bonasus[8]	Prohibited	DD	NT	-
Zapteryx brevirostris[4;21]	Prohibited	VU	VU	-

Sources of information: [1]Monteiro-Neto et al. (2003), [2]Araújo and Albuquerque-Filho (2005), [3]Ferreira et al. (2005), [4]Gasparini et al. (2005), [5]Rosa et al. (2005), [6]Nottingham et al. (2005b), [7]Nottingham et al. (2005a), [8]Sampaio and Rosa (2005), [9]Floeter et al. (2006), [10]Rosa et al. (2006), [11]IN Ibama 202/08, [12]Moura (2008a), [13]Moura (2008b), [14]Moura et al. (2008); [15]Moura and Sazima

(2008); [16]Moura (2008c); [17]Charvet-Almeida and Faria (2008); [18]Sampaio and Nottingham (2008), [19]Ibama (2008a), [20]Mohr et al. (2009), [21]Sampaio and Ostrensky (2013),[22]Autor's personal observation, [23]Marine aquarium discussion forums, [24]Brazilian pet shop's websites/auction webpages. Threatening categories according to the Brazilian list of threatened fish and aquatic invertebrate species (*Portaria* MMA 43/14 and *Portaria* MMA 445/14) and the IUCN red list of threatened species (version 3.1): (NE) Not Evaluated, (DD) Data Deficient, (LC) Least Concern, (NT) Near Threatened, (VU) Vulnerable, (EN) Endangered, (CR) Critically Endangered – for DD and NT species recorded in Brazil see http://www.icmbio.gov.br >> biodiversidade >> fauna brasileira >> lista de espécies quase ameaçadas e com dados insuficientes. Observation: (EI) Endemic of Brazilian oceanic islands; (NS) New Species; (DN) Different Name used in references – originally mentioned as (*) *Anthias salmopunctatus,* (**) *Halichoeres cyanocephalus*, (***) *Halichoeres maculipinna* and (****) *Microphis eigenmanni*.

Invertebrates were classified into seven groups: mollusks, cnidarians, crustaceans, echinoderms, polychaetes, ascidians and sponges. The first four were the most representative regarding the number of species, and some of them are included in both the Brazilian list of threatened fish and aquatic invertebrate species and IUCN red list (table 2).

Even though law 9,605/98 permits exploitation of mollusks and crustaceans (there defined as fishing resources), it prohibits the usage of species that figure in the Brazilian List of threatened fish and aquatic invertebrate species, as well as of those other invertebrates (cnidarians, echinoderms, polychaetes, ascidians and sponges). Hence, exploitation of the bivalve *Euvola ziczac* is forbidden because it is classified as EN, according to *Portaria* MMA 445/14.

Table 2 also presents species that were misidentified in marine aquarium discussion forums and Brazilian pet shop's websites or auction webpages, besides organisms that were incidentally exploited attached to liverocks.

Table 2 – Marine aquarium invertebrates traded in Brazil and their conservation status.

Species	Harvesting in accordance with the Brazilian Environmental Crime Law (9,605/98)	Brazilian list of threatened aquatic invertebrate species (*Portaria* MMA 445/14)	IUCN red list of threatened species	Observation
Mollusks				
Anadara brasiliana[17]	Allowed	NE	NE	-

Aplysia dactylomella[17]	Allowed	NE	NE	-
Aplysia parvula[17]	Allowed	NE	NE	-
Astraea phoebia[17;20;21]	Allowed	NE	NE	-
Astraea tecta[17;20;21]	Allowed	NE	NE	-
Atrina seminuda[17]	Allowed	NE	NE	-
Berghia sp.[20]	Allowed	-	-	-
Bornella calcarata[18]	Allowed	NE	NE	-
Cassis tuberosa[17]	Allowed	NT	NE	-
Cerithium atratum[19;20;21]	Allowed	NE	NE	-
Charonia variegata[17]	Allowed	NE	NE	-
Chlamys ornata[18]	Allowed	NE	NE	-
Caribachlamys sentis[18]	Allowed	NE	NE	-
Conus spp. [2;18]	Allowed	-	-	-
Cyphoma gibbosum[18]	Allowed	NE	NE	-
Cyphoma macumba[18]	Allowed	NE	NE	-
Cypraea brasiliensis[17]	Allowed	NE	NE	-
Cypraea spurca[17]	Allowed	NE	NE	-
Elysia subornata[20]	Allowed	NE	NE	-
Euvola ziczac[17]	Prohibited	EN	NE	BL
Lima lima[18]	Allowed	NE	NE	-
Lima pellucida[18]	Allowed	NE	NE	-
Loligo plei[17]	Allowed	NE	NE	-
Lyropecten nodosus[18;19]	Allowed	NE	NE	-
Macrocypraea zebra[20]	Allowed	NE	NE	-
Micromelo undatus[18;20]	Allowed	NE	NE	-
Neritina virginea[19;20;21]	Allowed	NE	LC	-
Octopus vulgaris[2]	Allowed	NE	NE	-
Phidiana lynceus[18]	Allowed	NE	NE	-
Pinna carnea[17]	Allowed	NE	NE	-
Pleurobranchus sp.[18]	Allowed	-	-	-
Pteria colymbus[17]	Allowed	NE	NE	-
Rostanga byga[18]	Allowed	NE	NE	-
Spondylus americanus[18]	Allowed	NE	NE	-
Strombus pugilis[20]	Allowed	NE	NE	-
Stramonita brasiliensis[19]	Allowed	NE	NE	-
Tegula viridula[19;20;21]	Allowed	NE	NE	-

Trachycardium muricatum[17]	Allowed	NE	NE	-
Turbo canaliculatus[18]	Allowed	NE	NE	-
Crustaceans				
Acanthonix sp.[20;21]	Allowed	NE	NE	OM
Alphaeus sp.[20]	Allowed	NE	NE	-
Brachycarpus cf. *biunguinculatus*[2]	Allowed	NE	NE	-
Calcinus tibicen[2;17;19;20;21]	Allowed	NE	NE	-
Cinetorhynchus rigens[2;20;21]	Allowed	NE	NE	-
Clibanarius spp.[19;20;21]	Allowed	-	-	-
Dardanus venosus[2;20]	Allowed	NE	NE	-
Enoplometopus antillensis[2;18;20]	Allowed	DD	LC	-
Gnathophyllum americanum[18]	Allowed	NE	NE	-
Lepas anatifera[18]	Allowed	NE	NE	-
Lepas anserifera[18]	Allowed	NE	NE	-
Lysmata grabhami[2;17;19;20;21]	Allowed	NE	NE	-
Lysmata rathbunae[17;20]	Allowed	NE	NE	-
Lysmata wurdemanni[2;17;19;20;21]	Allowed	NE	NE	-
Mithrax spp.[20;21]	Allowed	-	-	-
Mithraculus forceps[20]	Allowed	NE	NE	-
Parribacus antarcticus[18]	Allowed	NE	LC	-
Periclimenes aff. *pedersoni*[2;20]	Allowed	NE	NE	-
Periclimenes aff. *yucatanicus*[2]	Allowed	NE	NE	-
Petrochirus diogenes[2;17]	Allowed	NE	NE	-
Phimochirus holthuisi[18]	Allowed	NE	NE	-
Platypodiella spectabilis[2;19;20;21]	Allowed	NE	NE	-
Scyllarides aequinoctialis[18]	Allowed	NE	LC	-
Stenopus hispidus[2;17;19;20;21]	Allowed	NE	NE	-
Stenopus scutellatus[2]	Allowed	NE	NE	-
Stenorhynchus seticornis[2;17;19;20;21]	Allowed	NE	NE	-
Thor aff. *amboinensis*[2;18]	Allowed	NE	NE	-
Cnidarians				
Actinoporus sp.[2]	Prohibited	-	-	-
Alicia mirabilis[2]	Prohibited	NE	NE	-
Bellactis ilkalysae[2]	Prohibited	NE	NE	-

Carijoa riisei[2]	Prohibited	NE	NE	-
Cerianthomorphe brasiliensis[3]	Prohibited	DD	NE	-
Cerianthus brasiliensis[4]	Prohibited	NE	NE	-
Condylactis gigantea[2;5]	Prohibited	EN	NE	-
Discosoma spp.[2]	Prohibited	-	-	-
Favia gravida[2]	Prohibited	NE	NE	-
Heterogorgia uatumani[2]	Prohibited	NE	NE	-
Lophogorgia punicea[2]	Prohibited	NE	NE	-
Lophogorgia violacea[2]	Prohibited	NE	NE	-
Madracis decactis[2]	Prohibited	NE	LC	-
Meandrina braziliensis[2]	Prohibited	DD	DD	-
Millepora alcicornis[2;6]	Prohibited	NE	LC	-
Millepora braziliensis[2]	Prohibited	DD	DD	-
Montastrea cavernosa[2]	Prohibited	NE	NE	-
Muricea flamma[2]	Prohibited	NE	NE	-
Muriceopsis sulphurea[2]	Prohibited	NE	NE	-
Mussismilia braziliensis[2]	Prohibited	VU	DD	-
Mussismilia harttii[2]	Prohibited	EN	DD	-
Mussismilia hispida[2]	Prohibited	NE	DD	-
Palythoa caribaeorum[2]	Prohibited	NE	NE	-
Phyllogorgia dilatata[2;7]	Prohibited	DD	NE	-
Plexaurella grandiflora[2]	Prohibited	NE	NE	-
Plexaurella regia[2]	Prohibited	NE	NE	-
Porites branneri[2]	Prohibited	NE	NT	-
Scolymia wellsi[2]	Prohibited	NE	DD	-
Siderastrea stellata[2]	Prohibited	NE	DD	-
Zoanthus spp.[2]	Prohibited	-	-	-
Echinoderms				
Asterina stellifera[8;16]	Prohibited	NE	NE	-
Astropecten brasiliensis[16]	Prohibited	VU	NE	-
Astropecten marginatus[16]	Prohibited	NE	NE	-
Astrophyton sp.[2]	Prohibited	-	-	-
Echinaster spp.[2]	Prohibited	-	-	-
Echinaster (Othilia) brasiliensis[2;9]	Prohibited	NE	NE	-
Echinaster (Othilia) echinophorus[2;10]	Prohibited	NE	NE	-

Echinaster (Othilia) guyanensis[2]	Prohibited	NE	NE	-
Echinometra lucunter[20]	Prohibited	NE	NE	-
Eucidaris tribuloides[2;11;20]	Prohibited	NE	NE	-
Linckia guildingii[2;12;19]	Prohibited	VU	NE	-
Lytechinus variegatus[20]	Prohibited	VU	NE	-
Luidia clathrata[16]	Prohibited	NE	NE	-
Luidia senegalensis[16]	Prohibited	VU	NE	-
Narcissia trigonaria[2;13]	Prohibited	NE	NE	-
Ophioderma spp.[2]	Prohibited	-	-	-
Oreaster reticulatus[14]	Prohibited	VU	NE	-
Tropiometra carinata[20]	Prohibited	NE	NE	-
Polychaetes				
Eurythoe complanata[15]	Prohibited	NE	NE	-
Spirobranchus spp.[2]	Prohibited	NE	NE	-
Ascidians				
Botrylloides nigrum[20]	Prohibited	NE	NE	IE
Polycarpa insulsa[20]	Prohibited	NE	NE	IE
Styela plicata[20]	Prohibited	NE	NE	-
Sponges				
Aplysina fulva[1]	Prohibited	NE	NE	-
Axinyssa sp.[1]	Prohibited	-	-	-
Dragmacidon reticulata[1;22]	Prohibited	NE	NE	-
Tethya sp.[1]	Prohibited	-	-	-

Source or information: [1]Sampaio et al., (2004); [2]Gasparini et al. (2005); [3]Pires and Castro (2008a); [4]Pires and Castro (2008b); [5]Pires and Castro (2008c); [6]Pires and Castro (2008d); [7]Castro and Pires (2008); [8]Brites et al. (2008a); [9]Ventura et al. (2008a); [10]Ventura et al. (2008b); [11]Ventura et al. (2008c); [12]Brites et al. (2008b); [13]Brites et al. (2008c); [14]Brites et al. (2008d);[15]Amaral et al. (2008); [16]Amaral et al (2010); [17]Authorization of exportation issued by Ibama; [18]Authorization of exportation requested but not issued by Ibama; [19]Author's personal observation; [20]Marine aquarium discussion forums; [21]Brazilian pet shop's websites/auction webpages; [22]Hajdu et al (2011). Threatening categories according to the Brazilian list of threatened fish and aquatic invertebrate species (Portaria MMA 43/14 and Portaria MMA 445/14) and the IUCN red list of threatened species (version 3.1): (NE) Not Evaluated, (DD) Data Deficient, (LC) Least Concern, (NT) Near Threatened, (VU) Vulnerable, (EN) Endangered. Observations: (BL) Although law 9,605/98 allows collection of mollusks, the species cannot be harvested since it is classified as EN in the Brazilian List of threatened fish and aquatic invertebrate species, (OM) Originally Misidentified as *Xenocarcinus* sp. or *Macropodia longirostris,* (IE) Incidental Exploitation attached to “liverocks”.

It was also recorded the use of seaweeds and saltwater macrophytes in marine tanks throughout the country (table 3) and the great majority of species is neither cited in the Brazilian list of threatened flora species (*Portaria* MMA 443/14) nor in the IUCN red list of threatened species. The only exception is *Halophila decipiens*, which is categorized as Least Concern (LC) solely in the IUCN red list.

Table 3 – Seaweeds and aquatic macrophytes used in marine aquarium trading in Brazil.

Species	Harvesting in accordance with IN 89/06	Brazilian list of threatened flora species (*Portaria* MMA 443/14)	IUCN red list of threatened species
Green seaweeds (Chlorophyta)			
Acetabularia calyculus[2]	Allowed	NE	NE
Bryopsis sp.[2]	Allowed	-	-
Caulerpa prolifera[2]	Allowed	NE	NE
Caulerpa racemosa[2]	Allowed	NE	NE
Caulerpa sertularioides[2]	Allowed	NE	NE
Caulerpa taxifolia[2]	Allowed	NE	NE
Chaetomorpha linum[2;4]	Allowed	NE	NE
Chaetomorpha sp.[2;3]	Allowed	-	-
Codium sp.[2]	Allowed	-	-
Halimeda sp[2]	Allowed	-	-
Udotea sp.[2]	Allowed	-	-
Red seaweeds (Rodophyta)			
Acanthophora sp.[2]	Allowed	-	-
Ceramium sp.[2]	Allowed	-	-
Chondria sp.[2]	Allowed	-	-
Gracilaria sp.[2]	Allowed	-	-
Jania sp.[2]	Allowed	-	-
Lithothamnium spp.[1]	Allowed	-	-
Brown seaweeds (Phaeophyta)			
Dictyota cervicomis[2]	Allowed	NE	NE

Lobophora sp.[2]	Allowed	-	-
Padina sp.[2]	Allowed	-	-
Macrophytes (Sea grasses)			
Halophila decipiens[2]	Not applicable	NE	LC
Halodule sp.[2]	Not applicable	-	-

Source of information: [1]Ibama (2008a); [2]Marine aquarium discussion forums; [3]Author's personal observation; [4]Brazilian pet shop's websites/auction webpages. Threatening categories according to the Brazilian list of threatened flora species (*Portaria* MMA nº 43/2014 and *Portaria* MMA 443/15) and the IUCN red list of threatened species (version 3.1): (NE) Not Evaluated, (LC) Least Concern.

Discussion

From the wide variety of native organisms traded by the marine aquarium industry in Brazil, many species figure in Brazilian lists of threatened species. Currently, it is much easier to compare these species with those categorized in the IUCN red list. While preceding Brazilian lists of threatened species (IN MMA 05/04 and IN MMA 52/05) had their own categories and criteria, the most recent Brazilian lists (*Portaria* MMA 443/14 and *Portaria* MMA 445/14) followed the IUCN patterns, which allow more reliable comparisons, avoiding mismatches already detected (Bender et al., 2012). On the one hand, agreements regarding categories increase credibility of red lists, on the other hand, desagreemends can either do the opposite or demonstrate that in particular cases a species may locally present a distinctive threatening degree compared to the general reality along its whole distribution.

Bonefishes represent the great majority of the exploited species. Despite only 136 species can be legally commercialized according to IN Ibama 202/08, about 70 others are illegally traded in Brazil. This situation not only demonstrates a lack of more effective control by the Brazilian authorities but also indicates that many dealers and tank owners ignore or do not obey the norms that regulate the exploitation of marine aquarium organisms. Such illegal exploitation is specially worrying because some organisms are included in the Brazilian list of threatened species under

really threatening conservation statuses (e.g. EN or CR categories) or maybe worse, whose statuses are simply unknown (e.g. NE or DD categories).

Among many fish species, *Elacatinus figaro* (VU, in accordance with *Portaria* MMA 445/14) and *Gramma brasiliensis* (whose harvesting was prohibited until December 2014, for being categorized as threatened with extinction by an older norm - IN MMA 05/04) are frequently cited by different sources of information investigated, indicating that, despite the prohibition by IN Ibama 202/08, both have been commonly found in ornamental trade.

This statement is corroborated through the apprehension by Ibama of 18 barber goby specimens, that were being illegally traded by means of the Brazilian official postal service (L. M. Gurjão unpublished data), and through another apprehension of *E. figaro* and *G. brasiliensis* specimens, at Guarulhos international airport, during the 2014 Fifa World Cup in Brazil. (http://www.ibama.gov.br/publicadas/pagina-19-20). Another aspect that deserves special attention regarding the exploitation of the *E. figaro* is the potential negative ecological effect in reef areas, since it is a recognized cleaner species that plays an important role at cleaning stations (Sazima et al., 2000; Campos and Sá-Oliveira, 2011).

Considering the Brazilian list of threatened species and the distribution of the fish traded, it must be highlighted that four exploited species, classified as VU (*Choranthias salmopunctatus*, *Prognathodes obliquus, Stegastes rocasensis* and *S. sanctipauli*), are endemic to Brazilian oceanic islands and, hence, their populations are more vulnerable to exploitation due to isolation (Mohr et al, 2009). Even considering the fragile aspects of these isolated populations and the prohibition of harvesting individuals at Brazilian oceanic islands by IN Ibama 202/08, almost all of them were already recorded as being captured for the aquarium industry – the only exception is *C. salmopunctatus*, which, despite never observed in the Brazilian ornamental market, is a desired species, specially by the millionaire Asian commerce, due to its unique characteristics and extremely restricted geographic distribution (Sampaio and Nottingham, 2008).

Some authors mention the occurrence of certain fish species that could not be identified further than the genus level, but that are composed by species listed in *Portaria* MMA 445/14: *Micrognathus* (*M. erugatus* – CR), *Scarus (S. trispinosus* – EN and *S. zelindae* – VU), *Sparisoma* (*S. axillare* – VU, *S. frodosum* – VU and *S. rocha* – VU), *Stegastes* (*S. rocasensis* – VU, *S. sanctipauli* – VU and *S. trindadensis* – VU), *Dasyatis* (*D. centroura* – CR and *D. colarensis* – VU) and *Rhinobatos* (*R. horkelli* – CR and *R. lentiginosus* – VU) (Monteiro et al., 2003, Gasparini et al., 2005, Nottingham et al., 2005a, Sampaio and Rosa, 2005 and Rosa et al., 2006), thus, it is possible that other threatened species had been or even are still being exploited by the Brazilian marine aquarium industry.

Other important threatened species are the longsnout (*Hippocampus reidi*) and lined (*H. erectus*) seahorses. These species have received particular attention from the scientific community and governmental authorities, who decided to keep them with the lowest exportation quota (250 specimens of each species/exporter/year). This is because populations pressed by aquarium harvesting activities had shown lower densities and smaller individuals (Ibama, 2007, 2008a). However, the effectiveness of such measure is questionable since untrained and ill-intentioned dealers used to mislabel specimens of either *H. erectus* or *H. reidi* as they were *H. kuda* (Monteiro-Neto et al., 2003), while field surveys demonstrated that only *H. reidi* was actually exported, and that the given quota could be doubled if 250 *H. reidi* were traded under the name of H. *erectus* (Rosa et al., 2011). Furthermore, there is still controversy about the distribution and taxonomy of Brazilian seahorses. Despite most authors state that *H. reidi* has a wider distribution along the Brazilian coast, while *H. erectus* is more restricted to southern regions. However, evidences suggest that both species may have a continuous distribution along the Brazilian coast (Silveira, 2011). Moreover, while *H. reidi* and *H. erectus* are the only valid names for the Brazilian seahorses (Froese and Pauly, 2015), a revision of the genus *Hippocampus* not only revealed that individuals identified in Brazil as *H. erectus* are morphologically and genetically similar to *H. patagonicus* (Silveira et al.,

2014), but also indicated the existence of a population limited to northeastern Brazil, distinguishable from these two previously mentioned species (Ibama, 2009; Rosa et al., 2011).

Taxonomic problems are also on labrid, opistognatid and labrosomid fishes. After revalidation of some Brazilian wrasse species and reevaluation of their distribution (Rocha and Rosa, 2001; Rocha, 2004), it is likely that specimens referred as *Halichoeres radiatus*, *H. cyanocephalus* and *H. maculipinna* in previous works were actually misidentified, and should be, in fact, the labrids *H. brasiliensis*, *H. dimidiatus* and *H. penrosei*, respectively. Another possible mistake occurred for *Opistognathus aurifrons*, which shall be in fact a new species of the same genus - *Opistognathus* sp. n. - (Sampaio and Nottingham, 2008) and a third taxonomic incongruity is related to the forbidden exploitation of a new labrosomid species - *Malacoctenus* sp. n. (Floeter et al., 2003) -, which have being erroneously commercialized as a blenid, called 'red blenny'. Additionally, preceding articles also recorded the presence of *Microphis eigenmanni* in the Brazilian ornamental trade, which is a not valid synonym of *Microphis lineatus* (Froese and Pauly, 2015). Similarly, *Canthigaster figueiredoi* used to be referred as *C. rostrata* in previous works (Sampaio and Nottingham, 2008). Therefore, some fish scientific names recorded here may be different from those reported on original papers mentioning the usage of species for aquarium purposes, but are in accordance with the most recent synonyms used (Froese and Pauly, 2015).

With regards to unthreatened species, angelfishes have been systematically recorded among the most exploited species by the Brazilian ornamental industry (Nottingham et al., 2000; Monteiro-Neto et al., 2003; Gasparini et al., 2005; Nottingham et al., 2005a; Feitosa et al., 2015) and despite the paucity of updated information about the exploitation of marine fishes, the most recent official data available indicate that *Holacanthus ciliaris, H. tricolor*, *Pomacanthus paru, P. arcuatus* and *Centropyge aurantonotus* are still the most targeted species (Ibama, 2008a). Another fact that corroborates this statement is the growing demand for pomacanthids in the international market throughout the years, which lead the Brazilian authorities to attribute differentiated exportation

quotas to them - substantially higher than the ones given to the other species by means of the IN Ibama 202/08. Additionally, the illegal exploitation of rare specimens from isolated populations of *H. ciliaris* (e.g. wholly yellow, blue or white morphs and other unique color variants, endemic of St. Paul's Rocks) (Luiz-Júnior, 2003; Feitoza et al., 2003), whose individual prices in the Japanese market can achieve up to US$8.900,00, can decrease the genetic diversity (Gasparini et al., 2005) or even put these oddities in risk of extinction by means of an Anthropogenic Allee Effect (Courchamp et al., 2006).

Not only angelfishes, but also hogfishes, surgeonfishes and butterflyfishes are among the most frequently mentioned species by different sources and have been recorded among the top fifteen most exported marine fish species in Brazil (Ibama, 2008a).

None of the cartilaginous fishes identified could be exploited according to IN Ibama 202/08, but such restriction is not entirely abided by the Brazilian aquarium industry. The clandestine harvest of these species is especially serious due to the fact that some sharks and rays (*Ginglymostoma cirratum*-VU, *Zapteryx brevirostris*-VU, besides species of the genus *Rhinobatus, R. horkelii*-CR and *R. lentiginosus*-VU, and *Dasyatis*, *D. centroura*-CR and *D. colarensis*-VU) are listed in *Portaria* MMA 445/14. Illegal collections of *G. cirratum* and rhinobatids for the ornamental trade are not uncommon (Monteiro-Neto et al., 2003, Gasparini et al., 2005, Mohr et al., 2009). On the other hand, the harvest of sawfish for the same purpose seems to be more rare, despite newborn individuals be ordered by the aquarium industry (Charvet-Almeida and Faria, 2008).

Regarding the trading of unthreatened sharks and rays, most species are sporadically harvested, with exception of *Narcine brasiliensis* and *Rhinobatos percellens*, whose captures involve a great number of newborn individuals and possibly are concentrated at nursery sites (Sampaio and Rosa, 2005).

About the invertebrates, the exploitation of bivalves for marine aquarium purposes seems to

be negligible in Brazil, when compared to other organisms. However, in 2005, one of the Brazilian most famous ornamental trading companies requested Ibama's authorization to export these organisms. The company granted the demand for six species (*Anadara brasiliana*, *Atrina seminuda*, *Euvola ziczac*, *Pinna carnea*, *Pteria colymbus* and *Trachycardium muricatum*), noting that exports of *E. ziczac* occurred prior to its inclusion as EN in the Brazilian list of threatened fish and aquatic invertebrate species. However, Ibama did not authorize exportation of other six species (*Chlamys ornata, Caribachlamys sentis, Lima lima, Lima pellucida, Lyropecten nodosus* and *Spondylus americanus*) for different reasons. Although the exportation of these latter species was not allowed, they are still legally exploitable for the domestic market.

Distinct groups of gastropods are explored by the Brazilian aquarium industry. The prosobranchs *Cerithium atratum, Neritina virginea* and *Tegula viridula* are widely commercialized as aquarium 'clean up crew', due to their feeding habit of grazing on unwanted algae. Other prosobranchs are not frequently traded, but Brazilian aquarium dealers requested Ibama to give them authorization to export *Cassis tuberosa, Charonia variegata, Conus* spp., *Cyphoma gibbosum, Cyphoma macumba, Cypraea brasiliensis, Cypraea spurca* and *Turbo canaliculatus.* The harvest of *Macrocypraea zebra* and *Strombus pugilis* for marine tanks was mentioned at discussion forums and one of the authors observed a *Stramonita brasiliensis* specimen being sold at an aquarium pet shop, in Ceará state, Brazil. However, since *S. brasiliensis* is a predatory sea snail and may feed on other mollusks inside marine tanks, it is possible that the species was mistakenly harvested and unintentionally sold as a hermit crab carrying a mollusk empty shell.

Concerning opistobranchs, it shall be highlighted not only the maintenance of *Elysia subornata* individuals by aquarium owners but also spawnings of the species inside tanks. On the other hand, nudibranchs of the genus *Berghia* are wanted in marine aquariums to eradicate the undesirable sea anemone *Aiptasia* sp.

In spite of only two cephalopod species were recorded in the present inventory, it must be

considered the possibility of exploitation of a third species, *Octopus insularis* - a recently described species from the *O. vulgaris* complex that may have been misidentified as the latter, due to their pattern of distribution along the Brazilian coast and other similarities (Leite et al., 2008).

At discussion forums, unidentified chitons (Polyplacophora) were also mentioned as being kept in marine aquariums either for controlling excessive growth of algae or for revolving sediments. In many cases, these organisms were reported to be collected incidentally, attached to fouled rocks placed into tanks.

None of the crustaceans recorded here figure in *Portaria* MMA 445/08. The hermit crabs *Calcinus tibicen* and *Clibanarius* spp. are widely commercialized as members of the aforementioned 'clean up crew', while *Dardanus venosus* is wanted for aesthetic reasons, since the species often has a sea anemone attached to its shell. Other uncommon hermit crabs are wanted by marine tank owners because of their unique size and beauty, e.g. the giant hermit crab *Petrochirus diogenes* and the red-strip hermit crab *Phimochirus holthuisi,* respectively.

Concerning other crabs, while *Platypodiella spectabilis* and *Stenorhynchus seticornis* are traded mainly for their color pattern and unique features, respectively – in spite of the latter also act as a cleaner of reef fishes (Medeiros et al., 2011), the algae-eating crabs *Mithrax* spp. and *Mithraculus forceps* (Olivotto et al., 2011), are desired to control the growth of unwanted bubble algae *Valonia* spp. inside tanks. It was recorded a probable taxonomic mistake in the identification of the decorator crab mentioned at discussion forums and sold online through pet shop websites. The species is mentioned as 'gorgonian spider-crab' or simply as 'gorgonian spider', under the scientific names *Xenocarcinus* sp. or *Macropodia longirostris*. However, as both genuses are not reported for Brazil (L. E. A. Bezerra pers. comm.) and the crab advertised is very cheap and, so, presumably not imported, it is likely to be another majiid crustacean, the Brazilian decorator crab *Acanthonix* sp.

Besides their beauty, shrimps *Stenopus hispidus* and *Lysmata grabhami* are known for

removing ectoparasites from reef fish, while *L. wurdemanni* and *L. rathbunae* are valued to control population of *Aiptasia* sp. inside tanks. Gasparini et al. (2005) also reported the trade of the gold coral banded shrimp, *Stenopus scutellatus*, but the occurrence of the species was not mentioned at any other source of information investigated here.

The other shrimps *Cinetorhynchus rigens, Thor* aff. *amboinensis*, *Periclimenes* aff. *yucatanicus* and *Periclimenes* aff. *pedersoni* are unusually sold in Brazilian market, despite their conspicuous body shape, color pattern, and behavioral characteristics, including the known cleaning activities of the latter (Floeter et al., 2007). The snapping shrimp *Alphaeus* sp., also infrequently traded, is kept specially to control flatworm populations inside marine tanks. Since there are 29 species of the genus *Alphaeus* in Brazil, including *A. rudolphi* spec. nov. - a new snapping shrimp of the *Alpheus armatus* species complex (Almeida and Anker, 2011), – it was not possible to determine whether one or more species of the genus is traded.

Despite unattractive featured for ornamental purposes, the potential exploitation of the barnacles *Lepas anatifera* and *L. anserifera,* and the lobsters *Gnathophyllum americanum*, *Parribacus antarcticus* and *Scyllarides aequinoctialis* was also recorded, since authorization from Ibama to export these organisms alive was also requested. The dwarf reef lobster, *Enoplometopus antillensis*, also had its request of authorization for exportation denied by Ibama, but, differently from the other lobsters, this species is attractive to aquarium hobbyists due to its bright color and small size and, so, is still traded inside the country.

The recorded cnidarians belonged to distinct subgroups (sea anemones, octocorals, fire corals, besides other hard and soft corals) and among this wide variety of organisms, only three species are considered threatened in Brazil: *Condylactis gigantea* (EN)*, Mussismilia braziliensis* (VU) and *M. hartii* (EN). Special attention shall be given to the illegal exploitation of *C. gigantea*, due to its intensive harvest by the ornamental industry in southeastern Brazil and its local extinction at Arraial do Cabo region, Rio de Janeiro state (Gasparini et al., 2005). Through discussion forums

it was observed the illegal trading of sea whips, usually called 'monkey-tail gorgonian' and 'fox-tail gorgonian'. Despite forum members refer to them as members of the family Plexauridae, not only the precise identification of these two gorgonians is impossible based on common names, but also it is unknown whether or not they are recorded here, since this inventory mentions the plexaurid species *Plexaurella grandiflora and P. regia.*

The echinoderms listed were clearly dominated by sea stars, demonstrating the importance of a wide variety of species from this group to the Brazilian aquarium trade. It is worth notice that some echinoderm species are threatened with extinction in Brazilian waters and authorities should give special attention to the ban of the harvest of two species: *Linckia guildingii*, which have been traded illicitly through the Brazilian official postal service (L. M. Gurjão unpublished data) and *E. tribuloites*, since the species is constantly mentioned at discussion forums and seems to be commonly used in marine aquariums. Although sea cucumbers are not listed in the tables presented here, because it was not possible to identify the species traded, it was recorded the illegal selling of holothurians at discussion forums, in witch they are referred simply as 'giant sea cucumber', 'detritivorous sea cucumber' and 'burrowing sea cucumber'.

Differently from the other polychaetes identified here (*Spirobranchus* spp. and *Eurythoe complanata*), desired because of their beauty, *Diopatra cuprea* is, despite categorized as VU in the Brazilian official list of threatened species, not exploited directly by for ornamental purposes, but instead used as a source of food for some marine fish species (Steiner and Amaral, 2008). In addition, exploitation of other herein unreported native polychaetes is likely to happen in Brazil, since the country supplies the UK ornamental market with such worms (Murray et al., 2012).

Tunicates were also recorded among organisms used in marine aquariums in Brazil. While *Botrylloides nigrum*, *Styela plicata* and possibly one unidentified didemnid seems to be unintentionally harvested adhered to live rocks taken from the wild and set into tanks, other species sold as 'black ascidian' and 'red ascidian' are deliberately traded by discussion forum members. As

there was no photo of the black ascidian advertised, species could not be surely identified. However, due to its wide distribution throughout tropical waters, including Brazilian coast (Lotufo, 2002), the possibility of the latter be the solitary *Phallusia nigra* cannot be disregarded. Regarding the red ascidian, photos resembled *Polycarpa insulsa.* Although uncommon, previous studies had already recorded the presence of tunicates, as well as sponges, on other marine ornamental foreign markets (Wabnitz et al., 2003; Murray and Watson, 2014).

The four sponge species identified here, *Aplysina fulva, Axinyssa* sp.*, Dragmacidon reticulata* and *Tethya* sp. are usually called 'yellow sponge', 'finger', 'red ball' and 'yellow ball', respectively (Sampaio et al., 2004). Discussion forums showed that sponges known as 'red ball' and 'yellow ball' are traded through the internet, however it was not possible to assure the species' identity based exclusively on common names. Additionally, the exploitation of a subespheric morphotype of *D. reticulata*, called 'sponge-ball' and previously cited as *Pseudaxinella reticulata*, is reported (Hajdu et al., 2011).

In Brazil, seaweed trading for marine aquariums is extremely rare, since traditionally the co-habitation of corals and macroalgae is not wanted because seaweeds are avid competitors inside tanks, limiting coral growth. In most cases, macroalgae, e.g. *Chaetomorpha* spp., are kept solely in the aquarium's sump, aiming nitrogen and phosphorous removal. However, a few tank owners had chosen to keep 'marine planted aquariums' rather than coral reef systems, and, thus, seaweeds had been used associated to the sea grasses, e.g. *Halophila decipiens* and *Halodule* sp. Due to the low relevance of 'marine planted aquariums' compared to 'mini reef systems' little attention has been paid to the exploitation of those resources, with exception of Ibama (2008a), which briefly mentioned the usage of macrophytes and *Lithothamnium* spp.

The wide variety of native species inventoried in the present work demonstrates that Brazil is following the global trend of keeping a diversified marine life in aquaria, which have caused increasing concern about the sustainability of reef ecosystems' exploitation (Wabnitz et al., 2003;

LeGore et al., 2005; Calado, 2006; LeGore et al, 2008; Smith et al., 2010; Murray et al., 2012; Reynoso et al., 2012; Rhyne et al., 2012b).

The indiscriminate removal of pomacanthids (a true 'keystone guild') from reef ecosystems, for instance, might have serious negative reflexes on community structure and the impacts caused to the reef can be greater than angelfishes' abundance suggest (Gasparini et al., 2005). Similarly to other fish kept in aquaria, such as surgeonfishes (mainly living plant consumers) and parrotfishes (primarily detrital aggregates feeders) angelfishes perform vital ecological roles in coral reef trophodynamics (Hourigan et al., 1989; Hill, 1998; Sazima et al., 1999; Andréa et al., 2007; Konow and Bellwood, 2011; Batista et al., 2012; Reis et al., 2012) and, thus, their overexploitation and inter-specific relationships had also being object of concern (Hill, 1998; Comeros-Raynal et al., 2012).

In fact, the potential impact of fisheries targeting aquarium reef fishes in Brazil is difficult to be evaluated, because little is known about the distribution of this type of fishing effort throughout the country and the actual level of threat to reef fishes is hard to be assessed (Floeter et al., 2006).

Besides fish, invertebrate grazers are been collected at an increasingly rapid pace, mostly to control algal growth in home aquaria, but, as they play a corresponding role in the wild, their removal may strongly impact their native reefs (Rhyne et al., 2009). On healthy reefs, for instance, both the establishment and the survival of corals depend on high rates of herbivory to suppress macroalgae and reduce competition with cnidarians (Bonaldo and Hay, 2014).

Another interspecific association, the cleaning activity, may be negatively affected by continuous harvesting of fish and shrimps, intensified by the high turnover in ornamental trade, since specialized cleaners generally have a short life in aquariums due to their distinctive feeding habits (Gasparini et al., 2005). Hence, since the influence of the species abundance on cleaning interactions is modulated by the trophic habits and social behavior of the interacting species, the removal of a single cleaner species from a reef will deeply affect the ecosystem, as there seems to

be little redundancy on this role when pairs of species are concerned (Floeter et al., 2007).

Not only Brazilian coral reefs but also estuaries (Nottingham et al., 2005b) and sponge reefs (Rocha et al., 2000; Andréa et al., 2007) may be affected by uncontrolled ornamental fisheries. Additionally, large endangered vertebrates can also be harmed by indiscriminate collection of invertebrates and depletion of banks of either macroalgae or macrophytes, e.g. marine turtles (*Eretmochelys imbricata* and *Chelonia mydas*), that feed on a wide variety of invertebrates or graze the substratum (Stampar et al., 2007; Goatley et al., 2012), and the Brazilian marine manatee, *Trichechus manatus*, whose diet is composed of seaweed and sea grass species identified here (Borges et al., 2008).

Hence, in the face of such concerning scenery, consumers have an important role requiring species from regulated fisheries and shipped in accordance with well-established guidelines (eco-labeled products) and Brazilian authorities must seek environment friendly measures (e.g. implementation of eco-fees to support research on marine ornamental fisheries and mariculture (Leal et al., 2015).

Aquaculture initiatives must be incentivated, since they might considerably reduce collecting pressure over populations of targeted species (Calado et al., 2003; Pomeroy et al., 2006; Olivotto et al., 2011; Murray and Watson, 2014), specially because almost the totality of the exploited organisms in Brazil are wild-caught and captive breeding of native marine ornamentals is restricted to a few species (Meirelles, 2008; Hora and Joyeux, 2009; Ibama, 2009; Côrtes and Tsuzuki, 2010). However, captive bred shall not entirely substitute wild-caught species, because many people depend on the harvesting of aquarium species to survive (Rhyne et al., 2014)

Another way of preventing or reducing overexploitation, would be through ecosystem-based management initiatives (Tissot et al., 2010; Rhyne et al., 2014), as the creation of new marine reserves and the adequate management of the existing ones, in order to promote recovery of stocks of heavily exploited species by the aquarium fishery (Friedlander, 2001; Tissot et al., 2004; Tissot et

al., 2009; Stevenson and Tissot, 2013). Such initiatives, instead of preserving a particular species, aim not only the protection of the whole ecosystem but also assure the continuity of inter and intra-specific associations, including the safety of important spawning aggregation sites that are crucial for the survival of some aquarium traded species (Friedlander, 2001; Gerhardinger et al., 2009; Comeros-Raynal et al., 2012; Feitosa et al., 2015).

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CAPÍTULO 2 – *Regulatory framework of the marine ornamental trade in Brazil*

Regulatory framework of the marine ornamental trade in Brazil

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Abstract

Brazilian marine ornamental trade exploits a wide range of wild-caught species and such practice have raised concerns about the sustainability of collecting activities. Currently, there is a lack of rules specifically aiming the protection of marine aquarium species. Only marine fishes have a specific legislation regarding their usage for ornamental purposes, while the exploitation of other marine aquarium organisms is regulated by generic rules, including those driven to threatened species. The complex management tools adopted by the Brazilian authorities to control the exploitation of marine aquarium ornamentals (CTF, GTA, CZI, RGP, lists of threatened species and of species that can be collected, system of quotas, GTPON, GTAM and periodic reports, SISCOMEX and SISCITES) are not wholly efficient, since some important flaws were identified. Specific rules oriented to marine ornamental trade have to be issued, in order to protect a wider range of exploited species, and the already existing management tools must be improved to

guarantee a more efficient control related to marine ornamental trading activities.

Key-words: Aquarium species, Brazilian laws, environmental laws, legislation, management tools, marine aquarium.

Introduction

Marine aquarium trading involve the collection of around 1,800 fish species belonging to 125 distinct families, besides over 150 species of stony corals and hundreds of other invertebrates worldwide (Wabnitz et al., 2003; Stevenson et al., 2011; Rhyne et al., 2012).

Since consumers gradually shifted their preference from fish-only tanks to miniature reef ecosystems in the mid 1980s (Bruckner, 2005; Rhyne et al., 2009; Murray & Watson, 2014), collectors for aquarium trading started to act as a peculiar and unprecedented type of generalist predators (Rhyne et al., 2012), causing controversies concerning sustainability of the activity (Wabnitz et al., 2003; Olivotto et al., 2011).

Brazil has a significant participation in the international marine ornamental market (Wood, 2001; Bruckner, 2005; Rhyne et al., 2012) and the exploitation of most species, except fish (Nottingham et al., 2005a), must still to be regulated. Therefore, the paucity of rules driven to many marine aquarium species been a subject of concern (Gasparini et al., 2005; Ibama, 2008a) and just a few works have recently attained to a further analysis of the matter and its consequense for marine life conservation (Bender et al., 2012; Sampaio & Ostrensky, 2013; Sampaio et al., 2015).

Hence, the goal of the present study is to describe the legal framework related to marine aquarium trading in Brazil, as weel as to analyze the efficiency of the current management tools used to control and inspect the activity.

Materials and methods

It was carried out a survey concerning rules applied to the trading of native marine aquarium species in Brazil. Not only laws were taken into account, but also administrative regulations were evaluated regarding their applicability and efficiency to manage the exploitation of marine ornamental species. Part of the data analyzed here was also obtained from Nottingham et al. (2005a) and Ibama (2008a; 2008b), which report information about exploitation of marine ornamental fish and invertebrates in Brazil. These documents summarize results of meetings involving different segments of the exploitation chain (fishermen, aquaculturists, retailers, wholesalers, hobbyists and others) and the governmental institutions responsible for regulating and inspecting ornamental trading activities in the country.

Results

Fishing activities are controlled by distinct legal apparatuses in Brazil. Nevertheless, in general, there is an absence of rules oriented specifically to the exploitation of marine ornamentals. The only exception is for the management of marine aquarium fish, whose exploitation is particularly regulated by an administrative rule (IN Ibama 202/08), issued by the Brazilian Institute for the Environment and Renewable Natural Resources/*Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis* – Ibama). For all other species, exploitation is regulated mainly by generic laws, such as the Brazilian Environmental Crime Law (9,605/98).

Table 1 sumarises the whole regulatoy framework applicable to the exploitation of marine ornamentals in Brazil.

Table 1 – Legislation applicable to marine ornamental organisms traded in Brazil and their respective management tools.

Legislation	Number	Management tools
Law	6.938/81	Creation of CTF[6]
Law	9.605/98	Criminal sanctions (detention, reclusion and pecuniary sanctions)
Decree	6.514/98	Pecuniary sanctions
Decree	5.741/06	Implementation of GTA[7] and CZI[8]
Law	11.959/09	Implementation of RGP[9]
Instrução Normativa (IN)*	SEAP/PR 03/04[1,2]	Regulate the implementation of RGP
Instrução Normativa (IN)*	MMA 89/06[3]	Creation of GTAM[10] and trimestrial reports of industrial and commercial performance
Instrução Normativa (IN)*	Ibama 202/08[4]	Lists of species and respective exportation quotas, annual authorizations, SISCOMEX[11], SISCITES[12] and GTPON[13])
Instrução Normativa (IN)*	Ibama 06/13	Regulate the implementation of CTF
Instrução Normativa (IN)*	MMA 01/14	List of species that figure in the Convention on International Trade in Endangered Species of Wild Fauna and Flora – CITES appendices (I, II and III)
Instrução Normativa (IN)*	MPA 21/14[5]	Prescind the necessity of obtaining GTA for most cases of aquarium species transportation.
*Portaria**	MMA 445/14	Brazilian list of threatened fish and aquatic invertebrate species (appendix I) and those considered already extincted in wild (appendix II)

*Administrative rule. [1]Extinct Special Secretary of Aquaculture and Fishing/*Secretaria Especial de Aquicultura e Pesca da Presidência da República* – SEAP/PR. [2]Altered by IN MPA (Brazilian Ministry of Fishing and Aquaculture/*Ministério da Pesca e Aquicultura*) 06/10 and IN MPA 06/11. [3]Brazilian Ministry of the Environment/*Ministério do Meio Ambiente* – MMA). [4]Brazilian Institute for the Environment and Renewable Natural Resources/*Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis* – Ibama. [5]Extinct Brazilian Ministry of Fishing and Aquaculture/ *Ministério da Pesca e Aquicultura* – MPA. [6]Federal technical register (*Cadastro Técnico Federal* – CTF). [7]Animal transit form (*Guia de Trânsito Animal* – GTA). [8]International zoosanitary certificate (*Certificado Zoosanitário Internacional* – CZI). [9]Fisheiry general register (*Registro Geral de Pesca* – RGP). [10]Seaweed transit form (*Guia de Trânsito para Algas Marinhas* – GTAM). [11]Exterior commerce system (*Sistema de Comércio Exterior* – SISCOMEX), [12]System for transport of CITES species (SISCITES), [13]Domestic transport of ornamental fish form(*Guia de Trânsito de Peixes com fins Ornamentais e de Aquariofilia* – GTPON).

Regarding exploitation of marine aquarium fish, harvesting activities not only have to obey the limits imposed by IN 202/08, but also must follow rules established in IN MMA 01/14 and *Portaria* MMA 445/14. The great majority of exploitable marine ornamental fish are categorized as Not Evaluated – NE (113 species), followed by Data Deficient – DD (17 species), Vulnerable – VU (five species) and Near Threatened – NT (1 species) (figure 1) and two of these 136 species figure in CITES appendix II.

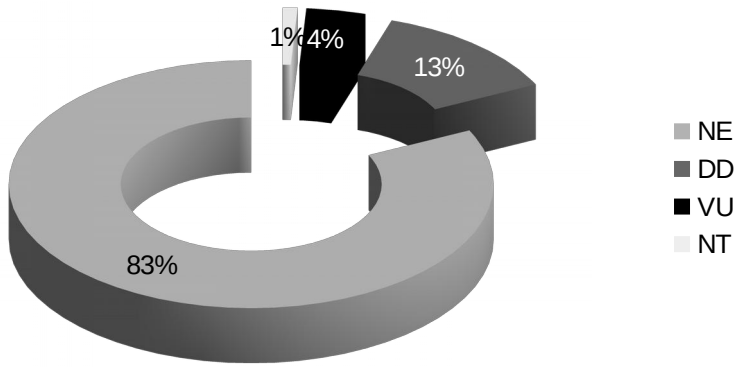

Figure 1 – Percentage of threatening categories (NE – Not Evaluated, DD – Data Deficient, NT – Near Threatened and VU - Vulnerable) concerning legally exploitable fish species, according to IN Ibama 202/08 and *Portaria* MMA 445/14.

Discussion

The lack of specific laws regulating marine ornamental trading in Brazil, as well as the necessity of improving the few existing rules have been object of concern (Gasparini et. al. 2005; Sampaio & Ostrensky 2013).

Federal law 6,938/81, for instance, established the Federal Technical Register (*Cadastro Técnico Federal* – CTF) as an instrument of the National Policy for the Environment, in which wholesalers, retailers, aquaculturists, importers and exporters must be registered to operate legally. In order to perform such registration, exploiters must fill out an electronic form, providing

identification of the person in charge, address and choosing the activities developed according to a list given by an administrative rule – IN Ibama 06/13.

Overall, CTF is a useful controlling tool, since its database allows governmental authorities to plan inspections *in situ*, check whether the activities actually developed correspond or not to the ones declared, verify if duties have or not been paid and also apply administrative sanctions if infractions are confirmed. However, CTF system has a serious flaw that allows honest people mistakenly buy ornamental organisms from illegal sellers. Some deceitful ornamental tradesmen do not completely fill out CTF electronic forms or even insert wrong information in the database, but the system provides a CTF number anyway.

Then, the given number or even another nonexistent number is included in website advertisements to make buyers believe they are dealing with legally registered sellers. This practice have been frequently detected in one of the biggest Brazilian e-commerce auction websites (*www.mercadolivre.com.br*) and the worst consequence is that smugglers will hardly be found or punished because information inserted in the CTF database is incomplete or incorrect. Not only has the CTF system to be improved (not to allow insertion of wrong or incomplete information), but it also should permit users to check the veracity of numbers posted on advertisements, e. g., through validation of electronic verification codes at Ibama's homepage. The most recent CTF validation system requires solely other Brazilian document numbers (CPF or CNPJ), which are almost never published on advertisements, and do not permit searching through CTF number.

The paucity of specific laws driven to aquarium usage of marine invertebrates, made the Brazilian Environmental Crime Law (9,605/98) the only applicable alternative to control the exploitation of those organisms for such purpose. According to article 29 of the aforementioned law, it is crime to kill, persecute, hunt, collect and use wild fauna, either native or under migratory routes, without permission from the appropriate authorities or in disagreement with the issued authorization. On the other hand, §6 of this article says that criminal imputations related to general

fauna cannot be applied to the act of 'fishing'. The definition of 'fishing' is stated in article 36 of this same law, and is considered as being every act in which one intents to remove, harvest and capture fish, crustaceans, mollusks and aquatic plants (aiming or not economic profits), except for organisms that figure in official lists of threatened species.

Thus, the direct consequence of such legal definition of 'fishing' is that only the capture of native unthreatened fish, crustaceans, mollusks and aquatic plants is allowed. On the other hand, the interpretation of articles 29 and 36 indicates that collection of all other marine organisms, even those widely kept in marine aquaria, such as cnidarians (soft and hard corals) or echinoderms (sea stars, sea urchins, sea cucumbers and crinoids), is forbidden in Brazil.

In addition, other articles of the Federal Law 9,605/98 also protect native organisms used in aquaria. Article 31 determine detention and fine for the introduction of unauthorized exotic species in Brazil. Concomitantly, article 33 (Sole Paragraph, II and III) states that it is crime to explore natural banks of aquatic invertebrates and algae without permission from the appropriate authority, as well as to anchor boats or dispose wastes over banks of mollusks or coral reefs plotted on nautical charts. Moreover, article 34 imputes criminal conducts to the ones who: (a) fish during a period in which fishing is forbidden or at places interdicted by the authorities (*caput*), (b) catch species that must be preserved or individuals under the minimum size permitted (Sole Paragraph, I), (c) capture quantities over the legal limit or by using forbidden equipments or techniques (Sole Paragraph, II) or (d) transport or commercialize specimens whose fishery is prohibited (Sole Paragraph, III). Ultimately, article 35 describes the crime of fishing by using explosives or analogous substances and by means of the usage of either toxic substances or other prohibited ways, whereas article 61 says it is crime to disseminate diseases and harmful species to biodiversity and ecosystems.

In order to permit application of the reprimands predicted in Federal Law 9,605/98, it was edited Decree 6,514/08, which establishes fine values and other sanctions, besides refers to an

specific crime concerning the illegal trade of ornamental species (article 35, Sole Paragraph, V). Prohibitions and punishments stated in both Federal Law 9,605/98 and Federal Decree 6,514/08 are important tools to inhibit and punish illegalities, since coercive measures can be very harsh if applied correctly. Nevertheless, due to the sluggishness of the Brazilian judiciary system, the benevolence of some judges when applying the law, and insufficient inspection by governmental authorities, some people simply ignore legal limits and exploit prohibited species anyway (Sampaio & Ostrensky, 2013).

Another rule, Decree 5,741/06 gave to the Brazilian Ministry of Agriculture, Husbandry and Provision (*Ministério da Agricultura, Pecuária e Abastecimento* – MAPA) the prerogative of controlling domestic and international transit of animals for sanitary reasons. Hence, MAPA created the Animal Transit Form (*Guia de Trânsito Animal* – GTA) and the International Zoosanitary Certificate (*Certificado Zoosanitário International* - CZI) as tools to prevent dissemination of animal diseases inside and outside the country, respectively. Whenever animals were transported, GTA or CZI must have been signed by veterinarians, certifying that the transported individuals were not sick. Despite the importance of these tools to preserve the health of Brazilian ecosystems, their efficiency is questionable. Some years ago, during an inspection of a sea snails shipment, Ibama agents observed that the GTA stated that the animals transported were crustaceans instead of mollusks. Therefore, the veterinarian certainly did not examine the animals properly and, consequently, could not have assured the organisms were not carrying transmissible diseases.

Careless sanitary inspections are serious problems, as translocation of ornamental species may facilitate the spread of newly infectious diseases or pathogens (metazoans, protozoans, bacteria and viruses) into native ecosystems (Whittington & Chong, 2007). Nevertheless, such risks seems not bother Brazilian government that recently, by means of IN MPA 21/14, substituted electronic invoice (e-invoice) for GTA, as the necessary document in most cases of animal transportation, i.e., ornamentals do not need to be examined anymore before translocation.

The Fishing General Register (*Registro Geral de Pesca* - RGP) was stated by Federal Law 11,959/09 and is regulated by IN 03/04 SEAP/PR (edited by the extinct Special Secretary of Aquaculture and Fishing/*Secretaria Especial de Aquicultura e Pesca da Presidência da República* - SEAP/PR), which was further altered by IN MPA 06/10 and IN MPA 06/11, both published by the former Brazilian Ministry of Fishery and Aquaculture/Ministério da Pesca e Aquicultura - MPA).

Fishermen, wholesalers, retailers, exporters, importers and also boats involved in the exploitation of ornamentals must be registered at RGP and, so, such requirement should allow public authorities to control almost every step of the trading activities. However, it is not rare to find unregistered traders working without any restriction, putting at risk the trustworthiness of the RGP system. The credibility of that database is also questionable due to the fact that some dishonest fishermen try to deceive authorities obtaining RGP to collect marine ornamental fish, for which the use of a breathing air compressor system is permitted, when they actually intend to fish lobsters – overestimating the real number of registers for ornamental purposes. Nottingham et al. (2005b) had previously reported the possibility of such prohibited practice, despite nobody had been caught in the act until that time. But recently, at Ceará state, Ibama apprehended some boats registered for ornamental fishery with lobsters aboard.

Marine ornamental fish exploitation is regulated by an specific administrative rule (IN Ibama 202/08) that prohibit harvesting at islands and oceanic banks, list 136 native species that can be commerced abroad in accordance with exportation quotas, besides reporting 530 species that can be imported and six that cannot.

The ban of collecting ornamental fishes at Brazilian islands and oceanic banks is specially important when one considers the fragility and vulnerability of isolated populations to any kind of exploration or habitat changing (Mohr et al, 2009). But, unfortunately, either such prohibition or the distances from the continent – including St. Paul's Archipelago, located in the mid-Atlantic Ridge (distant ~ 1.000 Km from Brazilian coast) - are not obstacles for illegal exploitation of high priced

endemic and rare species (e.g. *Choranthias salmopunctatus* (Lubbock & Edwards, 1981)*; Bodianus insularis* Gomon & Lubbock, 1980; *Prognathodes obliquus* (Lubbock & Edwards, 1980); *Stegastes rocasensis* (Emery, 1972); *Stegastes sanctipauli* Lubbock & Edwards, 1981; besides unique color morphs of *Holacanthus ciliaris* (Linnaeus, 1758)) (Luiz-Júnior, 2003; Feitoza et al., 2003; Mohr et al, 2009).

Regarding quotas, quantities were determined by means of a criteria matrix, based on the amount of aquarium fish commercialized at Ceará State (Nottingham et al. 2005b; Ibama, 2008b), a leading ornamental fish trader in Brazil, (Monteiro-Neto, et al 2003). Such restrictions were not easily accepted by exporters, who have been trying to increase the limits imposed since then (Ibama, 2007), under the allegation that the numbers were arbitrarily chosen, with no scientific support, and that those quotas only harm exporters and benefit wholesalers and retailers trading in the national market. In fact, it must be highlighted that the quantities established refer to exportation only, and collection of marine fish can exceed the limit imposed since overtaken individuals are sold inside the country.

So, it is clear that IN Ibama 202/08 failed partially not considering the potentialities of the domestic trade. One odd example of how seriously such flaw can impact ornamental fish populations is regarding seahorses exportation quotas. According to that IN, *Hippocampus reidi* Ginsburg, 1933 and *Hippocampus erectus* Perry, 1810 have a limit of 250 individuals exported/enterprise/year each. In the meanwhile, hundreds of them are captured without restrictions to supply marine aquaria inside national territory or traded dried for magic-religious, medical or curio purposes (Rosa et al, 2011). In order to be more efficient, the system of quotas should focus on the origin (the amount harvested) instead of solely on one of the endings (exportation) of the exploitation chain.

IN Ibama 202/08 also instituted four controlling tools: (a) exterior commerce system (SISCOMEX), (b) CITES (the Convention on International Trade in Endangered Species of Wild

Fauna and Flora) species transportation system (SISCITES), (b) import and export annual authorizations and (d) ornamental fish domestic transportation form (GTPON). Almost all of these tools, except annual authorizations, provide complete information about the identity of the trader, species and quantities transported, besides origin and destination of the shipments, which is a useful way to monitor the ornamental trade chain. Species that figure in CITES appendices (e.g. *Hippocampus erectus* and *H. reidi* – appendix II), but whose exploitation is allowed by IN Ibama 202/08, can only be commerced by means of CITES authorizations.

The concession of annual authorizations requires previous presentation of CTF, RGP and environmental licenses. Hence, authorized traders are assumed to have accomplished with all legal obligations. SISCOMEX and SISCITES are electronic systems under strict control, operated by a limited number of public agents, while GTPON are paper-based and, so, more susceptible to cheating. Recently, Ibama apprehended an ornamental fish shipment in which the signature of the GTPON issuing authority had been forged. Such evidence corroborates the urgency to implement a safer tool, i. e., the electronic system already under development (Ibama, 2008b).

Another important administrative rule, *Portaria* MMA 445/14, evaluated the conservation statuses of a wide range of threatened fish and aquatic invertebrate species (using the same threatening categories utilized in the International Union for Conservation of Nature – IUCN red list: (NE) Not Evaluated, (DD) Data Deficient, (LC) Least Concern, (NT) Near Threatened, (VU) Vulnerable, (EN) Endangered, (CR) Critically Endangered, (EW) Extinct in the Wild or (EX) Extinct) and created new rules for the exploitation of organisms based on their threatening categorization statuses.

Even listed in IN Ibama 202/8, species that figure as VU (*Hippocampus reid; H. erectus; Scarus zelindae* Moura, Figueiredo & Sazima, 2001; *Sparisoma axillare* (Steindachner, 1878) and *Sparisoma frondosum* (Agassiz, 1831)) depend on special authorizations to be exploited. On the other hand, there is no restriction to trade species classified as NE (more than 80% of the species

listed IN Ibama 202/8), DD (where are categorized pomacanthids – *Centropyge aurantionotus* Burgess, 1974; *Holacanthus ciliaris*, *Holacanthus tricolor* (Bloch, 1795), *Pomacanthus arcuatus* (Linnaeus, 1758) and *Pomacanthus paru* (Bloch, 1787) -, the main fish group exploited by the Brazilian ornamental industry (Nottingham et al., 2000; Monteiro-Neto et al., 2003; Gasparini et al., 2005; Ibama, 2008b) or NT (*Sparisoma amplum* (Ranzani, 1841)), while species categorized as EN or CR (none listed in IN Ibama 202/08) may be only harvested for scientific research or conservation purposes). Restrictions imposed by *Portaria* 445/14 not only were driven to ornamentals but also reached a wide range of fishing resources. For this reason, constraints were not pacifically acceped by fishing dealers and after many controversies the rule was temporarily suspended by the Brazilian judiciary, but not yet canceled by governmental authorities.

The necessity of frequent reviewing the Brazilian list of threatened species, keeping decision makers far from commercial and political interests, is imperative and had already been claimed (Ibama, 2008a; Mohr et al., 2009; Bender et al., 2012). Fortunately, *Portaria* MMA 445/14 predicts the possibility of updating the list whenever more recent monitoring data about any species is available. Such reviews are also important for the application of penalties defined in law 9.605/08, because sanctions are more severe when threatened species are involved in illicitness.

In Brazil, all entities of the federative republic are able to promulgate environmental laws, but state and Federal Distric laws have to be more restrictive than federal ones and counties laws cannot be more flexible than those edited by the union, states or the Federal District. For this reason, some Brazilian states have their own red lists (Bender et al., 2012) and, so, not only have the national red list to be considered, but also international (e.g. CITES appendices), state and municipal ones have to be taken into account for the application of punishments predicted at the Brazilian Environmental Crime Law.

The lack of administrative rules controlling the exploitation of invertebrates in Brazil has to be urgently fulfilled, specially when considered the potencial depletion of stocks due to the great

variety of uses for those species: handcraft, curio, food, raw material for pharmacological drugs and cosmetic industry, civil construction, aquaculture, aquarium trade and others (Ibama, 2008a).

On the other hand, exploitation of marine macroalgae in Brazil, whether or not for aquarium purposes, is regulated by IN Ibama 89/06. Both calcareous and non-calcareous seaweeds can be exploited either by companies or single persons registered at RGP. However, there are some restrictions regarding the amount collected, the way seaweeds are harvested, and the exploration sites. Additionally, IN Ibama 89/06 implemented paperwork for seaweed transportation (GTAM) and trimestrial reports of industrial and commercial performance, as mechanisms to control the exploitation of marine macroalgae. Apparently, both are useful tools to obtain information about origin, destination, species and amount explored. Nevertheless, similarly to GTPON, GTAM is paper-based and, thus, more susceptible to cheating.

For aquatic macrophytes, also used in planted marine tanks, there is no specific norm regulating their exploitation in Brazil.

Final considerations

To sum up, considering the flaws in the management tools here identified, the following suggestions shall be considered by Brazilian authorities to improve the sustainable exploitation of marine aquarium organisms: (1) making laws and administrative rules oriented specifically to ornamental trade, not only considering fishes, but also taking into account the exploitation of invertebrates and aquatic macrophytes; (2) CTF, RGP, GTPON and GTAM systems must be improved and substituted for paper-based documents; (3) Brazilian judiciary needs to be faster and more rigorous when punishing smugglers; (4) Environmental authorities must reinforce inspecting efforts driven to ornamentals; (5) GTA shall be an indispensible document to guarantee translocation of healthy spencimens only and veterinarians must be more criterious when evaluating

their health; (6) The system of quotas (IN Ibama 202/08) not only should be applied to exportation, but also have to take into account the domestic market and the different uses for marine ornamental fishes (e.g. dried seahorses); (7) Species listed in both IN Ibama 202/08 and *Portaria* MMA 445/14 must be periodically reviewed and such update cannot be driven by political or commercial interests to the detriment of scientific data.

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Capítulo 3 – *Comparative analysis of the marine ornamental fish exports in Ceará state and Brazil*

Comparative analysis of the marine ornamental fish exports in Ceará state and Brazil

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Abstract

Brazil is one of the main suppliers of marine aquarium fish in the world and Ceará state is the most relevant trader concerning Brazilian export. However, there is a paucity of updated information regarding the activity, which is crucial for the implementation of measures aiming the sustainable exploitation of those organisms. Thus, the present work provides the most recent data related to Brazilian and Ceará state exports, by means of the analysis of information from 420,871 authorizations of export issued by Brazilian environmental authorities in the last ten years. The analyzed data included the number of permits issued, species and quantities traded, daily commerce and countries of destiny. Results corroborate the relevant participation of Ceará state in Brazilian marine ornamental fish trade, but also showed a substantial decline of exports along the last decade. Sixteen species were the most abundant and frequent in either Brazilian or Ceará state exports.

Unsurprisingly, pomacanthids were the most important fish group traded, with more than 283,525 individuals wild-caught in an almost ten-years interval. The lack of information concerning population biology of the exploited species or with regards to the negative impact of their removal on the environment demands search for effective sustainable management initiatives. Slightly higher exports of ornamentals occurred in the Northern Hemisphere winter, while lower numbers were observed in summer. Asian countries are currently the main marine aquarium fish importers from Brazil.

Key-words: Brazilian exports, Ceará state exports, marine ornamental species, marine aquarium fish, marine aquarium trade.

Introduction

Marine ornamental trade is a global multi-million dollar industry, involving at least 45 countries and the collection of 30 million fish specimens, belonging to 125 different families, and 1,800 species (Wood, 2001; Tissot et al., 2010; Stevenson et al., 2011; Rhyne et al., 2014).

Brazil is considered one of the main suppliers of the marine aquarium market (Wood, 2001; Bruckner, 2005; Rhyne et al., 2012) and, like in the other exporting countries, the great majority of the exported specimens is wild harvested. Therefore, it has generated concern about the sustainable development of this activity (Gasparini et al., 2005; Nottingham et al., 2005a).

Ceará state is the leading Brazilian marine aquarium fish exporter (Monteiro-Neto et al., 2003; Nottingham et al., 2005b) and the regional data concerning exploitation have been used as reference for the establishment of norms to regulate the ornamentals trade in the whole country (Nottingham et al., 2005a).

Hence, given the importance of updated information to guide the implementation of policies

and rules for the sustainable exploitation of marine ornamentals in Brazil and Ceará state, it is not only crucial to fulfill the lack of basic knowledge concerning life history, reproduction and population dynamics of targeted species (Nottingham et al., 2000; Nottingham et al., 2003; Gasparini et al., 2005; Nottingham et al., 2005b; Feitosa et al., 2015), but also the paucity of updated information regarding export in the last decade must be repaired - since the most recent published statistics regarding Brazilian exports of marine aquarium fish were related to 2006 and 2007 (Ibama, 2008).

Therefore, the present work provides updated information regarding marine ornamental fish export in the country, in order to evaluate the role of Ceará state on Brazilian export. In addition, such assessment offers a better evaluation of the dynamic aspect of the trade, identifying changes that have been occurring in the activity along the last decade.

Materials and methods

Information obtained from 420,871 authorizations of export, issued by the Brazilian Institute for the Environment and Renewable Natural Resources – Ibama, was used in the current analysis. These data referred exclusively to the international market from January 2006 to August 2015, and provided information regarding the number of authorizations issued, participation of Ceará state in the Brazilian export, species and quantities traded, as well as daily commerce and buyer countries.

In order to estimate how important each species is for the trade, they were analyzed concerning two different criteria: frequency of occurrence - FO (the relative proportion of years in which a particular species is exported) and numerical abundance - %Num (the percentage of the total number of all specimens represented by individuals of a particular species). Then, to assess the development of the marine ornamental fish trade in Brazil and Ceará state, the number of exported specimens and the variety of species commerced were evaluated along almost 10 years of

monitoring. Average US Dollar exchange rate was used investigate the economic scenary faced by exporters in the last decade.

Additionally, exports were examined with regards to seasonal variations, and the authorizations issuing dates were distributed amongst the four seasons in the Northern Hemisphere, herein defined in accordance to the Earth's rotation axis and its orbital plane: Winter (December 21 – March 19), Spring (March 20 – June 20), Summer (June 21 – September 21) and Fall (September 22 – December 20). One-way ANOVA and Tukey HSD were used to investigate pairwise differences among seasons, by using PAST software (Hammer et al., 2001).

Subsequently, permits were analyzed regarding the destination countries, in order to identify and establish possible differences among the main importers from Brazil and Ceará state.

In general, scientific names were kept as originally written in the spreadsheets, after checked for valid species and distributions (Froese and Pauly, 2015). Nevertheless, in a very few cases names had to be updated according to the most recent literature and one of them was excluded from the analysis due to non-existence of the species recorded.

Results

During the analyzed period, the Brazilian international marine ornamental trade was represented by seven exporting states: Bahia, Ceará, Espírito Santo, Pará, Pernambuco, Rio de Janeiro and São Paulo. Ceará was the most relevant state given its highest numbers of exported specimens (Figures 1 and 2).

From 2006 to 2011, the number of exported specimens in Ceará increased almost continuously, reaching its peak in this latter year, when almost the totality (95%) of the marine ornamental fish exported from Brazil came from that state. In the following years (2012-2014), participation of Ceará state in the Brazilian market showed a slight decrease compared to 2011, but

continued significant, ranging from 69% to 85% of the total (data regarding 2015 were gathered only until the month of August).

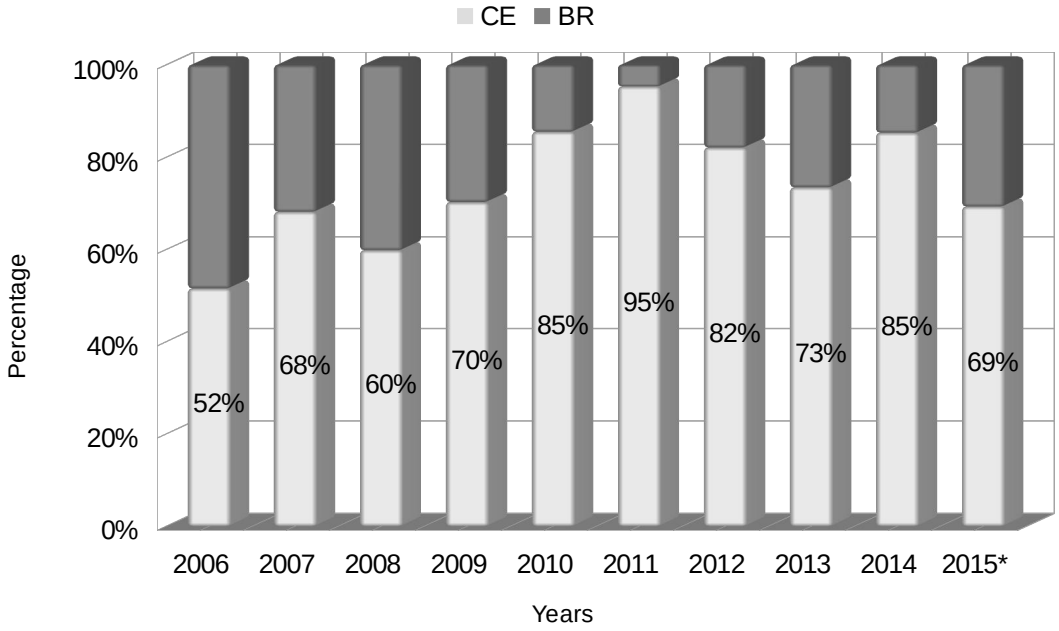

Figure 1 – Participation of Ceará state (CE) in the Brazilian (BR) export of marine aquarium fish. *Data from 2015 were only gathered until the month of August.

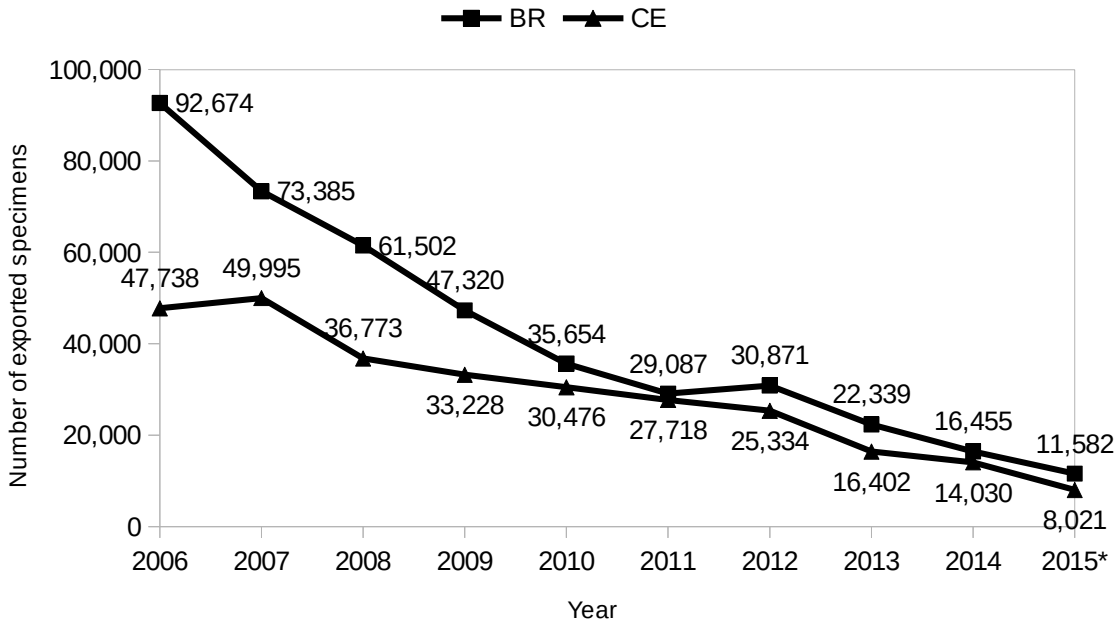

Figure 2 – Exportations of marine ornamental fish in Brazil (BR) and Ceará state (CE) along the last decade. *For 2015 data were available solely until August.

In either Brazilian or Ceará state exports, the number of marine aquarium traded species has been decreasing along the last decade - except for 2007 in Ceará state and 2012 in Brazil, when exports rose compared to the immediate previous years (Figure 2). From December 2006 to December 2014 the amount of exported marine ornamental fish plummeted around 82% in Brazil and 71% in Ceará state - since data regarding 2015 were still not completely available, it was used information from 2014 to establish comparisons with 2006.

Data analysis revealed that 136 species were traded from January 2006 to August 2015 in Brazil and that 31 of them (*Acanthurus bahianus, Acanthurus coeruleus, Amblycirrhus pinos, Anisotremus virginicus, Antennarius striatus, Bodianus pulchellus, Bodianus rufus, Cantherhines macrocerus, Cantherhines pullus, Centropyge aurantonotus, Chaetodipterus faber, Chaetodon ocellatus, Chaetodon sedentatius, Chaetodon striatus, Chilomycterus antennatus, Dactylopterus volitans, Diodon hystrix, Gymnothorax funebris, Gymnothorax miliaris, Halichoeres brasiliensis, Halichoeres dimidiatus, Halichoeres penrosei, Hippocampus reidi, Holacanthus ciliaris, Holacanthus tricolor, Lactophrys trigonus, Ogcocephalus vespertilio, Pareques acuminatus, Pomacanthus arcuatus, Pomacanthus paru and Thalassoma noronhanum*) were the most frequently traded species (being recorded in all of those years, FO = 100%). On the other hand, the trade in Ceará state involved 122 species and FO = 100% of the years was observed for 28 species: almost the same reported in Brazilian trade, except for *A. striatus*, *B. pulchellus* and *C. aurantionotus* (table 1 - appendix I). Despite the great number of species exploited, there were significant reductions concerning the variety of species exported in Brazil and Ceará state along the monitored period (figure 3).

It is important to notice that some names in the original data had to be modified: two

specimens named *Muraena trigonus* were excluded from the analysis, since the species does not exist – it was probably a mistake –, and *Halichoeres cyanocephalus* and *H. maculipinna* were replaced, respectively, for *H. dimidiatus* and *H. penrosei* in accordance with the most recent taxonomic reviews (Rosa and Rocha, 2001; Rocha, 2004). In addition, some of the numbers presented here are slightly different from those reported by Ibama (2008). But both this work and that one analyzed the same database, which have been updated continuously along the years, and, so, information presented here shall be more trustworthy.

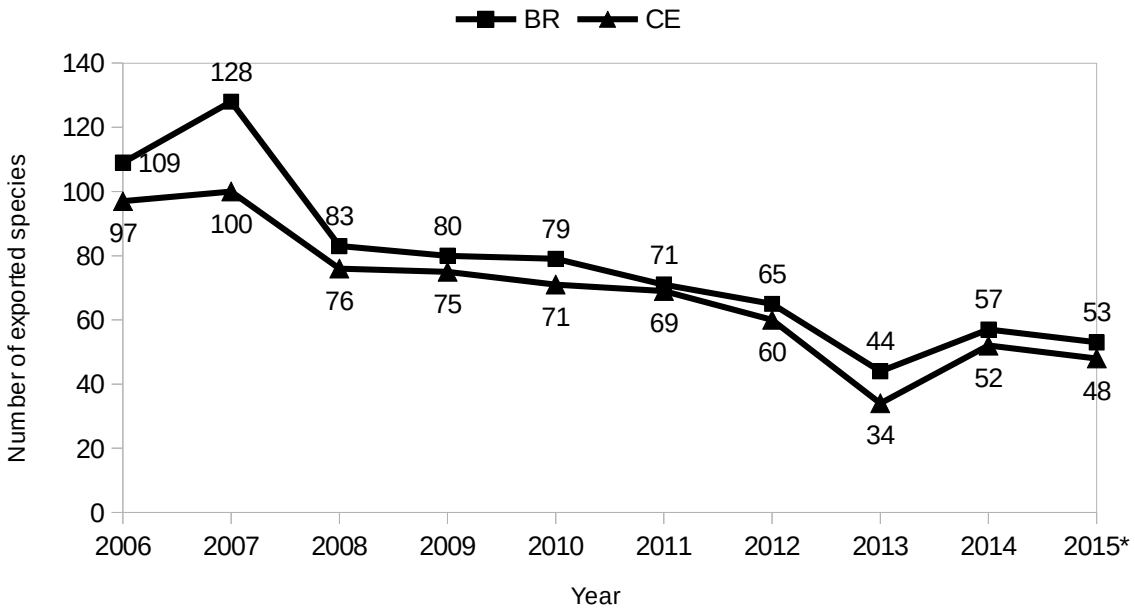

Figure 3 – Number of species exported in Brazil (BR) and Ceará state (CE) along the last decade. *In 2015 information was available just from January to August.

Despite both the number of individuals (figure 2) and the variety of species (figure 3) exported in Brazil and Ceará state have decreased during the last decade, the average US Dollar exchange rate had a small variation from 2006 to 2010 and then increased continuously from 2011 to 2015 (figure 4).

The abundance of specimens of each single species as a criterion to evaluate individual contribution for the trade was also recorded (table 1 - appendix I). 16 species (12 shared by both

Brazil and Ceará state, two exclusive to Brazil and the other remaining two limited to Ceará state, were the most numerically abundant, representing more than 80% of the total of exported individuals in both Brazil and Ceará state (Figure 5) - while specimens belonging to the other 120 (Brazil) and 106 (Ceará state) species represented, each, less than 1% of the trade. Additionally, almost all of these 16 species figured among those 31 most often (FO = 100%) recorded species. The only exceptions were *C. aurantionotus* (FO = 90% in Ceará state), *B. pulchellus* (FO = 80% in Ceará state) and *H. erectus* (FO = 70% in both Brazil and Ceará state) (table 1 - appendix I).

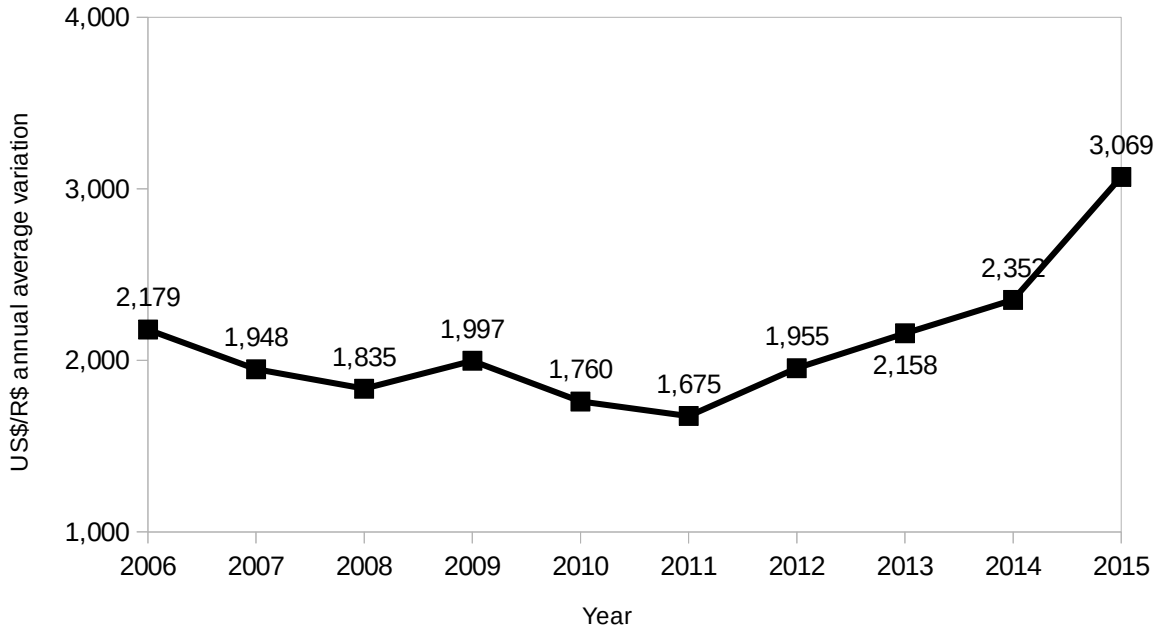

Figure 4 – Average American Dollar exchange rate in Brazil, during the period 2006-2015.

It must be stressed that angelfishes (*H. ciliaris*, *H. tricolor*, *P. paru*, *P. arcuatus* and *C. aurantonotus*) represented more than 60% of the amount of exported specimens in both Brazil and Ceará state and queen angelfish *H. ciliaris* had by far the largest numerical participation in the trade.

The longsnout seahorse *H. reidi* and the blue tang surgeonfish *Acanthurus coeruleus* were the most abundant non-pomacantid species and figured mixed to angelfishes as the most

numerically important traded species. Such heterogeneous group showed almost no change from one year to another in both Brazil and Ceará state, and, hence, sustained the 'top seven' positions in the export ranking. The amount of exported hogfishes, *B. pulchellus* and *B. rufus*, was similar for both species. However, remarkable contrasts on the quantities of exported lined seahorses, *H. erectus*, were observed when compared to its congeneric species, *H. reidi* (figure 5).

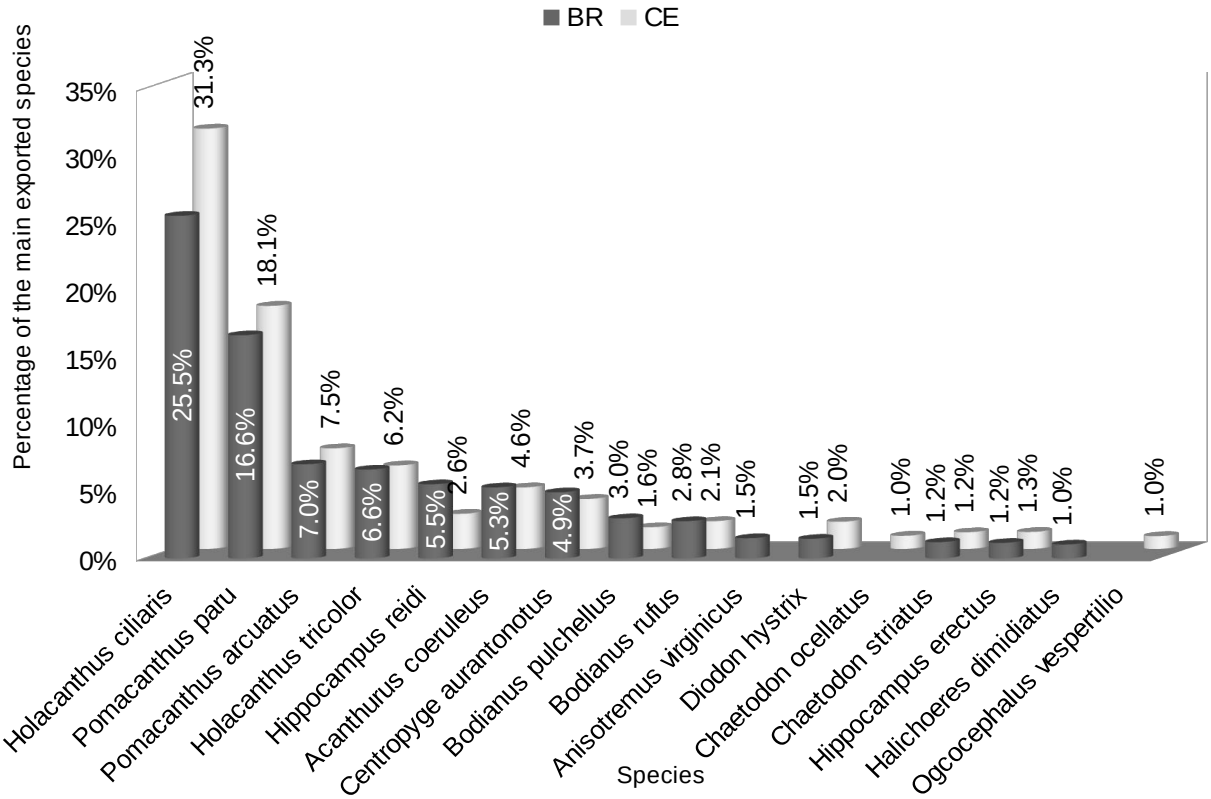

Figure 5 – Sixteen most abundant species in Brazil (BR) and Ceará state (CE) marine ornamental exportations, during the period 2006-2015.

The distribution of the quantity of exported specimens from Brazil (408,411 individuals) and Ceará state (272,828 specimens) throughout the months of the years (from January 2006 to December 2014), revealed seasonal variations. One-way-ANOVA showed differences withing Brazilian ($F = 4.8029$, $p = 0.0071$) and Ceará state ($F = 4.4665$, $p = 0.0099$) exports - $Fc = 2.9011$, $\alpha = 0.05$, $df = 3$) -, while Tukey HSD pairwise comparisons identified significantly different means

between summer and winter and also between summer and spring in both Brazil and Ceará state (Figure 6).

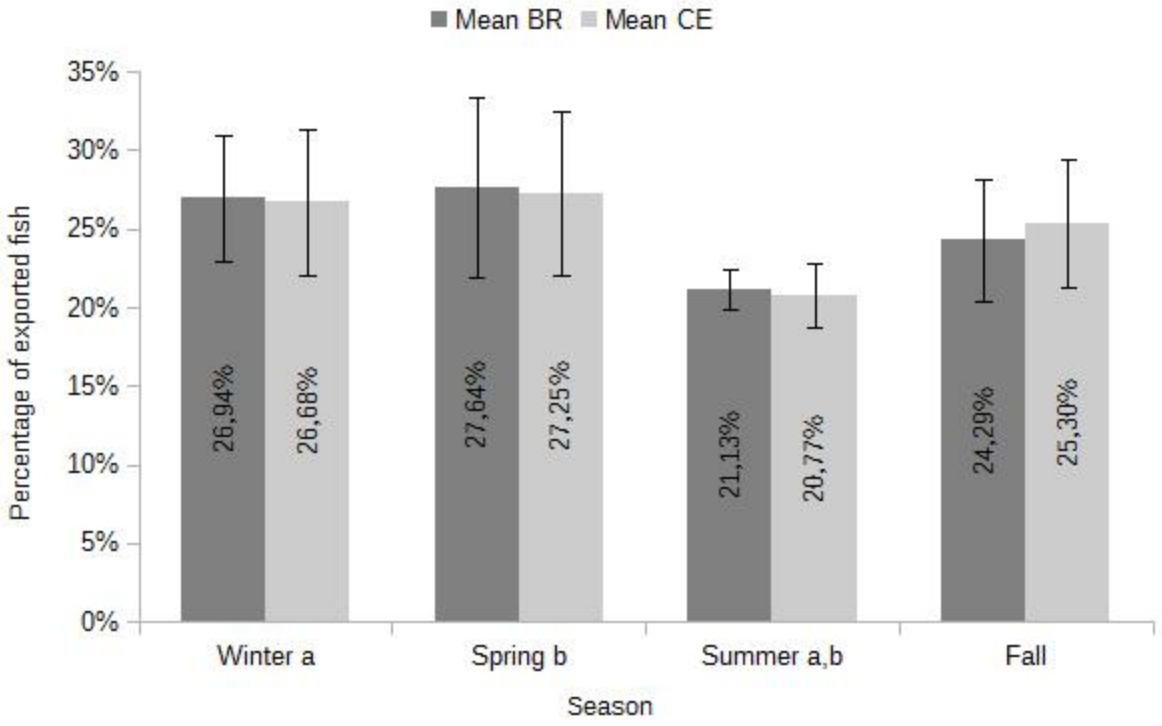

Figure 6 – Percentage of exported specimens and authorizations of exportation issued in Brazil (BR) and Ceará state (CE) distributed through the seasons in the Northern Hemisphere: Winter (December 21 – March 19), Spring (March 20 – June 20), Summer (June 21 – September 21) and Fall (September 22 – December 20). Error bars represent standard deviations and lower case letters refers to differences between winter and summer (a) and spring and summer (b) in both Brazilian and Ceará state exports, according to Tukey HSD.

During the period 2006-2015, Brazil exported marine aquarium fish to 37 countries - 15 of them achieved at least 1% of the exports from either Brazil or Ceará state (figure 7), while the other remaining countries did not reach that percentage (table 2 - appendix II). The great majority of the countries received fish from Brazil and, more specifically, from Ceará state. The only exceptions were Argentina, Bahrain Island and Hungary, which were supplied exclusively by other Brazilian states: Bahia (the former) and São Paulo (the other two countries).

It is important to emphasize that, considering the 15 aforementioned importing countries , Japan, USA and Hong Kong are responsible for around 70% of the exports in either Brazil or Ceará state (figure 7). France did not appear among Ceará state data in figure 7 because when considered

the total number of specimens exported by the state (17,605 individuals) the amount exported to that country (20 specimens) represented less than 1% - and not because there was no export from Ceará state to France, as one could think. The same explanation is given to the absence of information regarding export from Brazil to Sri Lanka.

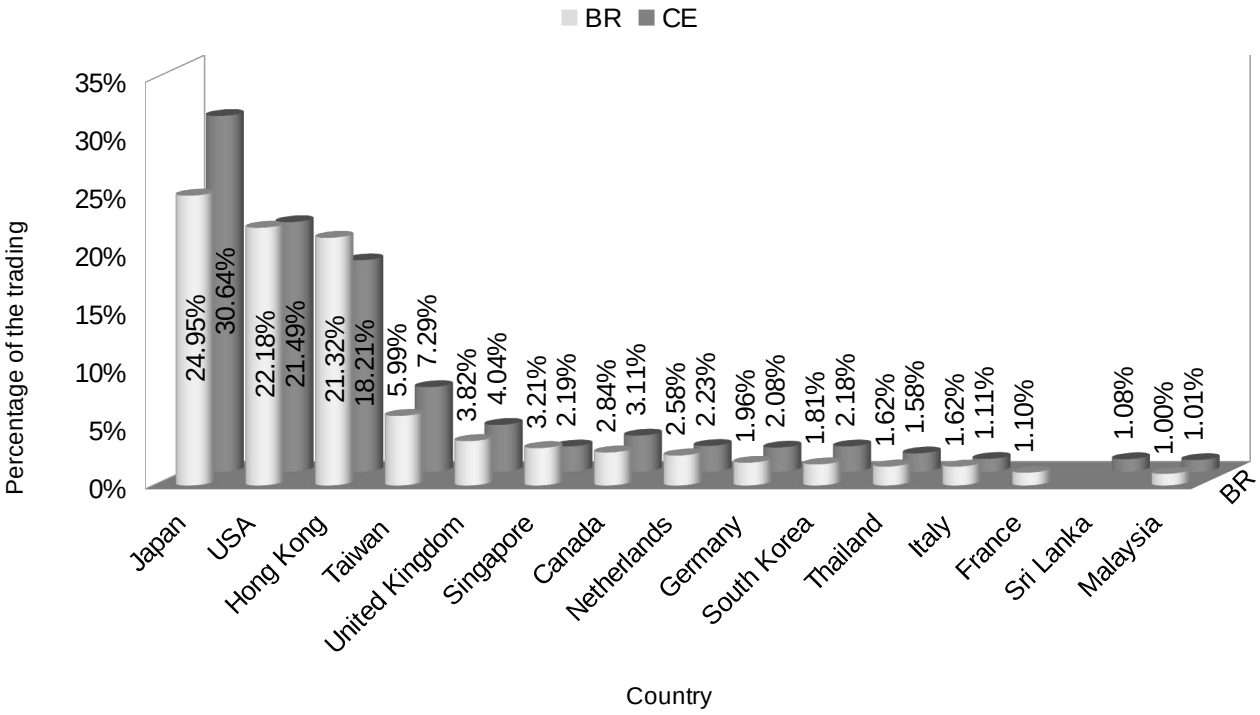

Figure 7 – Relative participation of the fifteen most representative marine ornamental fish importers from Brazil (BR) and Ceará state (CE), based on the number of exports.

Discussion

Although six other Brazilian states contribute for the total of marine aquarium fish export, Ceará has been considered the main trading center of the activity (Nottingham et al., 2000; Monteiro-Neto et al., 2003; Nottingham et al., 2005a). Information presented here demonstrate that from 2006 to 2015 Ceará contributed with an average 74% (sd = 13%) of the trade, reaching its lowest participation in 2006 (52%) and its highest in 2011 (95%). Along the last decade, no other

Brazilian state had such a significant participation in exports as Ceará and, thus, changes in exports that affect the latter shall directly impact Brazilian performance.

The strong influence of Ceará state exports in the Brazilian international commerce becomes more clear when the absolute numbers of individuals exported in Brazil and Ceará state are brought into comparison, in a conjunct analysis. In both cases, data showed that exports have been decreasing almost continuously along 2006-2015, presenting a considerable drop when numbers at the beginning and the end of the monitored period are compared to each other. Leal et al. (2015) also observed decreasing trends in Brazilian exports to Europe from ca. 282,000€ in 2000 to ca. 52,500€ in 2011.

Results also showed that, despite the great variety of species exported in Brazil and Ceará state in the first years of the last decade (2006-2007), the range of species decreased gradually until the end of the monitored period (2014-2015), when reached solely half of what it used to be. If the quantity of specimens had increased while the variety of species had diminished along the time, one could think that efforts were then concentrated in a fewer number of species due to scarcity of the originally targeted species, or that there were changes in the demands of the market. But it was not the case, such loss of diversity is probably a consequence of the diminishing number of exported specimens – the lower the amount of individuals captured and exported, the lower is the probability of a larger number of species to be included.

Those retractions in both the number of exported specimens and species along the last decade frustrated previous predictions of growth for the trade in Brazil (Monteiro-Neto et al., 2003) and unfortunately may be a sign of cumulative unsustainable fishery practices and/or economic adversities.

According to marine ornamental fish exporters from Ceará state, the decreasing number of specimens and species exported have three main causes: (a) elevation of essential material prices, (b) unfavorable US Dollar exchange rates and (c) excessive regulation (e.g. exportation quotas) and

bureaucracy to export the organisms - the latter, associated with legal changes, was also corrobored by Leal et al. (2015).

However, some of these allegations can be countered. If on one hand oscillations (2006-2010) of the US currency exchange rate may result in high prices of imported matters, on the other hand it will additionally rise profits obtained from fish export, and when this rate drops, export profits are reduced, as well as prices of imported materials. Later, from 2011 to 2015, US Dollar exchange rate increased steeply and, thus, probably created a favorable scenario for exports. Maybe, the allegation of elevated prices of essential imputs harming exports does make sense when referred solely to non-imported products, associated with lower exchange rates.

Regarding the export quotas, traders have been trying to increase the established limits, under the allegation that the numbers were arbitrarily set, with no scientific support, and that those limits only harm exporters, since they are not applied to domestic wholesalers and retailers. Nevertheless, export quotas were established after a hard effort towards the conciliation of sustainability and economic viability and, therefore, quantities were determined by means of a criteria matrix and based on the amount of specimens exported in Ceará – the leading Brazilian exporting state (Nottingham et al. 2005a). However, flaws exist and must be corrected: quotas do not reach collection but only export, overtaken individuals are unprotected and can be freely commercialized inside the country.

One odd example of how seriously such flaw can impact ornamental fish populations is the seahorses trade. According to Brazilian norms (IN Ibama 202/08), *Hippocampus reidi* (Appendix II - CITES and Data Deficient status – The IUCN Red List of Threatened Species), and *H. erectus* (Appendix II - CITES and Vulnerable status – The IUCN Red List of Threatened Species) have the lowest export limits: 250 individuals exported/enterprise/year, each. In the meanwhile, hundreds of them are captured without restrictions to supply domestic marine aquaria or traded dried for magic-religious, medical and curio purposes (Rosa et al, 2011). In order to be more efficient, the system of

quotas should focus on the origin of the chain (harvesting activities), instead of solely on exports, or even be substituted by other more effective measures, such as no-taking areas in important spawning grounds (Feitosa et al., 2015).

Although some authors estimated the presence of 120 and 109 native fish species in Brazilian and Ceará state trade, respectively (Monteiro-Neto et al., 2003; Gasparini et al., 2005), the current numbers are slightly higher, since 136 species are reported here in Brazilian and 122 in Ceará state exports. Nearly 23% of these species occurred in all years analyzed (FO = 100%), what indicates their constant participation and may suggest their great importance for the activity. However, if just FO was considered as a criterion to evaluate the importance of the species in the trade, it may magnify the participation of species that occur in small quantities but are very often recorded.

Hence, the abundance of specimens of each single species was also recorded as another criterion to evaluate individual contributions. However, %Num by itself would overestimate the participation of organisms that occur just once, but in great quantities.

Thus, the observation of these two criteria altogether intends to compensate biases caused by analysis based exclusively on either FO or %Num. So, most of the top 16 numerically abundant species were, in general, also the most frequent organisms in the trade and, hence, considered the most important fish species in the last ten years. Similarly, Rhyne et al. (2014) observed that only a small part of the total number of exported species (~15%) is handled in large volumes (85%).

Angelfishes were the most representative fish group, corroborating information of previous works that recorded pomacanthids as the main fish exploited by the Brazilian ornamental industry (Nottingham et al., 2000; Monteiro-Neto et al., 2003; Gasparini et al., 2005; Ibama, 2008). The importance of angelfishes in the international market throughout the years, associated to the demands to conciliate social, economic and environmental interests, made Brazilian authorities attribute substantially higher exportation quotas for them, when compared to other exploited species

(Nottingham et al., 2005a).

In addition, participation of seahorses and *A. coeruleus* among the most important traded aquarium species had already been reported (Monteiro-Neto et al., 2003; Gasparini et al., 2005). Notably, the much higher number of longsnout (*Hippocampus reidi*) compared to lined (*H. erectus*) seahorses, may have two complementary causes: (a) most of the seahorses exported as *H. erectus* were in fact *H. reidi* and they used to be misidentified to double the given quota (Monteiro-Neto et al., 2003; Rosa et al, 2011) – however, along the last decade the number of *H. erectus* traded decreased significantly, probably because exporters became more cautious due to further attention during inspections of the Brazilian environmental authorities -, and (b) captive bred *H. reidi* began to be exported under extra quotas, adding much more individuals to those exclusively wild-caught (Hora and Joyeux, 2009; Ibama, 2009).

Along the last decade, Brazil exported 255,658 angelfish specimens (107,453 *H. ciliaris*; 70,010 *P. paru*; 29,547 *P. archuatus*; 27,881 *H. tricolor* and 20,767 *C. aurantionotus*) – some previous works have presented numbers for an earlier period, which later were considered underestimated (Monteiro-Neto et al., 2003; Gasparini et al., 2005; Nottingham et al., 2005b), but that also may reveal fluctuations in the marine ornamental market. The higher numbers of exported *H. ciliaris* reflect the great abundance and demand for the species, while minor participation of *H. tricolor* and *C. aurantionotus* is probably associated with their scarcity in Ceará coast (and presumable collection in other states to be later exported from there). According to Ferreira et al., (2004), low quantities of traded *C. aurantionotus* are influenced by difficulties in harvesting them, because in Brazilian Northeastern coast flameback angelfishes are found solely on deep reefs. A similar situation is detected for other species, such as *B. pulchellus*, which does not occur at Ceará but is harvest in other Brazilian states and afterward exported from there.

It is also important to notice that 255,658 is the number of effectively exported pomacanthid specimens, but considering a mortality rate of 10,9% (Nottingham et al., 2005b) and assuming that

other pomacanthid specimens are not harvested for export, but to supply domestic trade (despite being a much minor commerce), it can be assumed that more than 283,525 angelfishes were wild-caught in the last ten years. Additionally, collection for ornamental purposes are not the only threat towards marine fish. Pomacanthids (as well as some acanthurids and chaetodontids) are by-catch in trap and gillnet lobster fisheries (Ivo et al., 1996), shrimp trawling (Braga et al., 2001) and fish traps (Feitosa et al., 2008) in Brazil and, so, it is difficult to address how deep ornamental fish are being negatively impacted by the marine aquarium industry, specially in face of the paucity of scientific information regarding their population biology.

Moreover, it is known that grazer fishes are an important biotic factor regulating the structure of benthic communities in reef ecosystems and tropical rocky shores, and their exclusion reduce the resilience of coral reefs in face of different kinds of disturbances, besides influencing abundance, distribution and shape of sponges (Batista et al., 2012). Hence, the indiscriminate removal of pomacanthids from reef ecosystems may have serious negative reflexes on community structure and the impacts caused to the coral reefs can be greater than angelfishes' abundance suggest (Gasparini et al., 2005). In fact, the potential impact of fisheries targeting aquarium reef fishes in Brazil is also difficult to be evaluated because little is known about the distribution of this type of fishing effort throughout the country, and the complete level of threat to reef fishes is hard to be assessed (Floeter et al., 2006).

The ecological effects of fisheries on pomacanthids populations are poorly known. Angelfishes may occupy a variety of trophic niches (Konow and Bellwood, 2011), and are typically considered spongivorous in Brazil – as in the Caribbean (Hourigan et al., 1989; Hill, 1998; Andréa et al., 2007; Reis et al., 2012) -, and, so, experiments involving their removal from reefs have resulted in decreasing coral covers caused by sponge overgrowth (Hill, 1998). However, some other works report ontogenetic variations in the foraging habit of pomacanthids in Brazil (Sazima et al., 1999) and the prevalence of algae rather than sponge in their gut contents, according to local food

availability and other factors (Batista et al. 2012; Reis et al., 2012). Hence, overexploitation of pomacanthids and some herbivorous species (e.g. the strict turf algae feeder surgeonfish *A. coeruleus* – Ferreira et al., 2004) could increase macroalgal abundance and therefore promote coral suppression by intense competition - on healthy reefs, for instance, both the establishment and survival of corals depend on high rates of herbivory to suppress seaweeds growth, reducing competition with cnidarians (Mumby, 2006; Box and Mumby, 2007; Hughes et al., 2007; Mumby and Harborne, 2010; Comeros-Raynal et al., 2012; Bonaldo and Hay, 2014).

Despite the potential damages the activity may cause to marine fish populations and ecosystems, marine aquarium trade can improve the economy of source habitats, promote conservation initiatives, and educate people and rise awareness about the crisis coral reefs are facing nowadays (Bellwood et a., 2004; Rhyne et al., 2012; Rhyne et al., 2014). In Ceará state, for instance, marine fish collection is an important source of income for many communities and some families depend exclusively on ornamental harvesting to survive (Nottingham et al., 2005b). Thus, Brazilian marine fish trade shall not be forbidden, but stimulated in sustainable basis, by means of conservation practices, in order to take back its growing expectations.

The implementation of conservation actions must take into account reproductive strategies of the targeted species (Comeros-Raynal et al., 2012). Thus, it has to be considered the fact that pomacanthids usually form harems (Moyer et al., 1983; Hourigan and Kelley, 1985; Feitosa et al., 2015) and that, at least in the Northeastern Brazil, they are able to spawn in a batch-like manner throughout the year (Nottingham et al., 2003; Feitosa et al., 2015). Additionally, it has to be kept in mind that not only angelfishes but also surgeonfishes form feeding or spawning aggregations, whose protection is imperative for both economic and ecological reasons (Comeros-Raynal et al., 2012).

Some ecosystem-based management initiatives, as the implementation of Marine Protected Areas, Fish Replenishment Areas, establishment of a limited entry program for aquarium fishery

and a number of other actions, have promoted recovery of stocks of heavily exploited marine aquarium species (e.g. the yellow tang *Zebrasoma flavescens* - Friedlander, 2001; Tissot et al., 2004; Tissot et al., 2009; Stevenson and Tissot, 2013; Rhyne et al., 2014). Such initiatives, instead of preserving a particular species, aim not only the protection of the whole ecosystem but also assure the continuity of inter and intra-specific associations, including the safety of the aforementioned spawning aggregation sites (Friedlander, 2001; Gerhardinger et al., 2009; Comeros-Raynal et al., 2012). Brazilian angelfishes, for instance, are likely to be impacted by harvesting in most unprotected areas, where lower abundances may be a sign of overexploitation (Ferreira et al., 2004).

Although Monteiro-Neto et al. (2003) verified the highest export numbers from Ceará state during the Nothern Hemisphere coldest months, when hobbyists spend more time taking care of their home aquaria, in the present work pairwise comparisons could not confirm such suggestion since no significant difference was detected among winter, spring or fall. On the other hand, summers presented the lowest mean of exported specimens - significantly different from winter and spring, but not from fall -, which may have been caused by intense windy seasons in Northeastern Brazil.

Periodically, displacements of the Intertropical Convergence Zone (ITCZ) intensify the power of trade winds in Northeast Brazil, specially in August-September – sometimes also coinciding with the arrival of strong swell waves (September-October) along the coast –, thus posing a real danger for fishing boats (Silva, 2003; Farias, 2008). Indeed, during windy seasons in Ceará state many vessels focused on distinct targeted species stay anchored until the end of the unfavorable weather conditions.

Hence, if catches and then exports - since they occur just a few days after harvesting (Nottingham et al., 2005b) -, decrease in Ceará in the second half of the year, the overall trade numbers are brought downwards. Unfortunately, the present work could not examine the direct

relationship between harvesting and windy season in Northeast Brazil, since data analyzed here were concerning exports only and not regarding catch. Nottingham et al. (2000) addressed the collecting of marine ornamental fish in Ceará but their data do not allow comparisons throughout the whole year. Thus, this subject still needs further investigation.

In the beginning of the last decade, Brazilian exports of marine ornamental fish involved just 19 countries (Monteiro-Neto et al., 2003), but in more recent years this number almost doubled, as a direct consequence of globalization (Rhyne and Tlusty, 2012). Another aspect of the international market that presented significant changes was regarding the main importing countries. According to Monteiro-Neto et al. (2003), Brazil used to export marine aquarium fish mostly, in decreasing order, to USA, Italy, Japan, Germany, China, Taiwan and others (including some European countries presenting shy participation). Nevertheless, current Brazilian exportations are mainly driven to Asian countries (specially Japan, Hong Kong and Taiwan), that displaced the USA, the previous and most noticeable leading buyer from Brazil, followed by many other European countries. Such change does not mean that USA reduced imports of marine ornamental fish, but quite the opposite, it is still the main destination of most of marine aquarium organisms traded worldwide (Rhyne and Tlusty, 2012; Rhyne et al., 2012; Rhyne et al., 2014) - what happened was that Brazilian traders seem to have found more marketable opportunities in Asia than in North America.

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Appendix I

Table 1 – Comparative data between Brazil and Ceará state concerning species, quantity, abundance and frequency of ocurrence of exported marine aquarium fish.

Species	Brazil			Ceará state		
	Subtotal	%Num	FO	Subtotal	%Num	FO
Abudefduf saxatilis	560	0.13%	20%	233	0.08%	20%
Acanthostracion polygonius	123	0.03%	60%	91	0.03%	40%
Acanthostracion quadricornis	122	0.03%	80%	92	0.03%	70%
Acanthurus bahianus	3,645	0.87%	100%	1,711	0.59%	100%
Acanthurus chirurgus	515	0.12%	80%	155	0.05%	60%
Acanthurus coeruleus	22,305	5.30%	100%	13,283	4.58%	100%
Achirus lineatus	380	0.09%	70%	39	0.01%	30%
Alphestes afer	333	0.08%	90%	301%	0.10%	80%
Aluterus schoepfi	243	0.06%	20%	206	0.07%	20%
Aluterus scriptus	68	0.02%	40%	17	0.01%	30%
Amblycirrhitus pinos	998	0.24%	100%	516	0.18%	100%
Anisotremus surinamensis	118	0.03%	20%	88	0.03%	20%
Anisotremus virginicus	6,370	1.51%	100%	2,358	0.81%	100%
Antennarius striatus	827	0.20%	100%	482	0.17%	90%
Apogon americanus	2,761	0.66%	80%	1.320	0.46%	70%
Apogon pseudomaculatus	1,275	0.30%	50%	277	0.10%	30%
Archosargus rhomboidalis	20	0.00%	30%	2	0.00%	10%
Aulostomus strigosus	13	0.00%	20%	10	0.00%	10%
Bathygobius soporator	234	0.06%	30%	216	0.07%	20%
Batrachoides surinamensis	239	0.06%	80%	200	0.07%	80%
Bodianus pulchellus	12,601	2.99%	100%	4,674	1.61%	80%
Bodianus rufus	11,710	2.78%	100%	5,998	2.07%	100%
Bothus lunatus	104	0.02%	70%	49	0.02%	50%
Bothus ocellatus	147	0.03%	70%	28	0.01%	40%
Calamus pennatula	1,370	0.33%	30%	184	0.06%	10%
Cantherhines macrocerus	354	0.08%	100%	144	0.05%	100%
Cantherhines pullus	1,167	0.28%	100%	978	0.34%	100%
Canthigaster figueiredoi	594	0.14%	70%	350	0.12%	70%
Centropyge aurantonotus	20,767	4.93%	100%	10,783	3.72%	90%
Cephalopholis fulva	52	0.01%	10%	-	-	-

Chaetodipterus faber	2,999	0.71%	100%	2,267	0.78%	100%
Chaetodon ocellatus	3,532	0.84%	100%	2,833	0.98	100%
Chaetodon sedentarius	1,924	0.46%	100%	1,583	0.55%	100%
Chaetodon striatus	5,118	1.22%	100%	3,598	1.24%	100%
Chilomycterus antennatus	3,571	0.85%	100%	2,410	0.83%	100%
Chilomycterus antillarum	572	0.14%	40%	433	0.15%	40%
Chromis multilineata	569	0.14%	50%	487	0.17%	40%
Clepticus brasiliensis	12	0.00%	10%	-	-	-
Conodon nobilis	62	0.01%	20%	-	-	-
Coryphopterus glaucofraenum	2,341	0.56%	70%	2,337	0.81%	70%
Cosmocampus albirostris	4	0.00%	10%	-	-	-
Cychlichthys spinosus	1,214	0.29%	90%	1,261	0.44%	90%
Dactylopterus volitans	1,560	0.37%	100%	654	0.23%	100%
Diodon holacanthus	1,655	0.39%	80%	1,632	0.56%	80%
Diodon hystrix	6,185	1.47%	100%	5,869	2.03%	100%
Diplectrum formosum	572	0.14%	10%	550	0.19%	10%
Diplectrum radiale	30	0.01%	10%	-	-	-
Doratonotus megalepis	44	0.01%	40%	14	0.00%	30%
Dules auriga	44	0.01%	10%	15	0.01%	10%
Echeneis naucrates	237	0.06%	60%	214	0.07%	30%
Fistularia tabacaria	75	0.02%	10%	75	0.03%	10%
Gobiesox strumosus	480	0.11%	80%	737	0.25%	70%
Gymnachirus nudus	12	0.00%	40%	3	0.00%	30%
Gymnothorax funebris	1,308	0.31%	100%	1,068	0.37%	100%
Gymnothorax miliaris	1,849	0.44%	100%	1,361	0.47%	100%
Gymnothorax moringa	189	0.04%	90%	156	0.05%	80%
Gymnothorax ocellatus	122	0.03%	80%	117	0.04%	70%
Gymnothorax vicinus	268	0.06%	80%	262	0.09%	80%
Haemulon steindachneri	147	0.03%	30%	147	0.05%	30%
Halichoeres bivittatus	193	0.05%	60%	156	0.05%	60%
Halichoeres brasiliensis	934	0.22%	100%	589	0.20%	100%
Halichoeres dimidiatus	4,396	1.04%	100%	2,184	0.75%	100%
Halichoeres penrosei	1,107	0.26%	100%	772	0.27%	100%
Halichoeres poeyi	271	0.06%	80%	226	0.08%	70%
Heteropriacanthus cruentatus	30	0.01%	40%	20	0.01%	30%
Hippocampus erectus	4,915	1.17%	70%	3,665	1.27%	70%

Hippocampus reidi	23,274	5.53%	100%	7,572	2.61%	100%
Holacanthus ciliaris	107,453	25.53%	100%	90,728	31,32%	100%
Holacanthus tricolor	27,881	6.62%	100%	18,029	6.22%	100%
Holocentrus adscensionis	56	0.01%	70%	50	0.02%	50%
Kyphosus incisor	12	0.00%	10%	6	0.00%	10%
Kyphosus sectatrix	460	0.11%	20%	-	-	-
Labrisomus nuchipinnis	225	0.05%	70%	219	0.08%	70%
Lactophrys trigonus	974	0.23%	100%	845	0.29%	100%
Lagocephalus laevigatus	6	0.00%	10%	-	-	-
Micropogonias furnieri	10	0.00%	10%	-	-	-
Mulloidichthys martinicus	6	0.00%	10%	6	0.00%	10%
Mullus argentinae	18	0.00%	20%	3	0.00%	10%
Muraena pavonina	579	0.14%	70%	521	0.18%	70%
Myrichthys breviceps	29	0.01%	60%	15	0.01%	50%
Myrichthys ocellatus	317	0.08%	90%	189	0.07%	90%
Myripristis jacobus	287	0.07%	50%	219	0.08%	50%
Odontoscion dentex	10	0.00%	10%	-	-	-
Ogcocephalus notatus	3	0.00%	10%	-	-	-
Ogcocephalus vespertilio	3,425	0.81%	100%	2,772	0.96%	100%
Oligoplites saliens	7	0.00%	20%	5	0.00%	10%
Ophioblennius trinitatis	3,034	0.72%	80%	1,933	0.67%	70%
Orthopristis ruber	16	0.00%	20%	-	-	-
Parablennius marmoreus	1,189	0.28%	40%	678	0.23%	40%
Parablennius pilicornius	1,243	0.30%	50%	571	0.20%	50%
Paraclinus rubicundus	54	0.01%	50%	24	0.01%	40%
Paranthias furcifer	193	0.05%	50%	73	0.03%	40%
Pareques acuminatus	2,696	0.64%	100%	1,619	0.56%	100%
Pempheris schomburgki	43	0.01%	10%	3	0.00%	10%
Phaeoptyx pigmentaria	70	0.02%	20%	25	0.001%	20%
Plectrypops retrospinis	254	0.06%	30%	22	0.001%	20%
Pomacanthus arcuatus	29,547	7.02%	100%	21,723	7.50%	100%
Pomacanthus paru	70,010	16.63%	100%	52,463	18,11%	100%
Pomadasys corvinaeformis	7	0.00%	10%	5	0.00%	10%
Porichthys porosissimus	33	0.01%	40%	33	0.01%	40%
Prionotus nudigula	150	0.04%	60%	102	0.04%	60%
Prionotus punctatus	10	0.00%	10%	-	-	-

Rypticus bitrispinus	48	0.01%	20%	10	0.00%	10%
Rypticus saponaceus	127	0.03%	30%	101	0.03%	30%
Scarus zelindae	95	0.02%	60%	76	0.03%	50%
Scorpaena brasiliensis	98	0.02%	60%	49	0.02%	50%
Scorpaena isthmensis	74	0.02%	50%	191	0.07%	50%
Scorpaena plumieri	20	0.00%	40%	12	0.00%	20%
Selene vomer	2,500	0.59%	80%	2,231	0.77%	70%
Serranus baldwini	694	0.16%	90%	570	0.20%	60%
Serranus flaviventris	289	0.07%	90%	220	0.08%	90%
Serranus phoebe	79	0.02%	20%	55	0.02%	10%
Sparisoma amplum	89	0.02%	30%	45	0.02%	30%
Sparisoma axillare	30	0.01%	20%	-	-	-
Sparisoma frondosum	19	0.00%	30%	14	0.00%	30%
Sparisoma radians	126	0.03%	40%	16	0.01%	30%
Sphoeroides greeleyi	43	0.01%	20%	-	-	-
Sphoeroides spengleri	352	0.08%	60%	146	0.05%	60%
Sphoeroides testudineus	26	0.01%	30%	3	0.00%	10%
Stegastes fuscus	133	0.03%	60%	105	0.04%	60%
Stegastes pictus	754	0.18%	80%	417	0.14%	80%
Stegastes uenfi	110	0.03%	60%	100	0.03%	50%
Stegastes variabilis	550	0.13%	90%	474	0.16%	90%
Stephanolepis hispidus	20	0.00%	10%	20	0.01%	10%
Stephanolepis setifer	8	0.00%	10%	4	0.00%	10%
Stygnobrotula latebricola	62	0.01%	80%	31	0.01%	40%
Synodus foetens	571	0.14%	20%	569	0.20%	20%
Synodus intermedius	192	0.05%	20%	180	0.06%	20%
Synodus synodus	20	0.00%	20%	12	0.00%	10%
Thalassoma noronhanum	774	0.18%	100%	678	0.23%	100%
Thalassophryne montevidensis	11	0.00%	20%	10	0.00%	10%
Thalassophryne nattereri	95	0.02%	40%	39	0.01%	40%
Trachinocephalus myops	201	0.05%	10%	181	0.06%	10%
Upeneus parvus	193	0.05%	40%	56	0.02%	40%
Xyrichthys novacula	273	0.06%	60%	121	0.04%	60%
Xyrichthys splendens	56	0.01%	30%	46	0.02%	30%
Total	420,869	100%	-	289,715	100%	-

Appendix II

Table 2 – Percentage of the exportations from Brazil and Ceará state distributed through each buyer country.

Buyer countries	Exporter	
	Brazil	Ceará state
Argentina	0.17%	-
Austria	0.11%	0.16%
Bahrain Island	0.04%	-
Belgium	0.38%	0.11%
Canada	2.84%	3.11%
China	0.20%	0.23%
Denmark	0.23%	0.18%
Ecuador	0.01%	0.01%
France	1.10%	0.11%
Germany	1.96%	2.08%
Greece	0.10%	0.15%
Hong Kong	21.32%	18.21%
Hungary	0.12%	-
Indonesia	0.10%	0.15%
Israel	0.73%	0.39%
Italy	1.62%	1.11%
Japan	24.95%	30.64%
Malaysia	1.00%	1.01%
Netherlands	2.58%	2.23%
New Zealand	0.01%	0.02%
Norway	0.02%	-
Peru	0.10%	0.14%
Poland	0.07%	-
Portugal	0.06%	0.02%
Singapore	3.21%	2.19%
South Africa	0.07%	-
South Korea	1.81%	2.18%
Spain	0.39%	0.01%
Sri Lanka	0.81%	1.08%
Sweeden	0.03%	-
Switzerland	0.07%	-

Taiwan	5.99%	7.29%
Thailand	1.62%	1.58%
Turkey	0.04%	0.05%
United Arab Emirates	0.10%	0.02%
United Kingdom	3.82%	4.04%
USA	22.18%	21.49%
Total of exportations	25,295	17,605

Capítulo 4 – *The illegal trade of aquarium species via Brazilian postal service at Ceará State*

The illegal trade of aquarium species via Brazilian postal service at Ceará State

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Abstract

Brazil is one of the main suppliers of aquarium species globally, and Ceará state recognized as a major trading center for this activity. Despite the existence of traders transporting these organisms in accordance with the law, some others illegally use the Brazilian postal services to promote their translocation throughout the country. In order to repress such unlawful practice, Ibama and ECT, in a joint effort, conducted 57 apprehensions, involving domestic transportation only. The main origin as well as the principal destination of the boxes was the Brazilian Southeastern region, particularly São Paulo state. All groups of species apprehended were evaluated

and freshwater fishes were by far the most representative organisms, pushed up by the intense translocation of *Betta splendens. S*ome marine fish, echinoderms and cnidarians species arrested are included in the Brazilian list of threatened species and, so, their exploitation is restricted or forbidden. Additionally, only 18 of the species confiscated are considered native from Brazil and just 12 of them occur naturally in Ceará state, raising concerns about potential bioinvasions and demanding more control of the Brazilian authorities upon e-commerce and illegal transportation of species. Although some traders were repeatedly caught mailing organisms, apprehensions *per se* (since fines usually took more than a year to be issued) seem to mitigate transgression concerning the illicit transportation of organisms.

Key-words: Brazilian mailing, e-commerce, mailing of species, ornamental market, ornamental species.

Introduction

Aquarium species trading is a global multi-million dollar industry, which exploits over a billion organisms worldwide annually – including more than 4000 freshwater and over 1800 marine species (Wabnitz, 2003; Whittington and Chong, 2007; Rhyne et al., 2014), and Brazil figures as a major supplier of the global ornamental market (Wood, 2001; Bruckner, 2005; Nottingham et al., 2005a; Anjos et al., 2009; Souza and Mendonça, 2009; Rhyne et al., 2012a). Ceará state is a well known trading center of ornamental species (Monteiro-Neto et al., 2003; Nottingham et al., 2005b; Ibama, 2008).

Despite the existence of many legally registered aquarium species retailers, wholesalers, exporters, importers and aquaculturists in Brazil, some of them, as well as hobbyists and many other informal traders, unlawfully use the Brazilian postal services to either commerce or exchange

aquarium organisms. Such practice has been encouraged by the intensive development of mail-order and e-commerce of species (Kay and Hoyle, 2001; Walters et al., 2006; Keller and Lodge, 2007; Derraik and Phillips, 2010; Collier et al., 2011) and maybe accelerated by an increasing and without boundaries exchange of information and techniques via internet, involving different types of traders, hobbyists and scientists (Rhyne, 2010). As in other countries, in Brazil animals and plants are shipped and handled through shipping companies and, mainly, by means of regular postal services (Magalhães and Jacobi, 2010) – being the latter commonly used to transport or hide species whose exploitation is forbidden. The rationale for using mail services is possibly the large volume of mail and cargo moved around, which could hinder the detection of unlawful transportations.

In order to repress such illegal practice, the Brazilian Institute for the Environment and Renewable Natural Resources (*Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis* – Ibama), one of the federal institutions responsible for inspecting and ruling the exploitation of aquarium species, have worked together with the Brazilian Postal Services (*Empresa Brasileira de Correios e Telégrafos* – ECT) representative at Ceará State, in a combined effort to identify packages carrying different types of organisms (from worms to bird eggs), which included ornamental aquatic species.

Hence, the present work aims to quantify and identify aquarium species transported via Brazilian postal services, analyze origins and destinations of these shipments and assess their participation in apprehensions. Finally, the efficiency of apprehensions to repress the illegal mailing of species was also investigated.

Materials and methods

By working together with ECT, Ibama took advantage of the fact that packages posted at distinct ECT offices around the country converge to Centers of Treatment of Letters and Mailing

Packages (*Centros de Tratamento de Cartas e Encomendas* - CTCE) placed in every Brazilian State, before being sent to their final destination. At the Ceará State CTCE, mailing volumes were randomly sorted and passed through an x-ray scanner. Whenever scanner operators detected images of organic matter in boxes, because of their distinguishable color patterns, Ibama officers were contacted and, using their prerogative of inspection assured by law, packages are violated to confirm or not the presence of living or dead organisms inside boxes. In positive cases, packs were arrested and individuals apprehended.

Therefore, from May 2010 to October 2012, whenever apprehensions of aquarium species were performed, organisms were quantified and identified to the lowest taxon possible and information regarding the senders and addressees were taken to allow Ibama to apply the pertinent sanctions and analyze the main origins and destinations of specimens.

In order to assess the participation in apprehensions, each group of organisms was evaluated regarding its diversity and every single species concerning two other different criteria: proportion of numerical abundance - %Num (the percentage of the total number of all the apprehended specimens represented by the individuals of a particular species) and frequency of occurrence - FO (the proportion of apprehended packs that contained a particular species, regardless its %Num). In addition, species were evaluated as to their categorization in the Brazilian Official List of Threatened Species of Fishes and Invertebrates (*Portaria* MMA 445/14), and also with respect to their natural distribution along Brazil and Ceará state.

Circumstances of the apprehensions and the percentage of recurrence - PR (the number of times a single sender or addressee used postal services to trade aquarium organisms divided by the total number of apprehensions) were also recorded. Additionally, One-way ANOVA and Tukey HSD were used to investigate pairwise differences among the years, by using PAST software (Hammer et al., 2001).

Results

A total of 57 apprehensions were conducted during the monitored period, 29 (50.9%) of which arriving at Ceará state from other Brazilian states, and 26 (45.6%) leaving Ceará state to other Brazilian cities. Two other apprehensions involved misdirected mailed packages inspected at Ceará state CTCE, one from Bahia (BA) to Paraíba (PB) state and another from São Paulo (SP) to Pernambuco (PE) state. None of the examined packages involved international sending or receiving of ornamentals.

The analysis of the main origins of the packages arriving to Ceará state showed that 48% came from southeastern (states: SP, Rio de Janeiro - RJ and Minas Gerais – MG), 33% from northeastern (states PE, PB, BA and Alagoas – AL), 14% from southern (Paraná – PR state) and 3% from mid-western (Goiás – GO state) Brazil (figure 1). A similar pattern occurred for the packages from Ceará state to other parts of the country: 61% would be delivered to southeastern (SP, RJ and MG), 28% to northeastern (PE, BA, PB Rio Grande do Norte – RN and Piauí - PI) and 12% to southern (Rio Grande do Sul – RS) regions. In both scenarios SP figured as the leading state in ornamental trading through the Brazilian postal service.

Considering the total apprehensions, a wide variety of both marine and freshwater species were identified (table 1). From the total of 384 individuals, marine specimens were both less abundant (%Num = 44.53%) and less frequent (FO = 29.82%) than freshwater individuals (%Num = 55.47% and FO = 70.18%) – it is worth noticing that whenever the former were present in the packages the latter were not and vice-versa, i.e., one mutually excluded the participation of the other.

Regarding the marine species, despite the low number of individuals arrested per apprehension, cnidarians were the most frequent (FO = 28.01%), and also the most abundant (%Num = 21.88%) and diverse group when compared to the others. Such diversity would be higher

if the remaining 51 individuals had been identified and if the one fire coral (*Millepora* sp.) specimen, apparently unintentionally attached to a harvested live rock, was included in table 1.

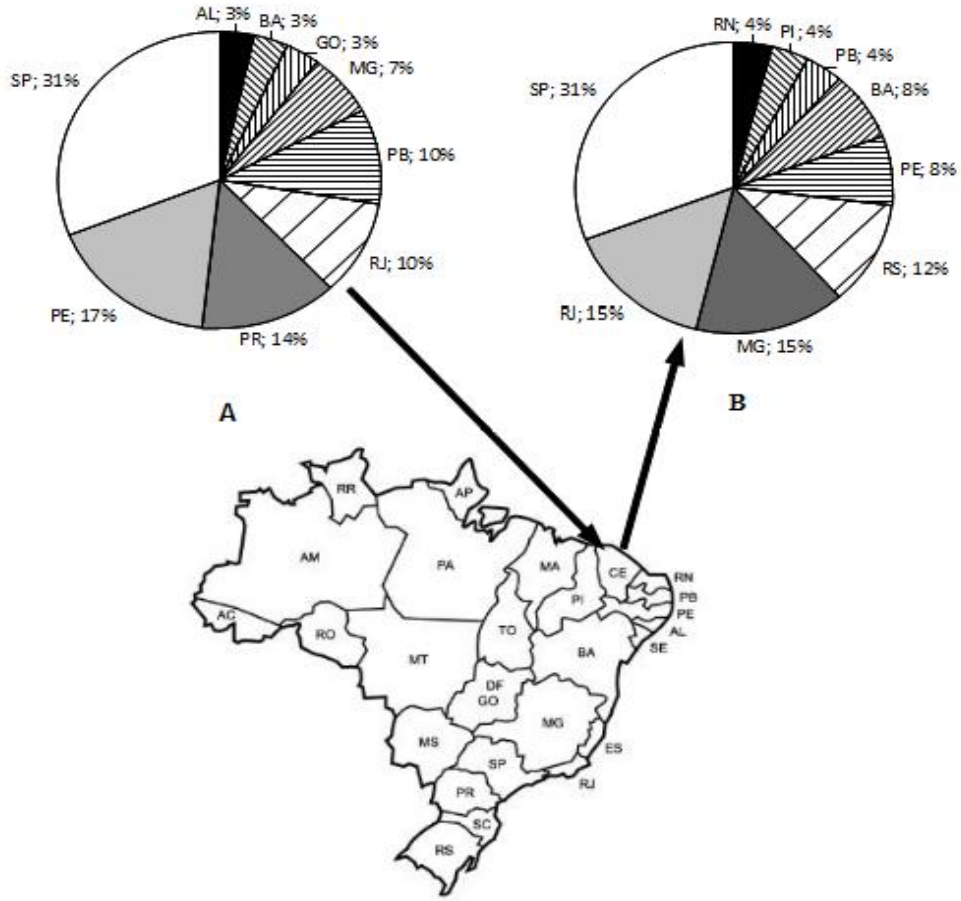

Figure 1 – Map of Brazil, indicating the states where aquarium organisms were traded illegally through the Brazilian postal service. (A) Brazilian states that sent ornamentals to Ceará state – 29 apprehensions. (B) Brazilian states that would receive ornamentals from Ceará state – 26 apprehensions. Capital letters refer to official abbreviations of the Brazilian states: AL - Alagoas, BA – Bahia, CE – Ceará, GO - Goiás, MG - Minas Gerais, PB - Paraíba, PE – Pernambuco, PI – Piauí, PR – Paraná, RJ - Rio de Janeiro, RN - Rio Grande do Norte, RS - Rio Grande do Sul and SP - São Paulo. Numbers associated with pie-charts indicate the percentage of each sender-state considering the amount of sendings (A) and the percentage of each addressee-state compared to the total that would be received (B).

Table 1 – Information about the apprehended organisms that were being illegally transported by means of the Brazilian postal service.

Apprehended organisms	Absolute number of specimens	%Num	FO (%)	Occurrence in Brazil	Occurrence in Ceará state
Marine aquarium species	171	44.53	29.82	-	-
Cnidarians	84	21.88	28.07	-	-
Acanthastrea lordhowensis[W, I, C]	1	0.26	1.75	Non-native	Non-native
Acropora millepora[W, I, C]	1	0.26	1.75	Non-native	Non-native
Acropora sp.[W, I, C]	2	0.52	1.75	Non-native	Non-native
Acropora suharsonoi[W, I, C]	1	0.26	1.75	Non-native	Non-native
Acropora tortuosa[W, I, C]	1	0.26	1.75	Non-native	Non-native
Discosoma sp.[W, I, C]	3	0.78	1.75	Native	Non-native
Entacnamea quadricolor[W, I, C]	2	0.52	3.51	Non-native	Non-native
Euphyllia ancora[W, I, C]	1	0.26	1.75	Non-native	Non-native
Favia sp.[W, I, C]	2	0.52	3.51	Native	Native
Montipora digitata[W, I, C]	1	0.26	1.75	Non-native	Non-native
Mussismilia sp.[W, ?]	1	0.26	1.75	Native	Native
Rhodactis sp.[W, I, C]	1	0.26	1.75	Non-native	Non-native
Ricordea sp.[W, I, C]	2	0.52	3.51	Non-native	Non-native
Sarcophyton sp.[W, I, C]	1	0.26	1.75	Non-native	Non-native
Trachyphyllia sp.[W, I, C]	1	0.26	1.75	Non-native	Non-native
Zoanthus sp.[W, I, C]	12	3.13	5.26	Native	Native
Unidentified cnidarians	51	13.28	14.04	-	-
Fish	28	7.29	7.02	-	-
Acanthurus leucosternon[W, I]	1	0.26	1.75	Non-native	Non-native
Cromis viridis[W, I]	4	1.04	1.75	Non-native	Non-native
Elacatinus figaro[C, W, VU]	16	4.17	1.75	Native	Native
Halichoeres dimidiatus[W]	2	0.52	1.75	Native	Native
Hippocampus reidi[W, C, VU]	2	0.52	1.75	Native	Native
Paracanthurus hepatus[W, I]	1	0.26	1.75	Non-native	Non-native
Holacantus tricolor[W]	1	0.26	1.75	Native	Native
Synchiropus splendidus[W, I, C]	1	0.26	1.75	Non-native	Non-native

Mollusks	49	12.76	1.75	-	-
Cerithium sp.[W]	42	10.94	1.75	Native	Native
Tegula viridula[W]	7	1.82	1.75	Native	Native
Echinoderms	5	1.30	5.26	-	-
Echinaster sp.	1	0.26	1.75	Native	Native
Linckia guildingii[W, VU]	3	0.78	3.51	Native	Native
Unidentified holothurian[W]	1	0.26	1.75	-	-
Crustaceans	5	1.30	3.51	-	-
Clibanarius sp.[W]	3	0.78	1.75	Native	Native
Stenopus hispidus[W]	2	0.52	1.75	Native	Native
Freshwater aquarium species	213	55.47	70.18	-	-
Fish	176	45.83	68.42	-	-
Aphoyocharax anisitsi[C]	5	1.30	1.75	Native	Non-native
Betta splendens[C]	143	37.24	57.89	Non-native	Non-native
Botia lohachata[C]	1	0.26	1.75	Non-native	Non-native
Danio rerio[C]	4	1.04	1.75	Non-native	Non-native
Poecilia reticulata[C]	15	3.91	1.75	Native	Non-native
Symphysodon sp.[C]	8	0.28	7.02	Native	Non-native
Mollusks	23	5.99	1.75	-	-
Pomacea diffusa[C]	23	5.99	1.75	Native	Non-native
Plants	10	2.60	1.75	-	-
Glossostigma elatinoides[C]	10*	2.60	1.75	Non-native	Non-native
Crustaceans	4	1.04	1,75	-	-
Caridina sp.[C]	4	1.04	1.75	Non-native	Non-native
Total	384	100.00	100	-	-

%Num - proportion of numerical abundance, FO - frequency of occurrence, W – wild-caught species, I – imported species, C – captive bred species. Status at the Brazilian list of threatened species (*Portaria* MMA 445/14): VU – vulnerable, ? - The genus can assume different statuses depending on the species (*M. braziliensis*: VU and *M. harttii*: EN – endangered). * Small volume of the species inside ten plastic bags.

Marine fish were the second most frequent (FO = 7.02%) and diverse (eight species) group of organisms, but the third most numerous (%Num = 7.29%). On the other hand, mollusks were the second most numerous group (%Num = 12.76%) amongst the marine aquarium species, but all the individuals belonged to just two species and were arrested only once in a single pack (FO = 1.75%).

Echinoderms and crustaceans reached the same amount of specimens (five individuals – %Num = 1.30%, each), but the former was more frequent and assorted than the latter (FO = 5.26%/three species and FO = 3.51/two species, respectively).

Concerning freshwater species, fish were by far the most representative group, either presenting the highest number of individuals (176 specimens – %Num = 45.83%) or being the most often (FO = 68.42%) and diversified confiscated organisms. This predominance is explained by numerous (143 specimens – %Num = 37.24%) and frequent (FO = 57.89%) apprehensions of siamese fighting fish, *Betta splendens*. Even whether the whole set of data is analyzed altogether, including marine and freshwater species, the participation of *B. splendens* would still stand out.

Participation of the other freshwater groups (mollusks, crustaceans and plants) was very modest, each one occurred just once (FO = 1.75%) and was represented by a single species: *Pomacea diffusa* (%Num = 5.99%), *Caridina sp.* (%Num = 1.04%) and *Glossostigma elatinoides* (%Num = 2.60%).

In Brazil, considering the whole set of apprehended species, the barber goby *Elacatinus figaro*, the seastar *Linkia guildingii* and the seahorse *Hippocampus reidi* are categorized as 'vulnerable' according to the Brazilian list of threatened species (*Portaria* MMA 445/14), while the brain corals of the genus *Mussismilia* assume distinct statuses depending on the species (*M. braziliensis* - vulnerable) and (*M. harttii* – endangered). According to the aforementioned rule, species classified as 'endangered' cannot be exploited anyway (harvesting is allowed just for scientific and conservation purposes), whereas those considered 'vulnerable' need a special authorization.

Two other aspects about the specimens confiscated must be highlighted. The first one concerns aquaculture - while many of the apprehended marine aquarium species are wild-caught, except for the great majority of the cnidarians and maybe the seahorse *H. reidi* (which is either harvested or captive bred in Brazil), freshwater organisms are mostly produced in captivity. The second aspect is related to the species' distribution: from the total of species retained, only 18 are native from Brazil and just 12 of them occur naturally in Ceará state.

Many traders (12 people – herein identified by means of the capital letters A to L) repeatedly (33 times of the 57 apprehensions – PR = 58%) used the Brazilian postal services to sell or exchange aquarium organisms (table 2).

Table 2 – Traders that repeatedly sent or would receive aquarium species through the Brazilian postal services.

Person	Sender	Addressee	Date (mm/dd/yy)
A	three times	-	06/08/10, 06/22/10 and 03/18/11
B	two times	-	06/30/10 and 11/18/10
C	three times	-	01/28/11 and 02/02/11 (two packs to two different people)
D	two times	-	01/25/11 (two packs to two different people)
E	six times	-	09/22/10, 11/25/10 (two packs to two different people), 01/05/11 and 01/13/11 (two packs to two different people)
F	three times	-	07/14/10, 08/10/10 and 08/17/10
G	-	three times	06/08/10, 06/09/10 and 09/15/10
H	-	three times	06/08/10, 06/22/10, 06/30/10
I	-	two times	01/25/11 and 02/04/12
J	-	two times	01/05/11 and 01/28/11
K	one time	one time	07/06/10 (addressee) and 07/20/10 (sender)
L	one time	one time	09/01/10 (sender) and 11/25/10 (addressee)

Along the monitored period, the absolute number of apprehensions plummeted dramatically from the first (46: May 2010 - February 2011) to the second (five: March 2011 - December2011) and the third (six: January 2012 - October 2012) ten-months interval. One-way ANOVA and Tukey

HSD revealed significant differences between the mean of the first ten-months period (F = 16.54, p = 0.00002, Fc = 3.35 and α = 0.05) compared to that of the second and the third periods, while these two latter were not significantly different from each other (figure 2).

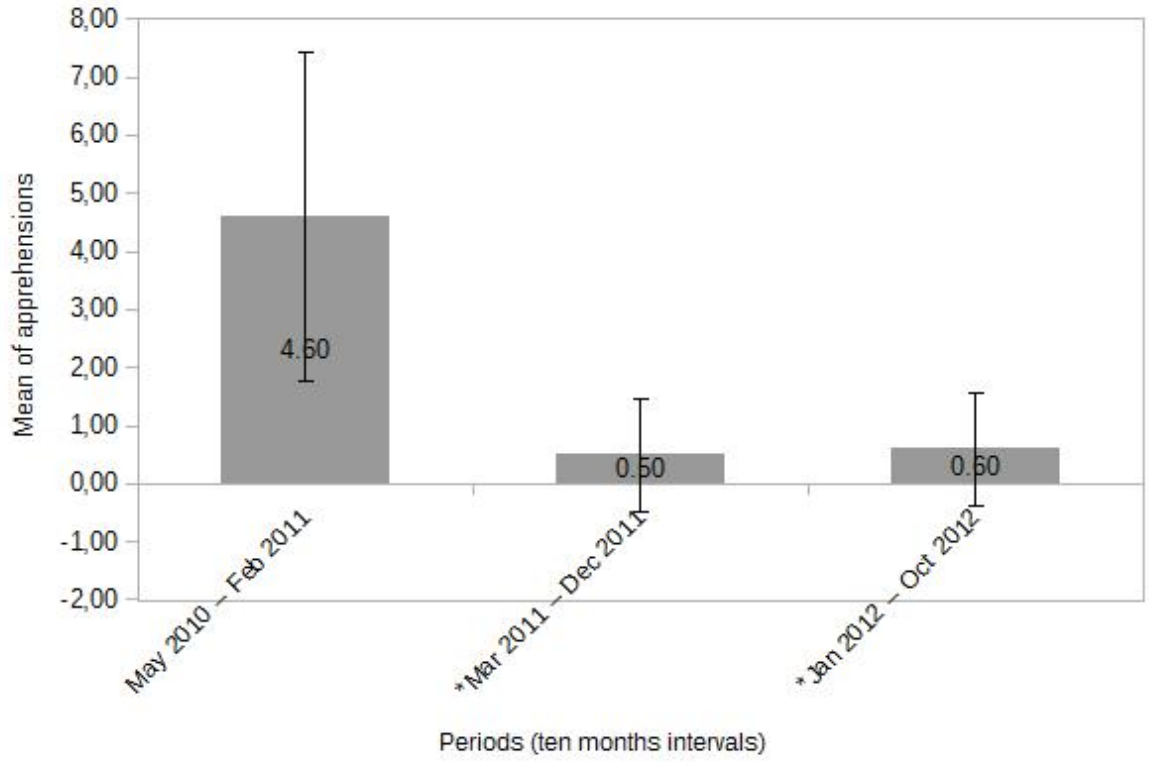

Figure 2 – Mean of apprehentions for three different periods (each one reffering to a ten months interval): May 2010 – February 2011, March 2011 – December 2011 and January 2012 – October 2012. Error bars represent standard deviations and (*) reffers to no significant difference between means according to Tukey HSD.

Discussion

According to the Brazilian Postal Law (# 6538/78, art. 13, V, VI and VII), the official mailing services will neither accept nor deliver live (except those admitted to international conventions ratified by Brazil) or dead animals or even live plants. Therefore, whenever organic

matter was detected inside packages, they were retained by ETC agents and Ibama was called to open the boxes and inspect their contents.

When aquarium species began to be confiscated in 2010, some traders tried to deceive scanner operators by adding sorted odd materials to the packages (e.g. broken dental molds, cds and dvds) or using them to wrap plastic bags (e.g. thin strips of newspaper, carbon paper and aluminium foil), in order to hinder the scanner. However, the usage of unusual matters inside boxes seems to be inefficient to deceive scanner operators, since illegally mailed organisms continued to be apprehended anyway.

Illegal traders not only tried to deceive public agents but also intend to cheat honest people, making them believe they were buying aquarium species from licit sources. For this purpose, cheaters take advantage of the fact that ornamental dealers must be registered at the federal technical register (*Cadastro Técnico Federal* – CTF, federal law 6,938/81 and IN Ibama 06/13) to operate legally in the country and, due to a serious flaw on the CTF system, it gives registration numbers even when incomplete or wrong information is provided. The counterfeiters then advertise the given or either a nonexistent number on e-commerce and auction websites. As currently the CTF system does not allow the general public to check the validity of the numbers posted on advertisements (but only through other identification document – CPF and CNPJ, which are almost never provided by dealers), such deceitful practice have raised difficulties to the people to detect illegal traders.

The results presented here demonstrate that the trade of aquarium species via Brazilian postal service at Ceará state was restricted to domestic mailing, since no international shipment was recorded, and involved almost all regions of Brazil, except the Northern region. Considering the states sending/receiving ornamentals from/to CE, the Southeast was the leading trader region, followed by Northeast and then by South region, in decreasing order of importance. It is worth to notice that SP state stood out as the main supplier and destination of the ornamentals apprehended –

certainly due to the fact of SP state is by far the most populous and richest Brazilian state, hosting the largest number of virtual shops, online auctions and home hobbyists e-commercing ornamental fishes (Magalhães and Jacobi, 2010). On the other hand, the largest ornamental aquaculture center in South America is located in MG, and it is considered the main source of plant, invertebrate, fish and frog introductions in the continent (Cardoso et al., 2012; Oliveira et al., 2014), but presented a low participation in the investigated trade.

Regarding the apprehended organisms, the great majority of individuals could be identified at least until genus level, with the exception of one holothurian and 51 cnidarians. Whenever the authors were part of the crew responsible for the apprehensions, they tried to identify the specimens to the lowest taxonomic level possible, either by using their own knowledge or asking for the help of specialists and legally registered aquaculturists. However, when the authors were not present at the confiscation moments, the other officers who performed the apprehensions sometimes not only could not identify the organisms by themselves (and did not look for someone else able to do it) but also misidentified some specimens at the first moment. Such lack of technical knowledge by the Ibama agents, as well as the absence of training and access to updated species identification guides, had already been mentioned by Monteiro-Neto et al., (2003) and Sampaio and Ostrensky (2013) as challenges to be overcame.

Each group of species was concomitantly evaluated regarding its diversity, %Num and FO, because the isolated observance of %Num would overestimate the participation of organisms that occur just once but in great quantities, while analyzes relying solely on FO would magnify the participation of species that occur in small quantities but are very often recorded. So, the observation of these two criteria altogether intends to compensate the biases caused by conclusions based exclusively on either %Num or FO.

Freshwater specimens, for instance, were just slightly more numerous (%Num = 55.47%) than saltwater individuals (%Num = 44.53%). However, the former (FO =70.18%) were much more

often observed than the latter (FO = 29.82%). Thus, the combined analyzes of %Num and FO criteria demonstrate that the participation of freshwater species in the trade through the Brazilian postal services seems to be much more significant than that of marine organisms.

Concerning marine species only, cnidarians were the most abundant (%Num = 21.88), recurrent (FO = 28.07%) and assorted group. Moreover, the diversity of coral and anemone species is likely to be even bigger, since the great majority of cnidarians could not be identified to the species level. After them, fish came out as the second most important (%Num = 7.29%, FO = 7.02) and diversified (eight species) group, followed by the other more uncommon organisms: mollusks (%Num = 12.76, FO = 1.75, at least two species), echinoderms (%Num = 1.30, FO = 5.26, at least three species) and crustaceans (%Num = 1.30, FO = 3.51, at least two species). Nevertheless, it is important to notice that marine gastropods increased expressively the number of saltwater organisms if one evaluates the %Num criterion only. The importance of these organisms was overestimated by a single apprehension (FO = 1.75%) of 49 specimens (42 *Cerithium* sp. and seven *Tegula viridula*) and the combined analyzes of %Num, FO and diversity criteria demonstrate that the participation of marine fish was greater than that of mollusks in two aspects (diversity and FO) and lower in just one (%Num), what made the former be considered more significant than the latter in this kind of trade.

With regards to freshwater aquarium species, the fact that fish are considered the most representative group, surpassing the other organisms in all the three criteria (%Num = 45.83, FO = 70.18, six species), was mainly due to regular apprehensions of *Betta splendens*. Such finding points to an intense trade of siamese fighting fish via mailing services, which is encouraged by e-commerce involving either clients and pet shops or hobbyists selling and exchanging specimens by means of auction websites. This statement is corroborated by constant advertisements of *B. splendens* in Brazilian auction websites (e.g. www.mercadolivre.com.br and www.olx.com.br), pet shop and personal webpages, blogs and facebook profiles (www.facebook.com), which in many

cases direct clients to a link of the ECT website to calculate costs of shipping by regular postal services.

Following freshwater fish, in the decreasing order of importance, mollusks appears as the second more significant group (%Num = 5.99), plants as the third (%Num = 2.60) and crustaceans as the fourth (%Num = 1.04%) - each of them being composed only by a single species (*Pomacea diffusa*, *Glossostigma elatinoides* and *Caridina* sp.) and occurring just once (FO = 1.75%). The number of *G. elatinoides* 'individuals' was determined based on the amount of approximately a handful species inside ten plastic bags.

Unlike freshwater ornamental commerce, where about 90% of fish species are produced in captivity, the great majority of marine aquarium organisms is wild-caught (Wabnitz et al., 2003; Livengood et al., 2014). However, in the specific case of marine species in the present work, such statement is not applicable to cnidarians, but just to the other groups of organisms.

Almost all genera of corals identified are exotic species (which can be either harvested or farmed abroad), captive bred by Brazilian aquaculture facilities or mainly home propagated by hobbyists that trade cnidarians through the internet and send them via postal services. In most of the cases, corals were transported attached to artificial substrata, e.g. ceramic tiles, suggesting they were captive produced through fragmentation (Rhyne et al., 2012b). The exception is for the genera *Discosoma*, *Favia, Zoanthus* and for endemic brain corals of the genus *Mussismilia*, whose natural occurrence is reported to Brazil and the three latter also to Ceará state (Almeida, 2012; Soares and Rabelo, 2014; Zilberberg et al., 2014). Other points that suggest harvesting of the native cnidarians are: (1) the recognized but illegal exploitation of many Brazilian coral species by the aquarium industry (Gasparini et al., 2005; Machado et al 2008); (2) the fact that the box containing *Mussismilia* sp. also included another native non-aquacultured species, e.g. two specimens of the common comet sea star, *Linckia guildingii* and (3) the apprehension of cnidarians adhered to natural substrata, commonly named 'live rocks', which is suggestive of wild harvesting - in these cases, not

only were corals present in the substrata but sponges, bivalve mollusks, polychaetes, as well as the fire coral *Millepora brasiliensis* were also observed.

Regarding marine fish, almost all non-native species are harvested in their home countries and then exported to Brazil, with exception of the mandarim dragonet *Synchiropus splendidus*, that can be either collected or captive bred (Rhyne, 2010). Whereas half of the native species are exclusively wild-caught (*Halichoeres dimidiatus* and *Holacanthus tricolor*), the other half (*Elacatinus figaro* and *Hippocampus reidi*) can also be either harvested or aquacultured in Brazil (Meirelles, 2008; Hora and Joyeux, 2009; Côrtes and Tsuzuki, 2010). It is important to notice that, according to the Brazilian list of threatened fish and aquatic invertebrate species – *Portaria* MMA 445/14, *H. reidi* and *E. figaro* are categorized as vulnerable and can only be harvested by means of special licenses issued by environmental authorities, which was not the case. Thus, in an attempt to reduce collecting pressure over natural populations of *E. figaro*, the individuals apprehended at the aforementioned CTCE were, in accordance with law, sent as breeders for an aquaculture initiative located at Ceará state, which is currently producing legalized captive bred barber gobies to the market.

Differently from other countries, where some marine species are already farmed in commercial numbers, further studies are still necessary to allow a regular supply of a large number of species (Tlusty, 2002; Olivotto et al. 2011). In Brazil, the other groups of marine invertebrates (mollusks, echinoderms and crustaceans) recorded are exclusively comprised by native wild-caught species and, hence, the sustainability of the exploiting activities is controversial (Gasparini et al., 2005; Nottingham et al., 2005a), specially when the illegal harvesting of threatened species is taken into account.

As previously reported, 51 cnidarians could not be identified to lower taxa and, thus, it is not possible to assure whether they were or not amongst the four cnidarian species listed at *Portaria* MMA 445/14 under vulnerable (*Mussismilia braziliensis* and *Millepora laboreli*) or endangered

(*Condylactis gigantea and Mussismilia harttii*) statuses. However, one can guarantee that the unidentified holothurian was not *Synaptula secreta*, the single sea cucumber species considered threatened in Brazil, and whose diminutive size did not matched with that of the specimen confiscated. Additionally, the three specimens of common comet sea star (*Linckia guildingii*) are categorized as vulnerable at the Brazilian list of threatened species. Thus, the illegal harvesting and mailing of threatened species demonstrate that the environmental authorities must intensify their actions and, specially, reduce collecting pressure over depleted populations.

Another aspect that deserves special attention is the natural distribution of the organisms, since invasive species are considered the second most serious threat to biodiversity in all ecosystems - the first is habitat destruction - (Kay and Hoyle, 2001; Garcia et al., 2014). Many aquarium owners, upon giving up their hobby, are reluctant to sacrifice their pets and plants and perform 'aquarium dumping', i.e., discard them into artificial or natural environments (Kay and Hoyle, 2001, Schofield, 2010; Diaz et al., 2012; Magalhães and Jacobi, 2013). Besides aquarium trade be historically recognized as a vector for aquatic non-indigenous species (Diaz, et al., 2012), specially in very populated regions with higher numbers of aquarium owners and stores (Strecker et al., 2011), e-commerce have not only made rural areas more susceptible to species invasions (Kay and Hoyle 2001) but also increased the number of ornamentals introduced into ecosystems, because a lot of invasive species are attractive, extreme popular, easily maintained and have low cost, allowing professional aquarists, shop owners and home hobbyists to sell their stocks via virtual shops and electronic auctions (Kay and Hoyle, 2001; Magalhães and Jacobi, 2010; Garcia et al., 2014).

In Brazil, it is reported the occurrence of both freshwater and marine non-native species in natural ecosystems (Langeani et al., 2007; MMA, 2009, Leão et al., 2011; Garcia et al., 2014) and in the present study, just 18 species are naturally distributed throughout the country and only 12 of them are native to Ceará state, i.e., the majority of the species identified was formed by non-

indigenous or allochthonous organisms, clandestinely traded by means of postal services, ignoring official rules to control the activity and increasing the risk of bioinvasion and disease and pathogens translocation to the environment (Whittington and Chong, 2007). The use of traditional postal services to engage both illicitly and legally e-commerced aquarium species had already been recorded in the US (Kam et al., 2005; Wyler and Sheikh, 2008) and Magalhães and Jacobi (2010) had previously called the attention to the high dispersal potential of species by means of postal services.

The Brazilian domestic ornamental freshwater fish market is dominated by exotic species, mainly those originated from Asia (Anjos et al., 2009), which had their reproductive cycle closed and are easily aquacultured in commercial quantities. However, Brazil not only trade non-native captive bred freshwater organisms but also exports many native wild-caught freshwater species, including the three native fish species recorded here (*A. anisitsi*, *P. reticulata* and *Symphysodon* sp.) (Anjos et al., 2009; Souza and Mendonça, 2009).

The expressive participation of *Betta splendens* in the trade via postal services is probably associated with many different hobbyists or very small-scale dealers (termed 'backyard producers') exchanging or selling desired lineages of captive bred siamese fighting fish (Faria et al., 2006; Monvises et al., 2009) rather than large aquaculture facilities mailing their production to final consumers. Although *B. splendens* is found in some natural environments throughout Brazil, likely due to aquarium dumping (Magalhães and Jacobi, 2008; Leão, 2011; Magalhães and Jacobi, 2013; Garcia et al., 2014, Oliveira et al., 2014), they are rarely collected (maybe just by playing children or beginner aquarists) but mostly captive bred, aiming the development of new morphology and color patterns for the species (Faria et al., 2006; Monvises et al., 2009).

A similar situation occurs for the guppy *Poecilia reticulata.* Despite not being exotic, the species is allochthonous and considered an invasive pest in some Brazilian basins, yet reproducing and changing native fish community structures (Magalhães and Jacobi, 2010, Leão et al., 2011;

Magalhães and Jacobi, 2013; Garcia et al., 2014) due to its frequent reproduction over an extended breeding season, allowing effective colonization of human-altered habitats (Oliveira et al., 2014). Likewise *B. splendens*, the presence of guppies in environments beyond their natural distribution is posed either by aquarium dumping (Magalhães and Jacobi, 2013) or old releases aiming biological control against mosquitoes (Cavalcanti et al., 2007; Cavalcanti, 2009; Milenkovic et al., 2014) and, in addition, they can be unusually collected farmed in natural or artificial water bodies (Cavalcanti et al., 2007), but are primarily tank bred in an effort to develop new varieties – there are more than 40 *P. reticulata* varieties being currently traded in Brazil (Cardoso et al. 2012).

Bloodfin tetra *Aphoyocharax anisitsi* and discus fish *Symphysodon* sp. are both collected and farmed in Brazil, in order to supply international and domestic demands. The former is one of the seven most exported characids and the latter is represented by high priced individuals (achieving up to US$1,500.00 per unit), whose decreasing exports may be associated with increasing aquaculture, and hence more easily aquarium-adapted specimens, or diminishing fish stocks (Anjos et al., 2009). The other two non-native fishes, *Botia lohachata* and *Danio rerio*, are recognized longstanding captive bred species in Brazil and the latter is one of the most produced ornamental fish at the Zona da Mata Mineira region (Magalhães and Jacobi, 2008; Cardoso et al., 2012).

The absence of other common freshwater fish species, e.g. additional poecilids (*Poecilia latipinna*, *Xiphophorus helleri*, *X. maculatus*, *X. variatus*), in the boxes inspected may indicate that very accessible species (ordinary, cheap and locally available) are mainly supplied locally.

On the other hand, not so common species like *A. anisitsi* and the possibility to obtain unique color patterns and some exclusive strains of even common species (e.g. *B. splendens* and *P. reticulata*) seem to be challenging to hobbyists and justify purchasing specimens from other Brazilian states. This is corroborated by the fact that: (a) *D. rerio* specimens were uncommon fluorescent individuals (Gong et al., 2003), (b) *Caridina* shrimps are seldom offered by most of the regular aquarium shops at Ceará state and (c) the uncommon *Glossostigma elatinoides* was being

traded while conventional species (e.g. the Brazilian elodea, *Egeria densa*, and the water hyacinth, *Eichornia crassipes*) were not.

Pomacea diffusa and other congeneric apple snails are pointed as threats to natural environments beyond their original distribution (Magalhães and Jacobi, 2010). In addition, that gastropod was recently recorded at Maranhão state, northeastern Brazil, where it has not previously been found (Cantanhede et al., 2014), and, even being native of South America, was caught in the Waikato River, New Zealand, probably due to aquarium release (Collier et al., 2011).

In order to check the effectiveness of the variable 'apprehension' to reduce the illegal trade of aquarium species along the years monitored, the estimated PR = 58% revealed that 12 traders continued sending and/or receiving organisms via postal services even after previous confiscations. Such information is misleading, giving the false idea that arrestments *per se* (considering that usually fines took more than a year to be issued) did not inhibit the illicit mailing of the organisms. In addition, the numbers presented herein are certainly underestimated because boxes are inspected by random sampling, i.e., some other packages from the same sender may have been delivered without examination.

On the other hand, when dates of apprehensions are analyzed, it is shown that most traders (Persons A, C, D, F, H, I, J and K) have sent or would receive packages in a short-time interval - suggesting that these actions were more likely restricted and that the arrestments helped to reduce the illegal activity -, and, aditionally, only four of them (Persons B, E, G and L) seem to have endured with shipments, ignoring the possibility of eventual penalties besides boxes retentions.

Moreover, a wider view of the distribution of arrests along the years corroborated their importance (even not followed by an immediate pecuniary penalty) to decrease the prohibited mailing of organisms. In addition, One-Way ANOVA and Tukey HSD revealed that the variable 'apprehension' was really important to diminish illigal trading via ECT services, since it significantly influenced the differentiation of the first ten-months mean compared to the other

remaining periods.

The prohibition of ornamental trade via postal services not only aims to preserve the wellness of the organisms transported but also intends to mitigate the potential risks caused by the frantic uncontrolled swap of aquarium species, e.g. introduction of invasive species and the spread of associated pathogens (Whittington and Chong, 2007). In addition, bureaucratic processes, the usage of appropriated transport services and the issuance of licenses by the Brazilian environmental authorities are required to control both the species and the amount of individuals translocated. The aim of such demands is to regulate the exploitation of species and not to create difficulties to the development of aquarium trade in the country. The aquarium industry has a relevant socioeconomic value (Wabnitz, 2003; Anjos et al., 2009; Souza and Mendonça, 2009; Stevenson and Tissot, 2013; Rhyne et al., 2014) and an eventual interruption of wild fishery, for instance, would force species to be aquacultured outside their original range with no economic return to their native countries, e.g. the captive breeding of cardinal tetras in Czech Republic, Singapore and USA generating no profits to Brazil (Tlusty et al., 2014). Similarly, the stopping of ornamental farming in Brazil would impact negatively many families that depend on this type of activity to survive (Cardoso et al., 2012).

The lack of knowledge regarding the rules applicable to the trade of aquarium species in Brazil may be the main cause of the transgressions herein reported. Just like in other countries, physical and virtual retailers are expected to be aware of regulations pertaining to the species traded as part of their livelihood (Diaz et al, 2012), while home hobbyists and backyard producers (believed to constitute the majority of the traders here identified) remain unaware of those rules (Walters et al., 2006).

In Brazil, as in the USA, animals and plants not only are traded through postal services but also via private shipping companies (Walters et al., 2006; Magalhães and Jacobi, 2010). Therefore, considering restrictions imposted by 6,538/78, the usage of the latter must be encouraged rather than the former. In addition, free communication aiming at a better translation between academia,

hobbyists and commercial industry have to be stimulated (Rhyne, 2010) in order to share information concerning expoitation of threatened species, aquarium dumping, bioinvasion and the licit transport of ornamentals via private shipping companies in Brazil.

In order to improve repression against the illicit transport of aquarium species via Brazilian postal services, ECT should acquire more x-ray scanner units and distribute them throughout the country, besides training a wider number of agents to become scanner operators. Additionally, costumers should be obligated to declare the content of the packages and give complete information regarding their identification and addresses, while ECT would promote advertisements concerning prohibitions imposed by Law 6,538/78.

In its turn, Ibama ought to (a) invest more efforts in the combined work with ECT by training officers with regards to identification of organisms, (b) accelerate the issuing of pecuniary penalties and (c) establish partnerships with managers of social networks, auction websites and e-commercing pet shops, aiming costumers to be aware of rules regarding aquarium species trading and potential risks involving aquarium dumping and bioinvasion. Moreover, as transport of ornamentals through private shipping companies replaces that via Brazilian postal services, Ibama will have to intensify inspections of pakages from those transporting enterprises.

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CONSIDERAÇÕES FINAIS

A explotação de espécies ornamentais marinhas necessita ser melhor ordenada, visando à garantir seu uso sustentável tanto pelas presentes como futuras gerações. Desse modo, é imprescindível que sejam respeitadas as normas que regem o setor, concernentes à captura e utilização apenas de espécies permitidas e nos moldes autorizados pela legislação.

A identificação de que mais de 30% das espécies de peixes utilizadas pelo aquarismo marinho brasileiro são ilegalmente coletas e comercializadas é impressionante. Igualmente surpreendente é a quantidade de espécies de invertebrados explotada de maneira indevida. Tais constatações são ainda mais graves pelo fato de vários desses organismos constarem em listas de espécies ameaçadas de extinção e de que o equilíbrio trófico das relações intra e interespecíficas pode estar sendo seriamente afetado por capturas desordenadas. Desse modo, fica evidente a necessidade de atuação mais incisiva por parte do poder público, através de fiscalizações, além da busca por alternativas que diminuam a pressão de captura sobre populações sobreexplotadas (ex: aquicultura e reservas marinhas).

A necessidade de elaboração de mais normas específicas para a utilização de espécies ornamentais, contemplando outros grupos taxonômicos e não exclusivamente peixes, e o aprimoramento das ferramentas de manejo atualmente utilizadas no Brazil (ex: GTPON, GTA, GTAM etc) são urgentes. Em alguns casos, medidas relativamente simples (ex: consulta de regularidade junto ao Ibama através do número do CTF, e não apenas pelo CPF ou CNPJ) poderiam melhorar tais ferramentas, o que auxiliaria sobremaneira o controle sobre o uso sustentável das espécies.

Para uma gestão eficiente das espécies utilizadas no aquarismo marinho, são necessárias atualizações constantes de informações sobre o setor, tanto pelo Ibama como pelo meio acadêmico. Pois, somente assim, é possível identificar os diversos aspectos inerentes à atividade, como por

exemplo, as espécies mais utilizadas, quantidades exportadas, tendências no mercado, entre outros. Esse tipo de informação é determinante para a formação de argumentos que visem à implementação de medidas de manejo.

Além das formas convencionais de comercialização de espécies ornamentais, a identificação de meios de transporte ilícitos de organismos (ex: Correios) é necessária para que sejam melhor planejados os esforços de fiscalização. Além disso, é possível mapear as principais origens e destinos dos espécimes, identificar as espécies comercializadas, avaliar se as apreensões atuam para diminuir o transporte ilegal dos organismos, entre outros.

Conforme dito ao longo desse trabalho, ainda persiste a necessidade de informações básicas relativas às populações das espécies mais utilizadas no aquarismo marinho, mesmo decorridos vários anos desde a identificação inicial dessa demanda. Continuam a existir também lacunas no conhecimento acerca da capacidade de resiliência dessas populações, tendo em vista não só os impactos negativos decorrentes de coletas com fins ornamentais, mas também somados a outras adversidades às quais os estoques podem estar sendo submetidos (ex: poluição, perda de habitat, capturas acidentais em outras artes de pesca etc).

Ante todo o exposto, as informações discutidas nessa tese certamente são úteis para a adoção de medidas que visem à explotação racional das espécies ornamentais marinhas no Brasil. No entanto, muito ainda há de ser feito em prol do desenvolvimento sustentável do aquarismo marinho brasileiro, uma vez que a gestão do uso das espécies pela atividade é bastante complexa e exige que se leve em consideração não somente os aspectos ambientais, mas também sociais e econômicos.