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ANALYSIS OF THE ORNAMENTAL FISH EXPORTS FROM THE AMAZON STATE, BRAZIL*

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ABSTRACT

The updated status of the ornamental fish trade from the Amazonas state was analyzed between the years of 2006-2015 (IBAMA database). The trade of ornamental fish from Amazonas State mainly consists of wild species. A total of 142,552,253 specimens were exported during the studied period. Sales plummeted since 2006 from 26,075,241 specimens exported to 2,729,846 specimens in 2015 (Jan-Jul). Between 2006 and 2015, a total of US$ 23.0 million in revenue was generated from fish exports destined to 35 countries. Germany, Taiwan, USA and Japan accounted for 75.5% of the volume and 76.7% of the value exported. During this time 375 species were exported, included *Paracheirodon axelrodi*, *P. simulans, Hemigrammus bleheri*, *Otociclus affinis* and *O. hoppei* that together represented 84.5% of exports. Thirty of them are not on the list of Brazilian Institute of the Environment and Renewable Natural Resources - IBAMA species released for export, and six are currently on the list of endangered fauna of Brazil: *Hopliancistrus tricornis*, *Leporacanthicus joselimai*, *Parancistrus nudiventris*, *Peckoltia compta*, *Scobinancistrus auratus* and *S. pariolispos*. The collection of this information can help producers, managers and environmentalists in the elaboration of the political policies to establish regulations to govern the trade.

Keywords: aquarium fish; export; monitoring; sustainability; Amazon basin.

ANÁLISE DAS EXPORTAÇÕES DE PEIXES ORNAMENTAIS DO ESTADO DO AMAZONAS, BRASIL

RESUMO

O corrente status do comércio de peixes ornamentais exportados do Estado Amazonas foi analisado entre os anos de 2006-2015 (banco de dados IBAMA). Esse comércio está concentrado em espécies extraídas da natureza. Foram exportadas 142.552.253 unidades de exemplares vivos durante o período do estudo. As vendas vêm decrescendo desde 2006, onde foram exportadas 26.075.241 unidades; esse número decaiu para 2.729.846 exemplares em 2015 (jan-jul). O valor total de ingresso de divisas das exportações foi de US$ 23,0 milhões. Dentre os 35 países importadores, destacaram-se a Alemanha, Taiwan, Estados Unidos e Japão que representaram juntos 75,5% do volume e 76,7% do valor das exportações. Nesse período foram comercializadas 375 espécies. As principais foram *Paracheirodon axelrodi*, *P. simulans, Hemigrammus bleheri*, *Otociclus affinis* e *O. hoppei* que representaram, juntas, 84,5% das exportações. Trinta espécies não estão na lista do IBAMA liberadas para exportação, e seis espécies que aparecem nas exportações atualmente estão na lista da fauna ameaçada de extinção do Brasil, dentre elas *Hopliancistrus tricornis, Leporacanthicus joselimai*, *Parancistrus nudiventris*, *Peckoltia compta*, *Scobinancistrus auratus* e *S. pariolispos*. A coleta dessas informações pode ajudar produtores, gestores, ambientalistas na elaboração de políticas públicas e regulamentos para reger o comércio extrativista.

Palavras-chave: peixe de aquário; exportação; monitoramento; sustentabilidade; bacia Amazônica.

INTRODUCTION

Ornamental fish trade started during the 1950's (Leite and Zuanon, 1991), becoming in 2014 a global industry of the US$ 10 billion, while the entire industry including plants, accessories, aquarium, feed, and drugs is estimated to be worth US$ 18-20 billion annually in 125 countries (Dey, 2016). In 2010, global exports of ornamental fish were estimated in 2 billion live ornamental fish that were moved annually worldwide (Monticini, 2010). That same year proximally 7.2 million homes in the United States

(USA) and 3.2 million in the European Union (EU) have aquariums (Monticini, 2010). Around 2,500 species are commercialized, 60% (1,500) being freshwater species (Dey, 2016). Most fishes going into this trade come from Southeast Asia, representing 80% of the market (Monticini, 2010; Dey, 2016). Only 10% of the traded fishes were wild caught mainly from South America (Anjos et al., 2009a; Monticini, 2010).

In 2014, USA was the single largest importer of ornamental fish, with 14.3% (US$ 42.9 million) of total imports. This was followed by the European Union with US$ 29.5 million, 9.87% of total imports (Dey, 2016). Most species commercialized are species with easy husbandry techniques and low cost (Monticini, 2010). In South America the majority of species traded are wild-caught fish from the Amazon (Moreau and Coomes, 2007; Anjos et al., 2009a). The three biggest producers and exporters of ornamental fish are Brazil, Colombia and Peru (Moreau and Coomes, 2007; Mancera-Rodríguez and Álvarez-León, 2008; Anjos et al., 2009a). In Brazil, the Amazonas State is the biggest producer quantitatively of tropical wild-caught fishes. Between the years 2002 and 2005, approximately 100 million specimens were exported to 35 countries, being 2005 the year record in sales reaching 36 million specimens exported, generating US$ 2.4 million. It was commercialized 169 species on that year. A total of 16 export companies housed their facilities around the Manaus Area, however, three of them controlled 82% of the market until 2005 (Anjos et al., 2009a).

Most wild-caught fish were from the middle Negro River Region, supplying 90% of the exports and generating income to the municipalities of Barcelos, Santa Isabel do Rio Negro and São Gabriel do Rio Negro. Wild-caught fish was the main source of income for these municipalities (Anjos et al., 2009a) generating 10,000 indirect and direct jobs to around 1,600 families of the region (Prang, 1996; Chao et al., 2001; Prang and Thomé-Souza, 2003; Prang, 2007), although that number has declined in recent years (Inomata and Freitas, 2015; Ladislau et al., 2020).

The market is organized in a way that the main players are the fisherman ("piabeiros"), usually older, who capture only what the export companies request via the middleman (patrones). The middleman is the communication channel between the piabeiros and the export companies that buy the fish and resell it with a 20% profit (Prang, 2001; 2007). The The *Paracheirodon axelrodi* was the number one export, representing 70% of total exports. Other exported species include *Hemigrammus bleheri*, *Otocinclus flexilis, Carnegiella strigata, Hyphessobrycon socolofi, O. affinis, Corydoras reticulatus, C. agassizii, C. schwartz, C. julii, Peckoltia ittate* and *Symphysodon discus* (Anjos et al., 2009a).

According to data from the Department of External Commerce-SECEX, the number of commercialized fish declined drastically in 2008 caused by the 2008 economic crisis that hit Brazil (Benzaken et al., 2015). This sharp drop in sales resulted in the closure of the biggest Brazilian export company that was responsible for 51% of sales (Anjos et al., 2009a; Benzaken et al., 2015). In addition to the economic crisis, other factors such as freight prices, which are one of the highest in the world from Manaus to beyond, a volatile exchange rate, and an extremely bureaucratic Brazilian customs contributed to this decline (Benzaken et al., 2015). According to ornamental fishermen (piabeiros) the middle men ("intermediário") was paying very little for the fish the caught (mainly the *Paracheirodon axeroldi*), the fisherman thought that the trade came to a halt because the middle men did not want to pay them (Anjos et al., 2009b). However, the true reason was that competition with neighboring countries (e.g. Peru and Colombia) with less bureaucratic systems, and fewer restriction on which species can be exported destroyed Brazilian Amazonian market (Moreau and Coomes, 2007; Anjos et al., 2009b). Additionally, international pressure to stop the commerce of wild-caught fish intensified. Gerstner et al. (2006) indicated that fishing grounds showed a decrease in abundance and diversity of species of tropical fish at the Peruvian Amazon. Finally, the increase of husbandry practices and reproduction in Southeast Asia decreased the trade in Brazil, leaving thousands of families without their livelihoods (Benzaken et al., 2015). This caused these fishermen to start working on sport fishing and commercial fisheries, which have larger negative impacts on fish stocks.

This paper is a thorough evaluation of wild-caught ornamental fish trade from the Amazonas State between the years 2006 a 2015. The main objective was to evaluate the diversity of species exported, assess the value and quantity exported and identify receiving countries. This contributes to a better understanding of the market, serving to assist public policy and so that lawmakers can produce better lists of species allowed for export.

MATERIAL AND METHODS

The data was collected from the Brazilian Institute of the Environment and Renewable Natural Resources – IBAMA export control for ornamental fishes database (COREP/CGFAP/DBFLO/IBAMA). The authors were given authorization from this department to produce this article. The database included the scientific name, quantity of fish exported, state of origin, authorization number, price per fish and country of destiny. Data from 2006 until 2015 was analyzed and the total of fish exported per species and the amount collected (until July 2015) in US$ dollars were verified. The analysis was made on descriptive statistics producing tables and graphs. The species list presented herein follows the taxonomic classification of Betancur et al. (2017), with the orders arranged following the systematic/phylogenetic organization of the latter, whereas families, genera and species were presented in alphabetical order. Some scientific names had to be corrected and checked for duplicates (Reis et al., 2003; Buckup et al., 2007; Beltrão et al., 2019). Some species *Loricariidae* are described throughout the text with the codes "L" as they are known internationally (Schraml and Schäfer, 2004; 2020).

RESULTS

Aquarium fish exports

Between 2006 and July 2015, more 142,552,253 fishes from 375 species, 8 Order and 34 families were exported from the Amazonas State for ornamental trade. Characiformes and Siluriformes were the two orders most exported, representing

82.6% (117,808,641) and 16.0% (22,914,367) of exports, respectively. The Cichliformes, represented 1.2% of total export. The order less exported the least was the such as Cyprinodontiformes, Myliobatiformes, Tetraodontiformes, Gymnotiformes and Pleuronectiformes corresponded to only 0.04% of total exports (Table 1).

Table 1. List of species, the total number of specimens and the percentage of total export volume between 2006 and 2015 from the Amazonas state, Brazil (2015* = database of Jan-Jul).

ORDER/Family/*Specie*	2006-2015*	%	ORDER/Family/*Specie*	2006-2015*	%
MYLIOBATIFORMES			**SILURIFORMES** (Cont.)		
Potamotrygonidae			**Doradidae**		
Potamotrygon cf. *henlei*	5	<0.01	*Acanthodoras cataphractus*	241	<0.01
Potamotrygon cf. *histrix*	6,399	<0.01	*Acanthodoras spinosissimus*	6,565	<0.01
Potamotrygon leopoldi	417	<0.01	*Agamyxis pectinifrons*	100	<0.01
Potamotrygon motoro	342	<0.01	*Amblydoras affinis*	220	<0.01
Potamotrygon orbignyi	32	<0.01	*Amblydoras hancockii***	5,314	<0.01
Potamotrygon shroedery	21	<0.01	*Hassar orestis*	115	<0.01
CHARACIFORMES			*Hassar wilderi*	35	<0.01
Acestrorhynchidae			*Opsodoras ternetzi*	10	<0.01
Gnathocharax steindachneri	220	<0.01	*Platydoras armatulus*	57	<0.01
Hoplocharax goethei	140	<0.01	**Heptapteridae**		
Anostomidae			*Pimelodella gracilis*	3,759	<0.01
Abramites hypselonotus	466	<0.01	**Loricariidae**		
Anostomus anostomus	4,398	<0.01	*Acanthicus adonis*	447	<0.01
Anostomus ternetzi	8,671	0.01	*Acanthicus hystrix*	33	<0.01
Leporinus agassizi	785	<0.01	*Acestridium discus*	860	<0.01
Leporinus fasciatus	16	<0.01	*Ancistrus aguaboensis*	650	<0.01
Pseudanos gracilis	46	<0.01	*Ancistrus claro*	15	<0.01
Pseudanos trimaculatus	1,195	<0.01	*Ancistrus dolichopterus*	45,836	0.03
Brynconidae			*Ancistrus hoplogenys*	12,194	0.01
Salminus maxillosus	1,812	<0.01	*Ancistrus multispinis*	150	<0.01
Characidae			*Ancistrus ranunculus*	16	<0.01
Aphyocharax anisitsi	6,944	<0.01	*Ancistrus* sp. “L255”	934	<0.01
Astyanax bimaculatus	230	<0.01	*Ancistrus* spp.	242,987	0.17
Astyanax fasciatus	890	<0.01	*Baryancistrus chrysolomus*	12	<0.01
Brittanichthys axelrodi	1,840	<0.01	*Baryancistrus* sp.	258,451	0.18
Brittanichthys myersi	8,198	0.01	*Baryancistrus* sp. “L142”	480	<0.01
Chalceus erythrurus	1,088	<0.01	*Baryancistrus xanthellus*	900	<0.01
Charax condei	1,780	<0.01	*Dekeyseria amazonica*	35	<0.01
Exodon paradoxus	20	<0.01	*Dekeyseria brachyura*	563	<0.01
Gymnocorymbus ternetzi	75	<0.01	*Dekeyseria pulcher*	1,103	<0.01
Hemigrammus belottii	6,445	<0.01	*Dekeyseria scaphirhyncha*	150	<0.01
Hemigrammus bleheri	7,178,906	5.04	*Farlowella amazona*	768	<0.01
Hemigrammus elegans	320	<0.01	*Farlowella nattereri*	80	<0.01
Hemigrammus marginatus	59,690	0.04	*Farlowella* sp.	6,503	<0.01
Hemigrammus ocellifer	7,701	0.01	*Hemiancistrus sabaji*	472	<0.01
Hemigrammus pulcher	3,320	<0.01	*Hemiancistrus snethlageae*	120	<0.01
Hemigrammus rodwayi	14,948	0.01	*Hemiancistrus spilomma*	4	<0.01

Table 1. Continued...

ORDER/Family/*Specie*	2006-2015*	%	ORDER/Family/*Specie*	2006-2015*	%
CHARACIFORMES (Cont.)			**SILURIFORMES** (Cont.)		
Hemigrammus stictus	20,249	0.01	*Hopliancistrus tricornis*	4,115	<0.01
Hemigrammus ulreyi	4,950	<0.01	*Hopliancistrus tricornis*	30	<0.01
Hemigrammus unilineatus	3,478	<0.01	*Hypancistrus inspector*	3,938	<0.01
Hyphessobrycon agulha	320	<0.01	*Hypancistrus* sp. "L004"	2,267	<0.01
Hyphessobrycon amandae	150	<0.01	*Hypancistrus* sp. "L066"	233	<0.01
Hyphessobrycon bentosi	90,295	0.06	*Hypancistrus* sp. "L136"	1,825	<0.01
Hyphessobrycon copelandi	3,646	<0.01	*Hypancistrus* sp. "L260"	2,855	<0.01
Hyphessobrycon erythrostigma	100,153	0.07	*Hypancistrus* sp. "L262"	26	<0.01
Hyphessobrycon heterorhabdus	1,620	<0.01	*Hypancistrus* sp. "L333"	377	<0.01
Hyphessobrycon parvellus	150	<0.01	*Hypostomus cochiliodon*	1,209	<0.01
Hyphessobrycon pyrrhonotus	6,750	<0.01	*Hypostomus soniae*	60	<0.01
hyphessobrycon socolofi	200,469	0.14	*Hypostomus* sp.	16,770	0.01
Hyphessobrycon sp.	1,903,629	1.34	*Leporacanthicus galaxias*	2,639	<0.01
Hyphessobrycon takasei	160	<0.01	*Leporacanthicus heterodon*	16	<0.01
Inpaichthys kerri	880	<0.01	*Leporacanthicus joselimai*	11,459	0.01
Moenkhausia affinis	1,060	<0.01	*Loricaria lata*	169	<0.01
Moenkhausia colletii	13,005	0.01	*Megalancistrus barrae*	109	<0.01
Moenkhausia gracilima	550	<0.01	*Megalancistrus parananus*	181	<0.01
Moenkhausia hasemani	200	<0.01	*Oligancistrus punctatissimus*	15,295	0.01
Moenkhausia intermedia	3,022	<0.01	*Otocinclus affinis*	6,542,195	4.59
Moenkhausia lepidura	4,506	<0.01	*Otocinclus flexilis*	12,615	0.01
Moenkhausia oligolepis	164	<0.01	*Otocinclus hoppei*	4,011,196	2.81
Moenkhausia sanctaefilomenae	720	<0.01	*Otocinclus vittatus*	2,182,380	1.53
Paracheirodon axelrodi	92,050,816	64.57	*Panaque ambrusteri*	7,192	0.01
Paracheirodon simulans	10,708,387	7.51	*Panaque* sp. "L002"	6,887	<0.01
Petitella georgiae	21,150	0.01	*Panaque* sp. "L271"	3,498	<0.01
Prionobrama filigera	100	<0.01	*Panqolus* sp. "L271"	130	<0.01
Roeboides descalvadensis	19	<0.01	*Parancistrus aurantiacus*	6,111	<0.01
Serrapinnus notomelas	378	<0.01	*Parancistrus nudiventris*	130	<0.01
Thayeria boehlkei	50	<0.01	*Parotocinclus jumbo*	10,890	0.01
Tucanoicthys tucano	59,707	0.04	*Parotocinclus maculicauda*	58,476	0.04
Chilodontidae			*Peckoltia bachi*	3,167	<0.01
Chilodus punctatus	4,006	<0.01	*Peckoltia braueri*	10,738	0.01
Crenuchidae			*Peckoltia brevis*	1,256	<0.01
Ammocryptocharax elegans	2,600	<0.01	*Peckoltia compta*	2,415	<0.01
Characidium fasciatum	7,020	<0.01	*Peckoltia* spp.	173,824	0.12
Crenuchus spilurus	18,295	0.01	*Peckoltia vittata*	8,235	0.01

Table 1. Continued...

ORDER/Family/*Specie*	2006-2015*	%	ORDER/Family/*Specie*	2006-2015*	%
CHARACIFORMES (Cont.)			**SILURIFORMES** (Cont.)		
Odontocharacidium aphanes	20	<0.01	*Pseudacanthicus leopardus*	222,448	0.16
Poecilocharax weitzmani	510,147	0.36	*Pseudacanthicus* sp. "L024"	22	<0.01
Curimatidae			*Pseudacanthicus* sp. "L025"	312	<0.01
Curimata vittata	4	<0.01	*Pseudacanthicus* sp. "L097"	46	<0.01
Curimatopsis macrolepis	90	<0.01	*Pseudacanthicus* sp. "L185"	23	<0.01
Erythrinidae			*Pseudacanthicus* sp. "L273"	235	<0.01
Erythrinus erythrinus	48	<0.01	*Pseudacanthicus spinosus*	711	<0.01
Hoplias malabaricus	79	<0.01	*Pseudancistrus* sp. "L067"	108	<0.01
Gasteropelecidae			*Pseudancistrus* sp. "L259"	160	<0.01
Carnegiella marthae	167,959	0.12	*Pseudorinelepis genibarbis*	10,413	0.01
Carnegiella strigata	2,698,586	1.89	*Pterygoplichthys gibbiceps*	7	<0.01
Gasteropelecus sternicla	1,410	<0.01	*Rineloricaria castroi*	25	<0.01
Thoracocharax stellatus	140	<0.01	*Rineloricaria fallax*	2,290	<0.01
Hemiodontidae			*Rineloricaria formosa*	817	<0.01
Hemiodus gracilis	14,892	0.01	*Rineloricaria lanceolata*	375	<0.01
Iguanodectidae			*Rineloricaria lima*	111	<0.01
Bryconops caudomaculatus	4,565	<0.01	*Rineloricaria parva*	14,685	0.01
Bryconops melanurus	2,359	<0.01	*Scobiancistrus* sp. "L048"	485	<0.01
Iguanodectes adujai	320	<0.01	*Scobiancistrus* sp.	32,825	0.02
Iguanodectes gracilis	40	<0.01	*Scobinancistrus aureatus*	267	<0.01
Lebiasinidae			*Scobinancistrus pariolispos*	140	<0.01
Copeina guttata	71,542	0.05	*Spectracanthicus murinus*	256	<0.01
Copella arnoldi	70,111	0.05	*Sturisoma barbatum*	25	<0.01
Copella metae	350	<0.01	**Pimelodidae**		
Copella nattereri	5,470	<0.01	*Brachyplatystoma juruense*	28	<0.01
Nannostomus anduzei	24,561	0.02	*Brachyplatystoma tigrinum*	266	<0.01
Nannostomus beckfordi	2,000	<0.01	*Pimelodus maculatus*	150	<0.01
Nannostomus digrammus	3,510	<0.01	*Pimelodus pictus*	20	<0.01
Nannostomus eques	192,294	0.13	*Pseudoplatystoma corruscans*	24	<0.01
Nannostomus marginatus	902,720	0.63	*Pseudoplatystoma fasciatum*	230	<0.01
Nannostomus trifasciatus	410,739	0.29	**Pseudopimelodidae**		
Nannostomus unifasciatus	157,955	0.11	*Batrochoglanis raninus*	3,081	<0.01
Pyrrhulina brevis	75	<0.01	*Batrochoglanis villosus*	80	<0.01
Serrasalmidae			*Microglanis poecilus*	140	<0.01

Table 1. Continued...

ORDER/Family/*Specie*	2006-2015*	%	ORDER/Family/*Specie*	2006-2015*	%
CHARACIFORMES (Cont.)			**SILURIFORMES** (Cont.)		
Catoprion mento	573	<0.01	**Trichomycteridae**		
Metynnis fasciatus	587	<0.01	*Trichomycterus davisi*	1,514	<0.01
Metynnis hypsauchen	120	<0.01	**GYMNOTIFORMES**		
Metynnis mola	12	<0.01	**Apteronotidae**		
Myloplus rubripinnis	6,929	<0.01	*Apteronotus albifrons*	2,745	<0.01
Pristobrycon calmoni	557	<0.01	**Sternopygidae**		
Pygocentrus nattereri	11,284	0.01	*Eigenmannia sp.*	441	<0.01
Pygopristis denticulata	15	<0.01	**Hypopomidae**		
Serrasalmus eigenmanni	44	<0.01	*Steatogenys duidae*	20	<0.01
Serrasalmus hollandi	1,851	<0.01	**CYPRINODONTIFORMES**		
Serrasalmus rhombeus	190	<0.01	**Poeciliidae**		
Serrasalmus spilopleura	694	<0.01	*Fluviphylax pygmaeus*	200	<0.01
Triportheidae			*Poecilia reticulata*	40,375	0.03
Triportheus angulatus	1,000	<0.01	**Rivulidae**		
SILURIFORMES			*Pterolebias longipinnis*	188	<0.01
Aspredinidae			*Rivulus punctatus*	7,150	0.01
Bunocephalus amaurus	3,918	<0.01	*Rivulus urophthalmus*	8	<0.01
Bunocephalus coracoideus	37,319	0.03	**PLEURONECTIFORMES**		
Bunocephalus verrucosus	20	<0.01	**Achiridae**		
Platystacus cotylephorus	30	<0.01	*Hypoclinemus mentalis*	34	<0.01
Auchenipteridae			**CICHLIFORMES**		
Ageneiosus marmoratus	234	<0.01	**Cichlidae**		
Asterophysus batrachus	5	<0.01	*Acarichthys heckelii*	15,902	0.01
Liosomadoras oncinus	17,980	0.01	*Aequidens diadema*	100	<0.01
Tatia aulopygia	11,538	0.01	*Aequidens pallidus*	280	<0.01
Tatia brunnea	4,380	<0.01	*Aequidens tetramerus*	294	<0.01
Tatia intermedia	2,945	<0.01	*Apistogramma agassizii*	274,914	0.19
Trachelyopterichthys taeniatus	812	<0.01	*Apistogramma bitaeniata*	8,819	0.01
Callichthyidae			*Apistogramma borellii*	23,187	0.02
Aspidoras pauciradiatus	42,200	0.03	*Apistogramma cacatuoides*	430	<0.01
Aspidoras poecilus	58,324	0.04	*Apistogramma commbrae*	210	<0.01
Brochis britskii	14,368	0.01	*Apistogramma diplotaenia*	7,229	0.01
Brochis splendens	46,297	0.03	*Apistogramma elizabethae*	17,423	0.01
Callichthys callichthys	759	<0.01	*Apistogramma geisleri*	280	<0.01
Corydoras acrencis	390	<0.01	*Apistogramma gephyra*	3,962	<0.01
Corydoras acutus	6,979	<0.01	*Apistogramma gibbiceps*	1,040	<0.01
Corydoras adolfoi	613,556	0.43	*Apistogramma hippolytae*	170	<0.01
Corydoras aeneus	31,732	0.02	*Apistogramma meinkeni*	500	<0.01
Corydoras agassizii	872,174	0.61	*Apistogramma mendezi*	10,103	0.01
Corydoras amandajanea	1,060	<0.01	*Apistogramma paucisquamis*	7,035	<0.01
Corydoras ambiacus	3,402	<0.01	*Apistogramma personata*	60	<0.01
Corydoras araguaiaensis	101	<0.01	*Apistogramma pertensis*	26,499	0.02
Corydoras arcuatus	44,870	0.03	*Apistogramma pulchra*	2,098	<0.01

Table 1. Continued...

ORDER/Family/*Specie*	2006-2015*	%	ORDER/Family/*Specie*	2006-2015*	%
SILURIFORMES (Cont.)			**CICHLIFORMES** (Cont.)		
Corydoras blochi	1,740	<0.01	*Apistogramma regani*	542	<0.01
Corydoras burgessi	57,855	0.04	*Apistogramma taeniata*	80	<0.01
Corydoras caudimaculatus	64,163	0.05	*Apistogramma trifasciata*	434	<0.01
Corydoras cervinus	721	<0.01	*Apistogramma uaupesi*	1,490	<0.01
Corydoras cochui	172	<0.01	*Apistrogramma ortomanni*	50	<0.01
Corydoras crypticus	1,888	<0.01	*Astronotus crassipinnis*	4	<0.01
Corydoras davidsandsi	5,989	<0.01	*Astronotus ocellatus*	275	<0.01
Corydoras duplicareus	12,550	0.01	*Biotodoma cupido*	4,551	<0.01
Corydoras elegans	468,260	0.33	*Biotodoma wavrini*	96	<0.01
Corydoras ellisae	250	<0.01	*Biotoecus opercularis*	5,284	<0.01
Corydoras ephippifer	2,382	<0.01	*Bujurquina mariae*	383	<0.01
Corydoras eques	33,330	0.02	*Caquetaia spectabilis*	8	<0.01
Corydoras evelynae	14	<0.01	*Cichlasoma bimaculatum*	5	<0.01
Corydoras gossei	4,700	<0.01	*Cichlasoma portalegrense*	533	<0.01
Corydoras gracilis	246	<0.01	*Crenicara punctulatum*	93,080	0.07
Corydoras griseus	12,472	0.01	*Crenicichla alta*	8,256	0.01
Corydoras haraldschultzi	47,958	0.03	*Crenicichla johanna*	123	<0.01
Corydoras hastatus	752,285	0.53	*Crenicichla lenticulata*	1	<0.01
Corydoras imitador	5,964	<0.01	*Crenicichla lepidota*	7	<001
Corydoras imitator	3,135	<0.01	*Crenicichla lugubris*	291	<0.01
Corydoras incolicana	210	<0.01	*Crenicichla marmorata*	11	<0.01
Corydoras julii	679,601	0.48	*Crenicichla notophthalmus*	14,508	0.01
Corydoras kanei	38,688	0.03	*Crenicichla regani*	14,531	0.01
Corydoras leucomelas	68	<0.01	*Dicrossus filamentosus*	199,146	0.14
Corydoras maculifer	1,150	<0.01	*Dicrossus maculatus*	568,783	0.40
Corydoras melini	143,125	0.10	*Geophagus altifrons*	4,183	<0.01
Corydoras narcissus	7,180	0.01	*Geophagus megasema*	121	<0.01
Corydoras nattereri	15,792	0.01	*Geophagus proximus*	1,130	<0.01
Corydoras nijsseni	5,006	<0.01	*Guianacara dacrya*	70	<0.01
Corydoras ornatus	4,897	<0.01	*Heros efasciatus*	112	<0.01
Corydoras ourastigma	820	<0.01	*Heros severus*	418	<0.01
Corydoras paleatus	2,589	<0.01	*Hoplarchus psittacus*	2	<0.01
Corydoras parallelus	1,461	<0.01	*Hypselecara coryphaenoides*	40	<0.01
Corydoras pinheiroi	160	<0.01	*Hypselecara temporalis*	44	<0.01
Corydoras polystictus	6,268	<0.01	*Laetacara curviceps*	4,825	<0.01
Corydoras pulcher	28,852	0.02	*Laetacara dorsigera*	80	<0.01
Corydoras punctatus	722,199	0.51	*Mesonauta festivus*	4,916	<0.01
Corydoras pygmaeus	128,228	0.09	*Mesonauta insignis*	90	<0.01
Corydoras rabauti	8,010	0.01	*Nannacara adoketa*	7,805	0.01
Corydoras reticulatus	245,541	0.17	*Pterophyllum leopoldi*	2,690	<0.01
Corydoras robineae	125,844	0.09	*Pterophyllum scalare*	58,657	0.04
Corydoras robustus	18,498	0.01	*Retroculus lapidifer*	26	<0.01
Corydoras sarareensis	1,800	<0.01	*Satanoperca jurupari*	1,823	<0.01
Corydoras schwartzi	3,165,797	2.22	*Satanoperca lilith*	1,069	<0.01

Table 1. Continued...

ORDER/Family/*Specie*	2006-2015*	%	ORDER/Family/*Specie*	2006-2015*	%
SILURIFORMES (Cont.)			**CICHLIFORMES** (Cont.)		
Corydoras serratus	3,129	<0.01	*Symphysodon aequifasciatus*	225,139	0.16
Corydoras seussi	4,902	<0.01	*Symphysodon discus*	133,664	0.09
Corydoras similis	8,154	0.01	*Taeniacara candidi*	2,410	<0.01
Corydoras sodalist	22,515	0.02	*Teleocichla prionogenys*	90	<0.01
Corydoras sterbai	86,254	0.06	*Uaru amphiacanthoides*	3,898	<0.01
Corydoras tukano	5,520	<0.01	**Gobiidae**		
Corydoras xinguensis	800	<0.01	*Awaous flavus*	25	<0.01
Dianema longibarbis	7,828	0.01	**TETRAODONTIFORMES**		
Dianema urostriatum	140,128	0.10	**Tetraodontidae**		
Hoplosternum littorale	24w	<0.01	*Colomesus asellus*	4,085	<0.01
Scleromystax barbatus	3,976	<0.01	*Colomesus psittacus*	450	<0.01
Cetopsidae					
Helogenes marmoratus	480	<0.01			
375 species			**Total**	142,552,253	100

***Amblydoras hancockii = Platydoras hancockii*

The top eight exported species represented 90.1% of the total trade. These species were the *P. axelrodi* (64.6% of the total), followed by *P. simulans* (7.5%), *H. bleheri* (5.0%), *O. affinis* (4.6%), *O. hoppei* (2.8%), *C. schwartzi* (2.2%), *C. strigata* (1.9%) and *O. vittatus* (1.5%). The other 367 species represented 9.8% of the total exported (Table 1). Most species came from the Rio Negro (278 spp.) and were captured close to Barcelos and Santa Isabel do Rio Negro. Figure 1 shows some of the most exported fish.

The family Loricariidae was the family with most species exported (85 species and 1,396,457 specimens), followed by Cichlidae (71 species and 1,766,310 samples), Callichthyidae (69 species and 8,847,300 specimens) and Characidae (47 species and 112,433,421 specimens). The genera with the biggest abundance of species were *Corydoras,* with 60 species and 8,533,396 (6.0%) specimens, followed by *Apistogramma,* with 22 species and 386,555 specimens (0.2%), *Hyphessobrycon,* with 11 species and 2,307,342 specimens (1.6%) and *Hemigrammus,* with 10 species and 7,300,007 specimens (5.1%). Some genera had few species exported, like *Paracheirodon,* with two species and 102,759,203 specimens, *Otocinclus,* with 4 species and 12,748,386 specimens, *Carnegiella,* with two species and 2,866,545 specimens and *Nannostomus,* with 7 species and 1,693,779 specimens (Table 1).

The number of species exported jumped from 169 among 2002-2005 (Anjos et al., 2009a) to 375 species between 2006 and 2015. The majority of species exported (345 spp.) are listed in the list of allowed species to be commercialized (Brasil, 2012). However, 30 species exported were not on the list being declared just by the genera (8 species, *Ancistrus* spp., *Baryancistrus* sp., *Eigenmannia* sp., *Farlowella* sp., *Hyphessobrycon* sp., *Hypostomus* sp., *Peckoltia* spp. And *Scobiancistrus* sp.). These species together represented 2,635,430 fish. Another three species were commercialized as edible fish due to their size: *B. tigrinum*, *P. corruscans* and *P. fasciatum* they represented 520 specimens. There were another 19 species that could not have been exported since they are not in the list of allowed export fishes. These were: *A. adonis*, *A. hystrix*, *A. hancockii*, *A. ortmanni*, *B. amaurus*, *C. metae*, *C. punctatus*, *G. sternicla*, *G. dacrya*, *M. parananus*, *M. affinis*, *O. flexilis*, *P. jumbo*, *P. maculicauda*, *P. longipinnis*, *R. lima*, *R. punctatus*, *R. urophthalmus*, *S. maxillosus* and *T. aulopygia* (Table 1).

The species *P. reticulata* found on the export list has natural occurrence in Venezuela and the Caribbean, however, this species is highly spread in the aquaculture circles with easy reproduction in captivity.

Six species of freshwater stingray were exported (Myliobatiformes). These species were: *P.* cf. *henlei*, *P.* cf. *histrix*, *P. leopoldi*, *P. motoro*, *P. orbignyi*, *P. schroederi*. These species are found in the CITES appendix III as species with a population status of protected species (www.cites.org).

There were 18 species that were possibly new species. They were members of the Loricariidae Family described with an "L" code as known internationally (Schraml and Schäfer, 2004; 2020), and exported according to list number 001 from 2012 (Brasil, 2012). Some of these species are *Ancistrus* sp. "L255", *Baryancistrus* sp. "L142", *Hypancistrus* sp. "L004", *Hypancistrus* sp. "L066", *Hypancistrus* sp. "L136", *Hypancistrus* sp. "L260", *Hypancistrus* sp. "L262", *Hypancistrus* sp. "L333", *Panaque* sp. "L002", *Panaque* sp. "L271", *Pseudacanthicus* sp. "L024", *Pseudacanthicus* sp. "L025", *Pseudacanthicus* sp. "L097", *Pseudacanthicus* sp. "L185" *Pseudacanthicus* sp. "L273, *Pseudancistrus* sp. "L067", *Pseudancistrus* sp. "L259" and *Scobiancistrus* "L048" (Table 1).

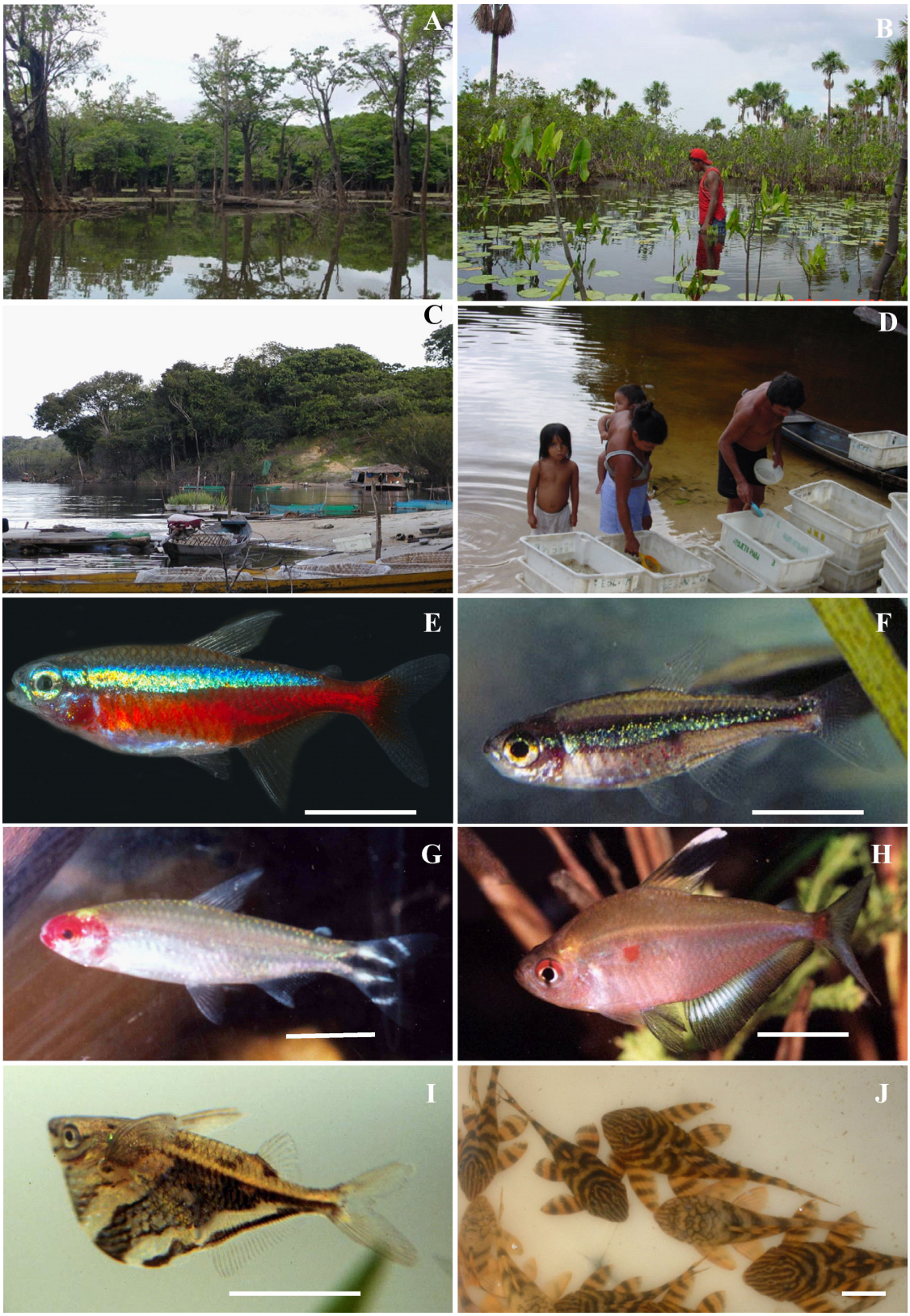

Figure 1. Rio Negro fishing grounds, flooded forests ("igapó") (A), interfluvial swamps (B), fisherman community at Rio Jufari with fishing utensils (C), fisherman "piabeiro" family selecting fish for sale (D), *Paracheirodon axelrodi* (E), *P. simulans* (F), *Hemigrammus bleheri* (G), *Hyphessobrycon erytrostigma* (H), *Carnegiella strigata* (I) and *Peckoltia* spp. (J). (Photos credits: B, F, G, H and I -Project Piaba/Ning Labbish Chao; E – Douglas Bastos). bar = 1 cm

Finally, six Loricariidae species exported out of Amazonas State are listed in the red list of species in danger of extinction (ICMBIO, 2016). Among them *H. tricornis* (30 specimens), *L. joselimai* (11,459 specimens), *P. nudiventris* (130 specimens), *P. compta* (2,415 specimens), *S. auratus* (267 specimens) and *S. pariolispos* (140 specimens) (Table 1).

Export rate and commercial values

A total of 142.5 million ornamental fish were sold between January 2006 and July 2015, generating a total of US$ 23,001,366 (Table 2). On average, 14.2 million fish were exported per year with an average annual revenue of US$ 2.3 million (Table 2). However, after analyses a sharp market decline is observed in recent years (Table 2; Figure 2A). During 2006, 26 million specimens generating US$ 3 million were exported. In 2014, there was a 75% drop in revenue from ornamental fish exports (Table 2; Figure 2A). The numbers continue to plummet and during 2015 fishing season (January to July) it was seen an even sharper drop (Figure 2B). The main specie exported, *P. axelrodi*, also saw a drop in sales. In 2006, 17.9 million of specimens were exported, and in 2014 only four million specimens were exported (Table 2). However, this is the main species exported out of Amazon state representing 61% (± 5,8) of the total (Table 2).

In 2006 to 2008, even with a decrease in exports, the revenue received for the trade increased 21.7% in 2006 and 28.3% in 2008. After 2008 sales dropped more than 50% when compared with the numbers of 2006 (Table 2; Figure 2A).

The months between August and December were when exporters received the largest number of orders (Figure 2B). Sales started to drop in January and strongly decreased by July. The revenue received followed similar patterns, with November being the strongest month. From April to September we had the lowest values received (Figure 2C).

Import countries

Between the years of 2006 and July 2015, a total of 35 countries imported fish from the Amazonas State (Table 3). Europe was the continent that imported the most, with 20 receiving countries, a total of 62,172,860 fish imported and total revenue of US$ 6,494,510 (Table 3). Asia was the second largest importer, with 10 receiving countries, 53,622,229 fish bought generating US$ 12,704,138 in revenue. North America followed Asia as an importer, with two receiving countries, 24,320,417 fish bought generating US$ 3,462,163. South America had two receiving countries (Argentina and Chile), buying 1,881,931 fish and generating US$ 207,623 in revenue. Africa had one buying country, 554,266 fish exported generated US$ 106,132 (Table 3).

Germany was the country that imported the largest fish quantities (38,9 million fish), followed by Taipei (27,2 million), USA (23,8 million) and Japan (17,6 million). These four countries imported 75.5% of all the fish that left the Amazonas state. However, revenue wise, Taipei presented the most value (US$ 5.99 million), followed by Japan (US$ 4.64 million), Germany (US$ 3.68 million), USA (US$ 3.34 million) and Hong Kong (US$ 1.26 million). These five countries accounted for 82.3% of all sales during these ten years reported here (US$ 18.9 million), except 2015 with data from January to July (Table 3).

DISCUSSION

This study has shown that the Amazonas State contributes with the selling species traded as ornamental fish for many countries, including mainly European Union, Southeast Asia and North America. The species of the Amazon commercialized out of the region are also bred in captivity (Chapman, 2000; Livengood and Chapman, 2020). Among fifty the species with the highest demand worldwide, five are native from the Amazon, most come of the Southeast Asian farms: *P. innesi* (Characidae), *A. ocellatus*,

Table 2. Total of fish exported and revenue received in US$ for all species and *Paracheirodon axeroldi* (cardinal) in specific, and total of the species exported from 2006 and July 2015 (2015* = database of Jan-Jul).

Year	Total exported	Total value (US$)	Cardinal	% of Cardinal	Number of species exported
2006	26,075,241	2,988,054.01	17,960,454	**68.88**	**128**
2007	25,254,409	3,639,030.85	17,799,730	**70.48**	**136**
2008	22,964,298	3,835,371.71	15,231,405	**66.33**	**145**
2009	18,996,682	2,547,642.72	12,190,095	**64.17**	**138**
2010	14,751,626	2,418,551.74	9,316,640	**63.16**	**111**
2011	10,157,867	1,802,769.58	5,344,893	**52.62**	**118**
2012	7,023,059	1,678,821.32	4,028,417	**57.36**	**194**
2013	8,070,257	1,472,788.42	4,660,480	**57.75**	**186**
2014	6,528,968	1,675,666.09	3,984,543	**61.03**	**220**
2015*	2,729,846*	942,670.54*	1,534,159*	**56.20***	**200***

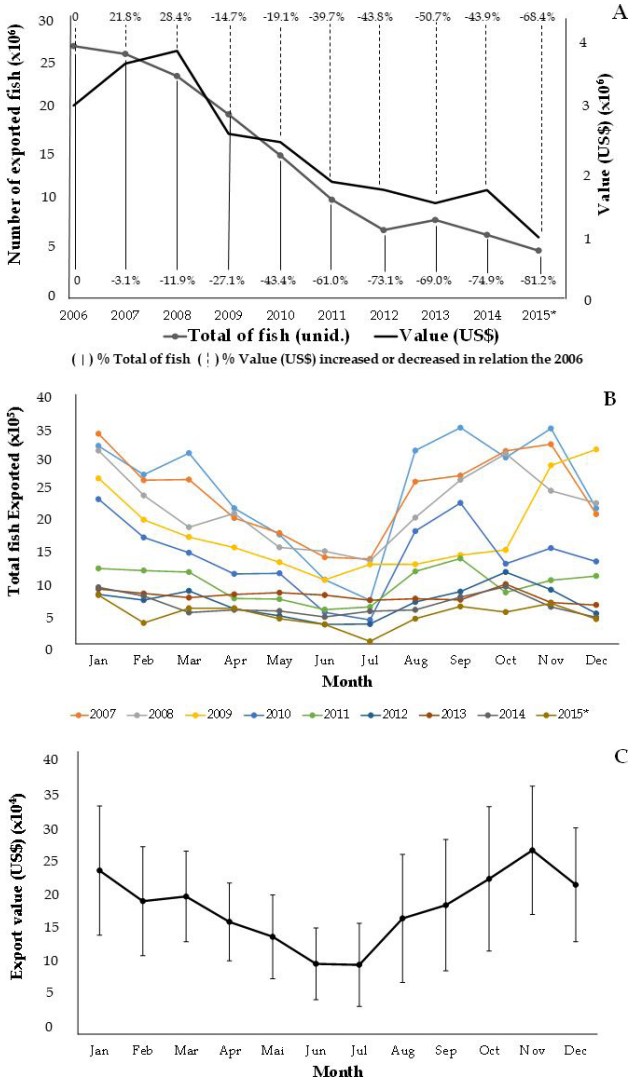

Figure 2. (A) Total exported and revenue received annually, and % of the increased or decreased is relation the 2006; (B) Monthly variation of amount exported yearly (C) average and standard deviation of revenue received monthly between 2006 and July 2015. Data from IBAMA (2006 to 2015* - *database of Jan-Jul).

P. scalare, *S. aequifasciatus* and *Symphysodon discus* (Cichlidae) (Chapman, 2000; Monticini, 2010). Currently the number of fish capture from nature is very small capture with the numbers sold out at the Southeast Asia (Anjos et al., 2009a).

It is believed that the number of species sold as ornamental fish is greater than the 375 species reported due to many are exported only by the genera: *Ancistrus* spp., *Baryancistrus* sp., *Eigenmannia* sp., *Farlowella* sp., *Hyphessobrycon* sp., *Hypostomus* sp., *Peckoltia* spp. and *Scobiancistrus* sp. most of these species belong to the Loricariidae Family and they have complex taxonomical classification. Studies carried revealed that exporters in Peru reported exports of 248 species, and in reality this number was 704 species (Moreau and Coomes, 2007).

Table 3. Import countries and amounts exported and monetary value received since 2006 to 2015*. (2015* = database of Jan-Jul).

Country	Quantity	%	Total value (US$)	%
Germany	38,891,521	27.28	3,682,973.15	16.01
Taipei	27,279,318	19.14	5,991,318.51	26.05
United States	23,868,660	16.74	3,342,063.34	14.53
Japan	17,674,694	12.40	4,643,677.44	20.19
Hong Kong	4,994,653	3.50	1,266,474.86	5.51
UK	4,238,862	2.97	582,243.90	2.53
Denmark	4,227,542	2.97	296,588.55	1.29
France	3,490,663	2.45	446,575.14	1.94
Nederland's	3,487,503	2.45	370,459.41	1.61
Sweden	2,092,831	1.47	188,112.12	0.82
Belgium	1,994,824	1.40	293,591.63	1.28
Argentina	1,716,857	1.20	187,059.40	0.81
South Korea	1,309,535	0.92	187,975.72	0.82
Singapore	1,137,688	0.80	152,336.78	0.66
Spain	905,899	0.64	101,025.18	0.44
China	887,754	0.62	388,519.84	1.69
Poland	722,387	0.51	188,005.69	0.82
Portugal	627,839	0.44	67,234.66	0.29
South Africa	554,266	0.39	106,132.00	0.46
Switzerland	456,048	0.32	56,969.21	0.25
Canada	451,757	0.32	120,100.00	0.52
Israel	266,881	0.19	42,964.48	0.19
Italy	232,467	0.16	41,485.18	0.18
Norway	205,490	0.14	63,629.55	0.28
Chile	165,074	0.12	20,563.86	0.09
Austria	163,375	0.11	26,845.55	0.12
Finland	161,574	0.11	41,288.41	0.18
Czech Republic	159,693	0.11	25,652.69	0.11
Greece	92,358	0.06	7,110.13	0.03
Thailand	53,888	0.04	25,045.95	0.11
Malaysia	17,518	0.01	3,832.00	0.02
Estonia	12,112	0.01	3,645.70	0.02
Hungry	6,492	<0.01	10,874.00	0.05
Bulgaria	3,380	<0.01	200.50	<0.01
N. Korea	300	<0.01	1,992.00	0.01
Unidentified	550	<0.01	26,800.45	0.12
Total	**142,552,253**	**100.0**	**23,001,366.98**	**100.0**

It was seen during the study that even with the decrease in sales, the number of species exported increased to 375 species between 2006 to 2015. Anjos et al. (2009a) reported that 169 species were exported between 2002 to 2005. This demonstrates that the market wanted different fish species, even with the decrease in exports. Even with the decrease between 2006 and 2015, *P.*

axelrodi continued to be the most exported species in all these years. *Paracheirodon axelrodi* apparently it is difficult to induce its reproduction in captivity (Anjos and Anjos, 2006) - compared with to the *Paracheirodon innesi* (neon tetra) that is easily reproduced (Chapman et al., 1997, 1998; Sanage et al., 2008; Kucharczyk et al., 2010), this difficult breeding in captivity, probably helps to keep exports of this species in high demand. The total valued received by the exported fish increased from 2006, when the price of cardinal tetra was US$ 0.11, to 2014, when the price was US$ 0.25, representing an increase of 120.0%. The period of lower activity is during the European summer when many families travel and do not buy pets. This period coincides with the wet season when it is hard to catch ornamental fish and they reproduce in large part of the Amazon. During the wet season, the exporters themselves proposed in 1992 that IBAMA create a law prohibiting fishing to allow species to reproduce (IBAMA, 1992).

From the 375 species exported, 28 not on the list of allowed species for commercialization (Brasil, 2012). Three did not occur in Brazil, *Apistrogramma ortmanni* (Essequibo River/Guiana), *Corydoras punctatus* (Suriname) and *Copella metae* (Meta River – Orinoco). Another five species are from other regions in Brazil. These were: *Megalancistrus parananus* (Paraná/Paraguay basin), *Otocinclus flexilis* (Rio Grande do Sul), *Parotocinclus jumbo* (small rivers in Ceará, Paraíba and Alagoas states), *Parotocinclus maculicauda* (small creeks in Espirito Santo and Santa Catarina) and *Acanthicus adonis* (Tocantins river). These species may have arrived at the export companies for increased demand from importer countries.

Among stingray species (Myliobatiformes), although on the CITES list (as endangered) are exported out of Amazonas and Pará states every year based on a quota established by the IBAMA authorities (IBAMA, 2013).

Six Loricariidae species exported out of Amazonas State are listed in the red list of species in danger of extinction (ICMBIO, 2016). Among them *Hopliancistrus tricornis*, *Leporacanthicus joselimai*, *Parancistrus nudiventris*, *Peckoltia compta*, *Scobinancistrus auratus* and *Scobinancistrus pariolispos*. Brazilian authorities should remove these species from the list of allowed species to be exported based on the 2016 red list published by the same institution (Brasil, 2012; ICMBIO, 2016).

The fall of exports of ornamental fishes

During 2008 there was an abrupt drop in sales of ornamental fish worldwide (Monticini, 2010) and the Amazonas State sales were also affected. Benzaken et al. (2015) explained this drop in sales as a consequence of the 2008 international economic crisis where the world economy collapsed, with steep drops of stock markets worldwide, devaluation of housing assets and economic recession.

Another factor that contributed to this decrease in sales was the closure of the biggest fish export company in the Amazonas State that represented 51% of the market (Anjos et al., 2009a). The 2008 economic crisis made the market non-viable for a big company with high costs (Benzaken et al., 2015). The closure of this company was followed by other smaller companies that could not keep up with the loss in revenues (H. Beltrão, personal observation). Benzaken et al. (2015) also points out the unfavorable exchange rate before 2008 - at R$ 1.5 to the dollar - high prices of freight (from Manaus to other locations in the world), customs bureaucracy, a small list of species allowed to be exported and competition with Southeast Asia producers as main factors leading to the drop in sales. Piabeiros (fishermen) were discontent with the price received mainly for cardinal sold. A large part of the fishermen gave up the profession because of the remuneration (Anjos et al., 2009b). Another reason for the down fall of the trade consists that our neighboring countries (Peru and Colombia) also export a significant number of ornamental species from the Amazon biome, without bureaucratic problems and without restriction list of exported species (Moreau and Coomes, 2007; Mancera-Rodríguez and Álvarez-León, 2008). On top of that they have a much lower air freight cost.

Fortunately, recently published legislation No. 10 of April 2020 (Brasil, 2020) releases a larger number of species for ornamental purposes, except those on the list of endangered species in Brazil (ICMBIO, 2016) and species that are on the CITES list.

The current market for ornamental fish from the Amazonas State

There is a historical tradition in Brazil and more exclusively in the Amazonas State to export ornamental fishes to Europe and North America (Falabela, 1985; Leite and Zuanon, 1991; Chao et al., 2001; Anjos et al., 2009a; Benzaken et al., 2015). Europe continues to be the biggest buyer representing 43.6% of the total fish exported (2010-2015), but they represented 58% between 2002 and 2005 (Anjos et al., 2009a) and 52.3% in 1983 (Falabela, 1985). The Asian continent has been buying increasingly more. In 1983 Asia represented 0.9% of the exports of Amazonas State (Falabela, 1985), 20 years latter (2002-2003), the continent was the destination for 26% of exports (Anjos et al., 2009a). Currently, Asia represents 37.6% of the exports (2006-2015). These increases show that Asia substituted Europe in the pet trade with the rise of the Chinese economy. Germany is still the biggest importer followed by Taipei, USA and Japan. Prang (2007) and Andrews (1990) reported that Europe bought 40% of the exports from the Amazon Region, indicating that this reduction was due to stronger competition from fish bred in Asia (Taipei, Thailand, Indonesia and Hong Kong) which also export many species from the Negro River.

CONCLUSION

In conclusion, the quantity of the ornamental fish exported from the State of Amazonas have decreased in the last ten years (2006-2015) and should be monitored more carefully. The monitoring ornamental fish exports over the years can help redefining public policies that focused on “piabeiros” and protect stocks of commercially exploited ornamental species by updating threatened species lists. In this sense, we believe that the export number of ornamental fish out of the Amazonas State will continue low and will concentrate on species that are not reproduced in big quantities in captivity (for example, *Paracheirodon axelrodi*, *P. simulans* and *Hemigrammus bleheri*) in order to improve the genetics of the stock reproduced in captivity. New described

species can also help maintain export numbers. Finally, we do not see the ornamental fish export of the Amazonas State going back to the glamorous years during the 70s, 80s, and 90s. We believe that these exports remaining with low quantity to the sole purpose of genetic improvement of stocks in other regions of the planet, since many native ornamental fish species of the Amazon are already reproduced largely in captivity mainly in Southeast Asia, European Union and USA.

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