Trabajo

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Herpeto-commerce: A look at the illegal online trade of amphibians and reptiles in Brazil

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ABSTRACT
The illegal sale of fauna and flora represents the third-largest illegal trade in the world. Social media has contributed considerably to the increase in this type of trade. We searched for posts announcing the sale of amphibians and reptiles in seven Facebook® groups (three public and four private groups) from 01 January 2019 to 31 July 2020. In total, we found 548 posts made by a total of 201 social network profiles announcing the sale of 1,049 animals. We found 58 herpetofauna species being traded in the network (15 amphibian and 43 reptile species). Most of the sale advertisements originated in Southeast Brazil, predominantly from the state of São Paulo. The most traded species were *Pantherophis guttatus* (N= 467), *Eublepharis macularius* (N= 152), and *Boa constrictor* (N=90). This study presents important data about the illegal herpetofauna trade through Facebook® in Brazil, proving this market is currently fully active. This trade has high growth potential, bringing possible risks to biodiversity and public health. In conclusion, we recommend the implementation of urgent, specific government measures for its regulation and effective inspection.

Key words: Herpetofauna; E-commerce; Animal Trafficking; Pet-trade; Facebook®.

RESUMO
A venda ilegal de fauna e flora representa o terceiro maior comércio ilegal do mundo. As redes sociais têm contribuído consideravelmente para o aumento deste tipo de comércio. Buscamos postagens anunciando a venda de anfíbios e répteis em sete grupos do Facebook® (três grupos públicos e quatro privados) de 01 de janeiro de 2019 a 31 de julho de 2020. No total, encontramos 548 postagens feitas por um total de 201 perfis de redes sociais anunciando a venda de 1.049 animais. Encontramos 58 espécies de herpetofauna sendo comercializadas na rede (15 espécies de anfíbios e 43 espécies de répteis). A maior parte dos anúncios de venda teve origem no Sudeste do Brasil, predominantemente no estado de São Paulo. As espécies mais comercializadas foram *Pantherophis guttatus* (N= 467), *Eublepharis macularius* (N= 152) e *Boa constrictor* (N=90). Este estudo apresenta dados importantes sobre o comércio ilegal de herpetofauna através do Facebook® no Brasil, comprovando que este mercado está atualmente em plena atividade. Esse comércio tem alto potencial de crescimento, trazendo possíveis riscos à biodiversidade e à saúde pública. Em conclusão, recomendamos a implementação de medidas governamentais urgentes e específicas para sua regulamentação e fiscalização efetiva.

Palavras-chave: Herpetofauna; E-commerce; Tráfico de Animais; Comércio Pet; Facebook®.

Introduction

Brazil is the most biodiverse country in the world, with approximately 117 thousand known animal species and around 50 thousand known plant species, showing a high rate of endemic species (Flora Brasileira, 2020; ICMBio, 2020; Charity and Ferreira, 2020). This large number of species makes

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the country a target for intense smuggling of wild species, one of the primary causes of local extinction, along with deforestation, farming activities, and urbanization processes (Hernandez and Carvalho, 2006; Heliodoro, 2009; RENCTAS, 2016). The illegal wildlife trade is responsible for spreading diseases and introducing exotic species, jeopardizing structured communities (Warchol, 2004; Carrete and Tella, 2008; Karesh *et al.*, 2012). This trade is also related to the considerable increase in violence and corruption rates (Warchol, 2004).

In Brazil, the institution responsible for dealing with animal trade is IBAMA (Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis). This institute is also responsible for the supervision and enforcement of the legal purposes, while other agencies have scientific competence on the subject, such as RAN/ICMBio (Centro Nacional de Pesquisa e Conservação de Répteis e Anfíbios), responsible for the herpetofauna (RENCTAS, 2001). The legal definition of the act of illegal trade, described under article 29, section 1, III of Law nº. 9,605/98, which includes in all respects: " Those who sell, exposes for sale, exports or acquires, retains, keeps in captivity or storage, uses or transports eggs, larvae, wild or native species, or in migratory route, as well as products and objects originating from such species, from breeding sites that are not authorized, without proper permit, competent authority or authorization."

Despite the legislation, the wild fauna trade from irregular breedings sites or specimens caught in nature, is still widely practiced in the country (Charity and Ferreira, 2020). The lack of investigation efforts is one of the reasons why this trade still occurs. E-commerce has been neglected, and the trafficking structure seems to benefit from online spaces that are lawless. Animal trafficking seems increasingly interconnected to the online network, which results in higher successes in sales that use these new means and make online supervision difficult (Hernandez and Carvalho, 2006; Siriwat and Nijman, 2018).

Globally, the acquisition of wild animals as pets through the internet has grown over the last several years due to the emergence of websites and social network groups specifically focused on the subject (Jansen *et al.*, 2018; Sy, 2018; Marshall *et al.*, 2020; Strine and Hughes, 2020). In most cases, sale advertisements through social networks have questionable origins (Magalhães and São-Pedro, 2012). Araújo (2014) and Auliya *et al.* (2016a) highlight the sale of amphibians and reptiles (herpetofauna) in this market. The authors also state that these animals are targeted due to the great variety of species, availability of individuals, and fewer care requirements when compared to mammals and birds.

Although the diversity of amphibians and reptiles is high, few species are legally regulated to be traded. According to data published in 2016, out of 10,272 species of reptiles, less than 8% are regulated by the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and by the European Wildlife Trade Regulations (EWTR) (Auliya *et al.*, 2016a). For amphibians, less than 3% of recognized species are listed in the three appendices of CITES (Auliya *et al.*, 2016b).

In most cases, the trade of these species jeopardizes their conservation, putting them in endangered or vulnerable statuses. The IUCN Red List of Threatened Species presents more than two thousand species of reptiles as threatened under the category "Biological resource use". This is the third largest threat category for this group, where 769 species are intentionally targeted by collectors for hunting and capture (IUCN, 2022). Over 290 amphibian species from the IUCN Red List are targeted for international pet trade and consumption purposes (Auliya *et al.*, 2016b).

This study aims to shine a light on illegal herpetofauna e-commerce due to the growing popularity of social networks in the last years and their increased use as a platform for worldwide illegal wildlife trading. Here, we collected quali-quantitative data from Brazilian public and private groups on the social network Facebook®, specifically created to sell or exchange herpetofauna individuals throughout the country.

Materials and methods

We searched for Brazilian groups on the social network Facebook® applying the following keywords in Brazilian Portuguese: "anfíbios", "répteis", "animais exóticos", "compra e venda de exóticos", "*pets* exóticos", "répteis e anfíbios" and "répteis e anfíbios venda" (English keywords: "amphibians", "reptiles", "exotic animals", "exotic marketing", "exotic pets", "reptiles and amphibians", and "reptiles and amphibians for sale"). We selected the first 15 groups we found online and got access to seven (four private and three public) that became the object of our research. We verified the number of members of each

group, the date they were founded, and number of advertisements (see 'Information from analyzed Facebook® groups' in Appendix S1, Supplementary information).

The research consisted of analyzing all posts between 01 January 2019 and 31 July 2020. We recorded the advertisements related to the sale of amphibian and reptile species, listing the total number of posts and traded animals. The names of the groups and their members will be kept confidential for legal reasons and to avoid higher visibility of the groups, following orientation from the Association of Internet Researchers Committee (Franzke *et al.*, 2020).

We recognized the species mainly through images as well as scientific or popular names mentioned in the posts. We discarded posts that did not have pictures or any other means that would allow us to identify the advertised species correctly. We based the identification of individuals (to species level when possible) on specialized literature. From posts that did not have pictures, we considered the scientific name mentioned and current nomenclature. The nomenclature and taxonomic classification for species of reptiles were based on Uetz *et al.* (2022), and Frost (2021) for amphibians. We classified the species as native from the Brazilian fauna or exotic (non-native), following the lists of Brazilian reptiles (Costa and Bérnils, 2018) and amphibians (Segalla *et al.*, 2021).

We investigated if the species found were included in the appendices of CITES (2021). The threat level for each species was verified in the Brazil Red Book of Threatened Species of Fauna (ICMBio, 2018) and the Red List of the International Union for Conservation of Nature (IUCN, 2022). We analyzed the frequency and location of each advertisement. Therefore, it was possible to understand which Brazilian regions contribute the most to this animal trade.

Results

During the 19 months of sampling, we list a total of 548 posts advertising animals for sale made by 201 Facebook® profiles. In total, 1,049 individuals of herpetofauna were commercialized. We recorded the sale of 58 species (Table 1), belonging to five orders: Anura (37 individuals from 12 species), Caudata (ten individuals from three species), Crocodylia (six individuals from one species), Squamata (Snakes: 815 individuals from 23 species; Lizards: 115 individuals from nine species) and Testudines (66 individuals from ten species) (Fig. 1). Between the groups we analyzed, two of them concentrated the majority of posts, with 218 and 186 on each one, with a total of 798 traded animals (see 'Information from analyzed Facebook® groups ' in Appendix S1, Supplementary information).

Thirteen individuals could not be identified to species level, belonging to the genera *Ceratophrys* sp., *Chelonoidis* sp., and *Pantherophis* sp. We added these species to Table 1; their conservation status was not specified, and their classification as native or exotic was not described for the first two species. The snake genus *Pantherophis* does not occur in Brazil, so we considered it an exotic species.

All analyzed posts refer to traded animals in Brazilian territory. Most animals were being traded in the state of São Paulo (n=506), followed by the state of Rio de Janeiro (n=82) and Distrito Federal (n=42) (Fig. 2). Most of the advertisements are concentrated in the southeast region. We could not verify the trading location of 358 announced individuals due to the information not being described in the posts.

Four announced species (*Caiman latirostris*, *Acrantophis dumerili, Acrantophis madagascariensis*, and *Python molurus*) are listed in Appendix I of CITES (2021), which are species not allowed to be internationally traded due to being endangered. We found twenty-one species in Appendix II, that described species likely to become endangered in the future. In addition, a special license is required for their trade. Only one species (*Crotalus durissus*) is listed in Appendix III, included after a direct request from Honduras. This appendix lists species that need international control, so their exploitation is either restricted or prevented. Half of the species (n=29) do not appear on the CITES list (Table 1).

Concerning the species threat level, only 49 were assessed by IUCN Red List of Threatened Species (2022), four species listed as Vulnerable (VU) (*Podocnemis unifilis*, *Chelonoidis denticulatus*, *Correlophus ciliatus*, *Python bivittatus*), one listed as Critically Endangered (CR) (*Ambystoma mexicanum*), and two listed as Near Threatened (NT) (*Python molurus* and *P. regius*). Regarding the threat level in national scope, out of 28 native Brazilian species announced, only *Ranitomeya ventrimaculata* is not on the list. Twenty-four species are classified as Least Concern (LC), and three other species (*Trachemys dorbigni, Podocnemis expansa*, and *Podocnemis uni-*

Table 1. List of reptile and amphibian species traded in Brazil through Facebook® groups from 01 January 2019 until 31 July 2020.

ORDER/FAMILY/SPECIES	Nº of Individuals	CITES (2021)	Conservation Status		Native or exotic
			IUCN Red List (2022)	Red Book ICMBio (2018)	
ANURA					
AMPHIBIA					
Bombinatoridae					
Bombina orientalis (Boulenger, 1890)	3	-	LC	-	EX
Brachycephalidae					
Brachycephalus ephippium (Spix, 1824)	5	-	LC	LC	NA
Ceratophryidae					
Ceratophrys aurita (Raddi, 1823)	1	-	LC	LC	NA
Ceratophrys sp. (Wied-Neuwied, 1824)	1	-	-	-	-
Dendrobatidae					
Adelphobates galactonotus (Steindachner, 1864)	6	II	LC	LC	NA
Dendrobates tinctorius (Cuvier, 1797)	2	II	LC	LC	NA
Ranitomeya ventrimaculata (Shreve, 1935)	2	II	LC	-	EX
Hylidae					
Dendropsophus minutus (Peters, 1872)	2	-	LC	LC	NA
Phyllomedusidae					
Pithecopus azureus (Cope, 1862)	7	-	DD	LC	NA
Pithecopus nordestinus (Caramaschi, 2006)	1	-	DD	LC	NA
Pipidae					
Xenopus laevis (Daudin, 1802)	5	-	LC	-	EX
Ranidae					
Lithobates catesbeianus (Shaw, 1802)	2	-	LC	-	EX/invasive species
CAUDATA					
Ambystomatidae					
Ambystoma mexicanum (Shaw & Nodder, 1798)	4	II	CR	-	EX
Salamandridae					
Pleurodeles waltl Michahelles, 1830	4	-	NT	-	EX
Triturus cristatus (Laurenti, 1768)	2	-	LC	-	EX
REPTILIA					
CROCODYLIA					
Alligatoridae					
Caiman latirostris (Daudin, 1802)	6	I	LC	LC	NA
TESTUDINES					
Chelidae					
Hydromedusa tectifera Cope, 1870	1	-	-	LC	NA
Mesoclemmys gibba (Schweigger, 1812)	2	-	-	LC	NA
Mesoclemmys tuberculata (Luederwaldt, 1926)	4	-	-	LC	NA
Emydidae					
Trachemys dorbigni (Duméril & Bibron, 1835)	20	-	-	NT	NA
Geoemydidae					

Rhinoclemmys punctularia (Daudin 1801)	1	-	-	LC	NA
Podocnemididae					
Podocnemis expansa (Schweigger, 1812)	2	II	CD	NT	NA
Podocnemis unifilis Troschel, 1848	2	II	VU	NT	NA
Testudinidae					
Chelonoidis carbonarius (Spix, 1824)	11	II	-	LC	NA
Chelonoidis denticulatus (Linnaeus, 1766)	12	II	VU	LC	NA
Chelonoidis sp.	11	-	-	-	-
SQUAMATA					
Agamidae					
Pogona vitticeps (Ahl, 1926)	33	-	LC	-	EX
Diplodactylidae					
Correlophus ciliatus Guichenot, 1866	6	-	VU	-	EX
Rhacodactylus leachianus (Cuvier, 1829)	1	-	LC	-	EX
Eublepharidae					
Eublepharis macularius (Blyth, 1854)	152	-	LC	-	EX
Iguanidae					
Iguana iguana (Linnaeus, 1758)	49	II	LC	LC	NA
Polychrotidae					
Polychrus acutirostris Spix, 1825	7	-	LC	LC	NA
Polychrus marmoratus (Linnaeus, 1758)	1	-	LC	LC	NA
Teiidae					
Salvator merianae Duméril & Bibron, 1839	16	II	LC	LC	NA
Varanidae					
Varanus exanthematicus (Bosc, 1792)	1	II	LC	-	EX
Boidae					
Acrantophis dumerili Jan, 1860	2	I	LC	-	EX
Acrantophis madagascariensis (Duméril & Bibron, 1844)	2	I	LC	-	EX
Boa constrictor Linnaeus, 1758	90	II	LC	LC	NA
Boa imperator Daudin, 1803	1	II	LC	-	EX
Corallus hortulana (Linnaeus, 1758)	2	II	LC	LC	NA
Epicrates assisi Machado, 1945	5	II	LC	LC	NA
Eryx colubrinus (Linnaeus, 1758)	12	II	LC	-	EX
Eunectes murinus (Linnaeus, 1758)	3	II	LC	LC	NA
Colubridae					
Heterodon nasicus Baird & Girard, 1852	3	-	LC	-	EX
Lampropeltis getula (Linnaeus, 1766)	19	-	LC	-	EX
Lampropeltis californiae (Blainville, 1835)	7	-	LC	-	EX
Lampropeltis polyzona Cope, 1860	6	-	LC	-	EX
Pantherophis guttatus (Linnaeus, 1766)	467	-	LC	-	EX
Pantherophis obsoletus (Say, 1823)	3	-	LC	-	EX
Pantherophis sp.	1	-	-	-	-
Pituophis catenifer (Blainville, 1835)	1	-	LC	-	EX
Xenodon merremii (Wagler, 1824)	1	-	LC	LC	NA
Pythonidae					

Antaresia maculosa (Peters, 1873)	2	II	LC	-	EX
Morelia spilota (Lacépède, 1804)	2	II	LC	-	EX
Python bivittatus Kuhl, 1820	5	II	VU	-	EX
Python molurus (Linnaeus, 1758)	5	I	NT	-	EX
Python regius (Shaw, 1802)	23	II	NT	-	EX
Viperidae					
Crotalus durissus Linnaeus, 1758	2	III	LC	LC	NA
Total	1049				

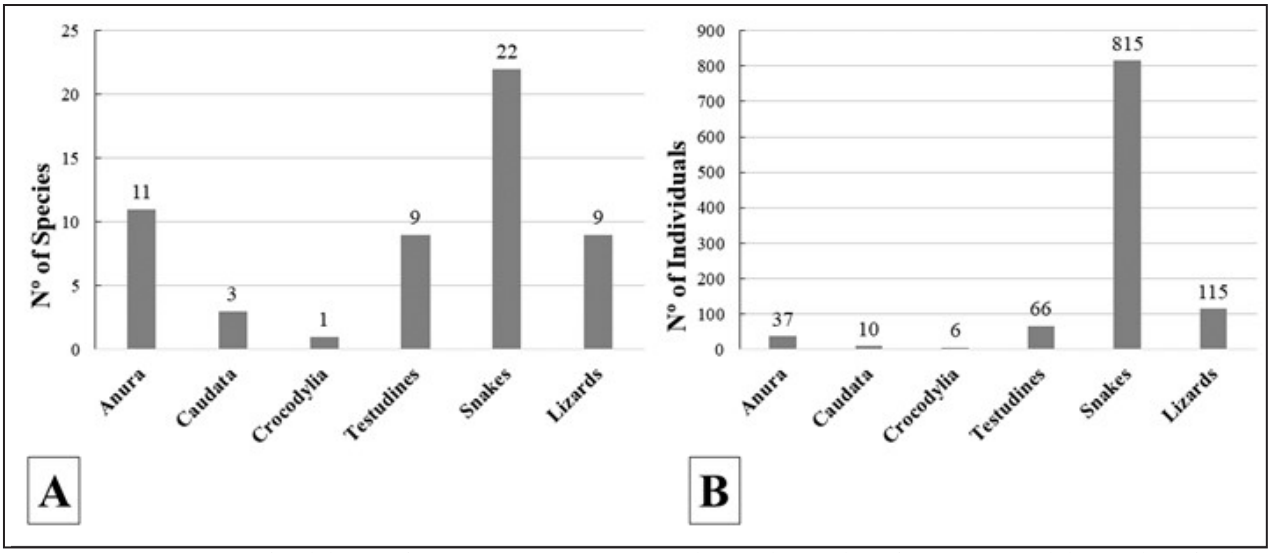

Figure 1. Representation of each herpetofauna taxonomic group, according to the number of species (A) and the number of individuals (B) announced for sale on Brazilian Facebook® groups, from 01 January 2019 until 31 July 2020. Species identified only to genus level were disregarded.

filis) are considered Near Threatened (NT) (ICMBio, 2018). Nearly half of the traded species (n=27; 46%) are exotic, one of which (*Lithobates catesbeianus*) is considered an invasive species in Brazil (Both *et al.*, 2011).

Discussion

Of the 19 sampling months in Facebook® groups, we recorded 548 posts, announcing a total of 1,049 individuals that belong to 58 herpetofauna species. Even though our data present a temporal overlap with those collected by Máximo et al. (2021), our study was more comprehensive, including the analysis of more Facebook® groups and researching not only amphibians but also reptiles. Although our results still represents a small sample of the herpetofauna e-commerce in Brazil, they are enough to prove that this is an active and unregulated market in the country. Due to the lack of information in the posts, it is not possible to confirm if the traded individuals come from illegal breeding sites, illegal imports, or if they were removed from the wild and introduced in the market, as observed by Máximo *et al.* (2021).

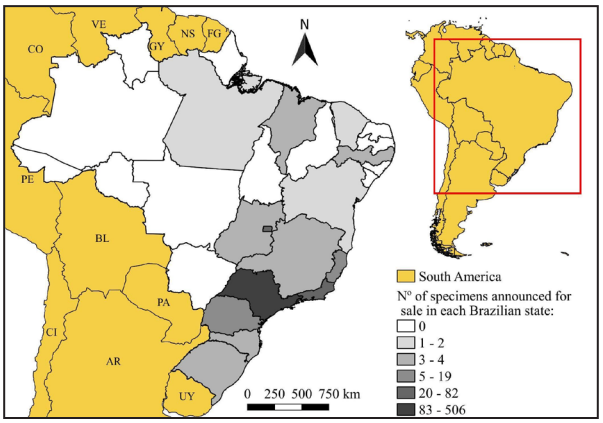

Figure 2. Number of herpetofauna individuals announced for sale on Facebook® from 01 January 2019 until 31 July 2020, in each Brazilian state.

However, the origin of the advertisements strongly suggests that they are mainly illegal trades. Even in advertisements with few potentially legal species, such as *Boa constrictor*, there is no mention of certificates that prove the origin of the animals.

The illegal herpetofauna trade is linked to several demands, from by-products exploitation (skin, meat, carapace, venom, etc.) to the pet market (Carpenter *et al.*, 2014; UNODC, 2020). Groups from the social network Facebook® we analyzed were specifically created to promote the trade of amphibians and reptiles as pets. The pet market is among the markets that benefit the most from resources offered by social networks for trading illegal or irregular products (Lavorgna, 2014). For this reason, it is fundamental to understand the consumers' motivations and the characteristics that might make certain animals attractive to this market. Therefore, strategies can be planned to inhibit or regulate such activities. Our data corroborate the demand for large-sized species (e.g. *Ceratophrys* sp., *Lithobates catesbeianus*, snakes of the families Boidae and Pythonidae) or bright-colored animals (e.g., anurans of the families Dendrobatidae and Phyllomedusidae, snakes of the genera *Lampropeltis* sp. and *Panterophis* sp.), as pointed out by previous studies (Van Wilgen *et al.*, 2009; Mohanty and Measey, 2019). Usually, the interest in keeping amphibians and reptiles as pets can be motivated by some specific issues, such as the opportunity to observe behaviors rarely seen in the wild (e.g., predation) and the relative ease of captivity maintenance (e.g., small space required, no bathing needed, infrequent feeding.) (Warwick, 2014; Measey *et al.*, 2019). However, the false perception of the low captive herpetofauna maintenance results in the mortality of approximately 75% of acquired individuals after one year (Toland *et al.*, 2012).

In our study, reptiles correspond to the majority of announced species (n=43; 71%), with a prevalence of snakes (n=22; 38%), showing the preference for these animals among the reptile breeders in Brazil (Alves *et al.*, 2019). According to published data in the last report from World Wildlife Crime Report (UNODC, 2020), reptiles are considered the second most trafficked animal globally, behind mammals. Between 2007 and 2017, the main illegally traded living reptiles were tortoises and freshwater turtles (47.4%), followed by snakes (26.7%) and lizards (17.8%) (UNODC, 2020). Brazil has only contributed with information to this report from 2015 to 2016, not providing any data since then. Unfortunately, this leaves a gap in the current knowledge regarding illegal wildlife trading.

One of the main environmental problems resulting from the pet market is the introduction of invasive species (Lockwood *et al.*, 2019; Gippet and Bertelsmeier, 2021), which corresponds to one of the main current threats to biodiversity and ecosystems (Simberloff *et al.*, 2013; Gallardo *et al.*, 2015). Out of the 27 recorded exotic species, some have a high capacity to invade new environments (e.g., *Lithobates catesbeianus*, *Xenopus laevis*, *Panterophis* sp., *Python* sp.) (Kraus, 2009). Although the number of exotic species from the herpetofauna recorded in Brazil is growing (e.g., Eterovic and Duarte, 2002), their impacts on national ecosystems are still practically unknown, with few exceptions, such as the bullfrog (Silva *et al.*, 2011; Both *et al.*, 2014). However, the invasive herpetofauna might bring several negative consequences to the local biodiversity through predation, competition, hybridization, and disease transmission (Kraus, 2015). It can also bring risks to human health by spreading zoonoses (Mendoza-Roldan *et al.*, 2021).

Although amphibian species are traded in a smaller proportion than reptiles, the possible impacts from the illegal trade of this group are not less significant. One of the main threats is related to the transmission of emerging diseases, such as chytridiomycosis, which represents the greatest loss of amphibian biodiversity ever caused by a disease (Scheele *et al.*, 2019). Two of the species recorded in this study, the bullfrog (*L. catesbeianus*) and the African clawed frog (*Xenopus laevis*), are possibly the primary species responsible for the global dissemination of the fungus *Batrachochytrium dendrobatidis* (*Bd*) (Kilpatrick *et al.*, 2010; O'Hanlon *et al.*, 2018). These species are tolerant to chytrid infection and can act as a natural reservoir (James *et al.*, 2015). In a recent study, Máximo *et al.* (2021) tested the presence of *Bd* in illegally traded amphibians. The researchers reported that none of the individuals were infected, which might indicate that fungus transmission is low. However, this issue must be further investigated. Besides chytrid, the bullfrog can act as a vector of *Ranavirus* (Santos *et al.*, 2020), an emerging virus considered responsible for the mortality of ectothermic vertebrates worldwide (Duffus *et al.*, 2015). There is another emerging disease, recently described, caused by the fungus *Batrachochytrium salamandrivorans* (Martel *et al.*, 2013). Although it has only been recorded in European countries and

Asia, this disease may be spread to other countries through the global amphibian trade, resulting in another panzootic (Yap *et al.*, 2017).

Regarding online trading in Brazil, we verified that the state of São Paulo is responsible for most advertisements and traded animals, followed by Rio de Janeiro and Distrito Federal. Alves *et al.* (2019) reported the same Federative units as the ones with the most owners of pet reptiles in Brazil. The researchers also indicated the probable existence of trafficking routes for these animals. According to Máximo *et al.*, (2021), the highest concentration of sellers of pet amphibians in Brazil is located in the states of São Paulo and Rio de Janeiro. São Paulo state is considered a key state for understanding and combating this type of activity, due to being the country's primary destination of illegally traded fauna (Charity and Ferreira, 2020). Not accidentally, nearly half of the amphibians and reptiles announced on Facebook®, were for sale in São Paulo, proving the importance of this state in understanding the illegal herpetofauna e-commerce. This fact reinforces that animal trade through social networks strengthens the already existing wildlife trafficking and its distribution networks (Nassaro, 2017; Siriwat and Nijman, 2018, Máximo *et al.,* 2021).

As reported in World Wildlife Crime Report (UNODC, 2020), the trade in digital platforms such as Facebook® and other social networks is dominant in the illegal wildlife trade, especially reptiles. Through e-commerce, anonymous traders with fake profiles are less subject to inspection and reach a much larger audience. We verified that most of the animal trading groups on Facebook® have restricted access, restraining the admittance of new members, consequently jeopardizing inspections. Other factors help explain the success of this clandestine online trade, such as the ease of purchase and lower prices when compared to legal trade. Legally traded animals can cost ten times more money than those illegally sold (Nassaro, 2017). Our data confirm this finding, as we found boa constrictor individuals (*Boa constrictor*) with prices between R$ 300.00 and R$ 1,500.00, while animals of the same species cost from R$ 3,500.00 to R$ 10,000.00 in a legal breeding website (T. Lima, personal communication, 2021). Owning pet reptiles in Brazil is found predominantly among people with medium to high purchasing power due to the high costs associated with purchasing and maintaining these animals (Alves *et al.*, 2019). That makes the low prices in e-commerce an even more important factor in leveraging this market, making this product accessible to a much larger share of the population. This fact reinforces the global phenomenon of gradually replacing the clandestine sale of animals in markets, physical stores, and fairs in favor of illegal online trading (Nijman *et al.*, 2019; Alves *et al.*, 2019; UNODC, 2020).

It is fundamental to know and quantify the number of traded species, emphasizing those classified as threatened, to understand the impact caused by the wildlife trade (Marshall *et al.*, 2020). Based on data from the IUCN Red List of Threatened Species (2022), out of the four species currently listed as vulnerable, only two have information on what causes their threats. *Correlophus ciliatus* is threatened by the categories "Biological resource use", "Natural system modifications" and "Invasive and other problematic species, genes & diseases" and its trade is related to the pet, display animals, and horticulture market. While *Python bivitatus* is mainly threatened by "Agriculture & aquaculture" and "Biological resource use" and its trade is associated with medicine, crafts, pet, clothing and food. Other studies show how the illegal trade of species for several purposes can lead to a considerable decrease in populations, as is the case of *Astrochelys yniphora*, a Madagascar endemic species of tortoise, considered at imminent risk of extinction in 2018, as a consequence of the illegal trade (Mandimbihasina *et al.*, 2018).

The National Biodiversity Policy (Decree Nº 4.339 of 22 August 2002; Brasil, 2002) defines the importance of predicting, preventing, and acting against the origin of processes leading to the decrease or considerable loss of biodiversity. However, there are several flaws in the legislation, and the lack of government investment and attention to this activity in the country is sadly prevalent. The Brazilian legislation features the protection of the native fauna from the illegal trade of vertebrate animals. However, it lacks knowledge of key factors in wildlife trafficking. This interferes with the differentiation between animal traders and pet owners, as reported by Charity and Ferreira (2020) in their study on wildlife trafficking in Brazil.

This problem is also observed through Federal Law nº 9,605/1 998 (Brasil, 1998), where there is no definition for animal trafficking. Therefore, every act against wildlife (killing, chasing, catching, and using wild animals) is considered an "Environmental Crime", and is subject to a fine and penalty of six months to one year in prison. We highlight the Com-

plementary Law nº 140 of 08 December 2011, which establishes that each Brazilian state is responsible for elaborating the assemblage of wild fauna species destined for breeding sites and scientific research (Brasil, 2011). However, to date, only Paraná state has provided this document (Paraná, 2015).

The lack of current documents defining the species likely to be traded possibly stimulates the internal wildlife market, aside from hindering inspections and differentiation of legal from illegal trade. This market is a worrying situation concerning the herpetofauna trade, especially in the Southeast and Midwest of Brazil. Additionally, the flexibility of legislation and mild penalties reinforce the neglect of protecting the wild fauna, and easing illegal activities in the country, especially through social networks, as demonstrated in this study. Since traffickers can easily migrate to other platforms (as observed in other countries) once their illegal activity in a determined social network is detected, governmental regulation of digital media is required (UNODC, 2020).

Aside from highlighting the primary negative aspects of social networks, it is essential to emphasize that they can also be advantageous (Di Minin *et al*., 2015; Siriwat *et al*., 2020). Specifically, social networks have become an important place to obtain data that might help us understand the relation of users with issues involving biodiversity, which makes these networks a critical tool for the development of several policies and strategies for conservation (Di Minin *et al*., 2015; Roberge, 2014; Correia *et al*., 2021). Initiatives for environmental education and scientific dissemination created with support from social networks are increasingly common, expanding the range of traditional activities, generating information, and stimulating the public interest in protecting biodiversity (Bik and Goldstein, 2013; Roberge, 2014; Irga *et al*., 2020).

Conclusion

Overall, our results show that herpetofauna e-commerce in Brazil happens with no legal obstacles. This market compromises the integrity of Brazilian reptile and amphibian species since native species proved to be the main target of the trade. Species with a high threat level can be the focus of "animal dealers" due to the profit acquired from them, bringing higher extinction risks to these species. This study presents the data from this form of trade, emphasizing how unrestrained animal trafficking is in Brazilian territory. In conclusion, this study may be used as a tool to combat animal trafficking in Brazil, helping at the same time with the conservation of species that show some level of threat.

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Appendix S1

Information from analyzed Facebook® groups: Availability of groups to users of the social network (Public or private group); Number of participants (information collected on 19 August 2020, may have changed); Date of creation of groups; Number of reptiles and/or amphibians individuals being marketed in each group; Number of publications containing reptiles and/or amphibians being marketed in each group. The asterisk indicates that the group was deleted from the social network during the search period, making it impossible to collect some information.

Groups	Public/Private	Nº of Participants (19/08/2020)	Creation Date	Nº of individuals	Nº of Publication
Group 1	Private	1.831	01/02/2019	399	218
Group 2	Public	892	09/09/2013	106	66
Group 3*	-	-	-	100	60
Group 4	Public	329	29/04/2014	25	23
Group 5	Private	122	15/04/2020	10	7
Group 6	Private	10.915	22/06/2015	399	168
Group 7	Public	6.122	29/05/2013	10	6