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Understanding the drivers of the live bird trade in Brazil

Luane Maria Melo Azeredo[1,*] and Rômulo Romeu Nóbrega Alves[2]

ABSTRACT

In this work we sought to evaluate the factors that influence the public's interest in wild birds sold as pets in Brazil, and the relationship of those factors with new occurrences of birds outside their natural range. We compiled the richness of bird species traded in Brazil and obtained comparative data of public interest directed to these species through the Google Trends tool. In addition, we gathered data on biological attributes and the sale price of the species in the trade, to analyze which factors would be related to public interest. Then, factors related to public interest were used to assess whether there was a relationship with these new occurrences. The main founds indicated that the public interest is greater for songbirds, omnivore, which live in more open environments, and are sold at lower prices. All those factors also showed to be related to the birds that presented new occurrences. The public's preference for birds more generalist and from more open environments are important results, as such factors generally indicate greater environmental tolerance, which may favor the establishment of these birds in new environments. Therefore, it is likely that species releases or escape from captivity, combined with their life history attributes, may favor the establishment of isolates in new environments. Thus, the present results demonstrate that actions aimed at the conservation of commercialized species are essential to reduce the interregional trade of species, and consequently reduce the impact on natural populations and reduce the potential for new biological introductions.

Keywords: Google Trends; bird trade; conservation culturomics.

1 Programa de Pós-Graduação em Etnobiologia e Conservação da Natureza, Universidade Federal Rural de Pernambuco – UFRPE. Rua Dom Manuel de Medeiros, s/n, Dois Irmãos - CEP: 52171-900 - Recife/PE.

2 Departamento de Biologia, Universidade Estadual da Paraíba, Av. das Baraúnas, 351 / Campus Universitário, Campina Grande, PB, 58109-753, Brasil.

* Corresponding author ✉. E-mail address: LMMA (luaneazeredo@gmail.com), RRNA (romulo_nobrega@yahoo.com.b)

SIGNIFICANCE STATEMENT

The present work brings a connection between the public's preference for birds sold in the market as pets, with factors that favor their survival in areas outside their native region. Our observations indicated that factors that make the species popular in the market, such as song and low price, are related to occurrences of species in environments far from their native range. These factors are possibly related to escapes or abandonment of birds by their keepers. In addition, we also observed that the records of occurrences of species in environments outside their native range, were related to their popularity in the trade, and to their generalist life-history traits. The findings of this work are important because they establish the point that connects the popularity of the species in the trade, with the possibility of release in new environments, as well as their ability to establish themselves in these new places.

INTRODUCTION

Birds represent the majority of species traded as wild pets in Brazil, most of which come from illegal capture in the wild (Alves et al. 2013; Araujo et al. 2010; Farias et al. 2019; Ferreira and Glock 2004). The trade of these birds occurs inter-regionally in the country, taking species from one region to another (Destro et al. 2012; Nascimento et al. 2015; Oliveira et al. 2020a; Regueira and Bernard 2012). In addition, there are recent reports about traded species of birds occurring outside their natural range (BirdLife International 2019; Wikiaves 2021), possibly due to escape or release of these animals (Destro et al. 2019, 2020a). Since the wild pet trade is one of the responsible for introducing exotic species in nature (Lockwood et al. 2019), there is a need to investigate whether there's a relationship between the interest of people in traded birds, and the occurrences of these birds outside their natural range.

Until recently, measuring people's interest in wild animals on a large scale would be a complicated task requiring extensive social and ethnozoological research, demanding time, and resources (Alves et al. 2018; Jepson and Ladle 2005). As a result, most studies that analyzed the trade and breeding of wild birds in Brazil were conducted at local scales (Alves et al. 2010; Licarião et al. 2013). Furthermore, due to the semi-clandestine nature of the use and sale of wild animals in Brazil, obtaining information on these activities *in loco* is not necessarily easy. However, the dynamics of the trade in wild animals for pet purposes has expanded through the internet in recent years, mainly on platforms such as Twitter and Facebook (Alves et al. 2019; Mazza et al. 2015; Minin et al. 2019; Sy 2018). Thus, virtual spaces have become a fertile field of information on a large scale on various environmental issues, including the illegal trade in wild animals in several countries (Borges et al. 2021; Magalhães and Jacobi 2010; Morcatty et al. 2021; Svensson et al. 2015).

Research using internet data to answer environmental questions is part of a new conservation field called conservation culturomics, which aims to analyze data generated by the public on the internet to infer about human-nature interactions and biodiversity conservation (Ladle et al. 2016). An example of a tool for such data collections is Google Trends, which provides indirect measures of popular interest on any topic searched on the web in temporal and spatial scales (Davies et al. 2018; Funk and Rusowsky 2014; Proulx et al. 2014). Thus, the higher the value returned by the tool, the greater the number of people interested in the researched topic (Troumbis and Iosifidis 2020). In this scenario, it is possible to obtain data on public interest in wild birds as pets during a certain period of time in different geographic classes.

This information can be used to determine which bird-related factors influence public preference, as well as determine whether there is a preference for birds that occur inside or outside the areas where online surveys are being conducted. Therefore, conservation culturomics can be an ally in ethnobiological studies, since Internet has become a fertile field of information wildlife trade in Brazil (El Bizri et al. 2015) and in the world (Svensson et al. 2015), due to the great social engagement that has been increasing over the years on the Internet.

Several factors can influence the public's interest in birds sold for pet purposes, including the species' appearance, coloration, and vocal capacity (Bezerra et al. 2013, 2020; Licarião et al. 2013; Silva et al. 2023). The latter is particularly linked to the existence of activities such as singing competitions, in which birds with a 'singer' profile are more valuable in the market (Burivalova et al. 2017; Costa et al. 2017; Jepson and Ladle 2005; Souto et al. 2017; Roldán-Clarà et al. 2021, 2022). However, the popularity of a species on the market can simply be determined by its abundance in the wild and how easy it is to keep in captivity. For example, species with a wide distribution tend to be more generalist, requiring less specialized care in captivity, generating a low cost to the trader and the breeder (Carrete and Tella 2008; Fernandes-Ferreira et al. 2012). Widely distributed birds tend to be more abundant in nature and consequently also cheaper, as already observed in other works on the bird trade (Siriwat et al. 2019; Souto et al. 2017; Su et al. 2015).

Biological characteristics such as body mass, diet, longevity, and brood size can also be important in determining the popularity of wild birds in the trade. This is because from a commercial point of view, smaller bird species can be easily accommodated in small spaces such as cages and transported without attracting attention, which facilitates clandestine illegal trade (Destro et al. 2012; Sick 1997). Regarding diet, breeding more generalist species can mean a low cost to keep the species in captivity for traders, thereby making these birds more popular in the market (Blackburn et al. 2009; Lockwood et al. 2019). In turn, longevity and brood size can also be important considering that species with a longer life expectancy or those which show reproductive success in captivity are an investment that can generate profit in the long term (Lockwood et al. 2019).

In parallel, all the characteristics mentioned above can also be important for the survival of a bird in new environments. Animals with a generalist diet, high longevity, and/or numerous offspring tend to be more likely to survive in new locations, as survival is also tied to resource availability and reproductive

success (Blackburn et al. 2009; Ducatez and Shine 2019; Lockwood et al. 2019; Stringham and Lockwood 2018; Vall-llosera and Cassey 2017). Moreover, birds with wide distributions have a history of ease in establishing themselves in other environments (Carrete and Tella 2008). In addition, more open habitats are more conducive to new bird colonization, especially if the species can explore anthropogenic environments (Bregman et al. 2014; Samia et al. 2015).

In this context, the present work sought to evaluate the factors that influence the public's interest in wild birds sold as pets in Brazil, and their relationship with new occurrences of birds outside their natural distribution area, discussing the relationship of commercial trade with possible introductions of birds in new environments. Thus, we aim to answer the following questions: 1) Does the public's interest in wild birds correlate with the seizure data provided by *IBAMA* and commercialization records? 2) Does the public's interest in species vary according to their occurrence in the locations from which online searches are carried out? 3) What are the factors associated with birds that arouse greater public interest? and 4) Is there a relationship between public interest and birds that have new occurrences outside their natural range? As a result, we sought to find a relationship that indicates that the greater interest in certain birds on the market may also be related to the occurrences of these species in new environments.

MATERIAL AND METHODS

Ethical considerations

Our research protocol complies with the guidelines of the Declaration of Helsinki and Tokyo for research with humans. The project was approved by Ethics Committee of Universidade Estadual da Paraíba - UEPB.

Data collection

A bibliographic survey was initially conducted on bird species which are commercialized for pet purposes in Brazil, gathering information in articles published in scientific journals, theses, dissertations and reports available online. The databases used for the survey were: Science Direct (www.sciencedirect.com), Google Scholar (www.scholar.google.com.br), Scopus (www.scopus.com) and Web of Science (www.isiknowledge.com). The search terms used included: "Wild birds" + Trade + Brazil; Birds + Commercialization + Brazil; "Wildlife trade" + Brazil; Birds + "Pet trade" + Brazil; Avian + "Pet trade" + Brazil; Psittacidae + "Wildlife trade" + Brazil and "Keeping birds" + trade + Brazil in both English and Portuguese languages between the years 1945 to 2020. The search for works was performed from October to December 2020 using the PRISMA protocol (Moher et al. 2009).

The works returned in the databases were first screened based on the presence of keywords in the title and/or abstract of the works, also excluding duplicates. The screened works were then analyzed according to previously established inclusion and exclusion criteria. Studies dealing with the trade of wild birds for pet purposes and containing a list of duly identified species were considered for inclusion. Works which only presented keeping species in captivity without association with trade and works that did not present a list of commercialized species and literature review studies were excluded for not meeting the inclusion criteria. The number of individuals per species cited in each work was counted, and when in the absence of this information, the number of individuals was considered as one (1).

At the same time, the Brazilian Institute for the Environment and Natural Resources (*Instituto Brasileiro do Meio Ambiente e dos Recursos naturais - IBAMA*) was asked to list the number of individuals per bird species seized in the last 20 years in Brazil. These data represented the volume of assessments by *IBAMA* on trade and amateur breeding of wild birds without proper authorization. *IBAMA* data were obtained through the citizen information service (e-sic.cgu.gov). Thus, the data were composed of both trafficked bird species and legally traded birds. Finally, we used the list of species compiled in the bibliographic review and the seizure data to conduct research of popular interest on each of the bird species registered through Google Trends (www.trends.google.com), obtaining the values of online search volumes for each species across Brazil.

Google Trends values do not represent absolute search volume but reflect the number of searches for a specific term in relation to the total number of Google searches. Values are normalized and indexed on a scale from 0 to 100, where 100 is maximum research interest and each point is divided by that value (Choi and Varian 2012). Each bird was searched separately in queries using their respective scientific names and popular names (*Sicalis flaveola* + *canário da terra* + *canário-chapinha*).

The scientific names used for native birds followed the nomenclature of the List of Birds of Brazil of the Brazilian Committee of Ornithological Records (*Lista de Aves do Brasil do Comitê Brasileiro de Registros Ornitológicos - CBRO*) (Pacheco et al. 2021) and the popular names followed the same list, in addition to descriptions from the Wikiaves website (Wikiaves 2021). The nomenclature used for exotic birds fol-

lowed the Birds of the World list (eBird 2021), and the common names followed the terms found in Google. In addition, common names for more than one species were not used. A Google Category Filter for Animals and Pets was used to ensure that the present study only reflected research associated with the poultry and pet trade, and to eliminate sources biased by homonymous terms such as city and object names, for example.

The species that returned the highest result in the Google Trends search (previously identified as *Sicalis flaveola*) was chosen as the reference term to obtain comparable trends for all birds, and then compared to all other species to obtain relative trend values. This is important as Google Trends is a measure of relative search patterns, and the results are highly sensitive to the referencing term used (Ficetola 2013; Le Nghiem et al. 2016). The data returned represented the search volume for the given query with the proportion of total search through Google.

The time range researched was from 2004 to 2020, as it was the longest time range available for searching Google Trends, to obtain the largest volume of data possible. The values of public interest were collected according to the states of Brazil. In addition, the values were used to compare the public interest according to the occurrence areas of the birds by extracting the medians of the values by state. In this case, only birds that were native to Brazil, which did not occur throughout the country, were considered. The polygons of the birds' natural distribution provided by BirdLife International (2019) were taken as a reference to find out whether the bird occurred in each location. Thus, two groups were created: one with the median values of surveys that occurred within the occurrence location of the birds, and another with the median values of surveys that took place outside the occurrence location.

The biological attributes of commercialized birds were obtained from several sources in the literature. The information considered were longevity (in years), body mass (g), brood size and diet. Species longevity was compiled from publications by a compilation of several authors (Lopes et al. 1980; de Magalhães and Costa 2009; Silva-Jr et al. 2020; Young et al. 2012). Body mass (median) was mainly based on Dunning (2007), supplemented with data from eBird (2021); brood size considered the average number of offspring of each species (Jetz et al. 2008; Myhrvold et al. 2015). The species food guilds were adapted from Wilman et al. (2014) and updated with information available in the literature. We merged all four categories of vertebrate eaters (including carnivores and piscivores) into a single grouping called vertebrates. Any species with <50% of its diet belonging to a single category, or with exactly 50% of its diet in one category and the remaining <50% distributed in the other categories, were classified as omnivorous. Thus, the food guilds gathered in this work were: plants, seeds, invertebrates, vertebrates, fruits, nectar, and omnivores.

Some environmental attributes such as the habitat type and the extent of the species distribution were also used. In addition, the "songbird" factor was added, classifying the birds in terms of being songbirds or not to verify whether people would be more interested in birds with vocal attractiveness. The songbird species were identified as those belonging to suborder Passeri (Sigrist 2009) Habitat types were classified according to Tobias et al. (2016), complemented by (Sigrist 2009) and Stotz et al. (1996). closed habitats include dense closed canopy forests, while semi-open habitats include environments such as open shrub forests, parks, forest dry, or dense savannah; in turn, open habitats include deserts, grasslands, undergrowth, rocky habitats, beaches, oceans, and cities.

The extent of species distribution (km^2) was also compiled from Tobias et al. (2016). The polygons of natural distribution were also used to evaluate the presence of new occurrences of the species, and therefore to count which species remain with the same distribution and which present occurrences in new areas. The new occurrences were observed based on the Wikiaves (2021) and eBird (2021) databases and compared with the natural distribution polygons of BirdLife International. Thus, the occurrence points located outside the polygon areas were considered as potential introductions (similar to Destro et al. (2019)). To classify an occurrence as outside the natural distribution, we considered a minimal distance of 800 km from de boarder of polygon and the point of occurrence itself.

The price of the species was considered as an economic factor and was obtained through a search on social networks such as Facebook, Whatsapp as well as sales forums on the internet. Finally, the species were also classified according to the different conservation status of the (IUCN 2023) to analyze whether the interest in birds would be related to rarity or some threatened degree in view of the great exploitation of these species in nature.

Data analyses

We performed Spearman correlations between the values returned from Google Trends, the seizure data (individuals/species) and the list of commercialized birds (data from the literature) to verify if the Google values would indicate similar results to the other datasets. The paired Wilcoxon test was used to compare the level of popular interest in bird species inside

and outside their natural ranges. We performed an analysis of variance (ANOVA: annual mean conservation status) to analyze whether the interest would be related to the conservation status of the species.

Next, we performed a Generalized Linear Mixed Models (GLMM) to analyze public interest and determine which variables influence this interest and make the species more popular in the market. The public interest (response variable) was measured through the values of on Google Trends by each State of Brazil and the explanatory variables were the biological attributes (body mass, diet, longevity, brood size), environmental attributes (habitat type, distribution area in Km^2) and the market price of birds. We considered the States of Brazil as a random effect (Google Trends Search body mass, diet, longevity, brood size, habitat type, distribution area, price, and songbird, (1| States); negative binomial family, link=log). Then, we generated another GLMM using a binary response variable to assess whether the bird species that presented occurrences outside their natural range were related to public interest, indicating whether the species presents new occurrences (1) or not (0) outside of its natural distribution range (new occurrences Google Trends Search, binomial family, link= logit). We generated another GLMMs to assess whether the factors related to people's interest would also be related to the birds that presented new occurrences (new occurrences significant variables, (1| States); family=binomial, link=logit). Models were compared using ΔAIC values (ΔAIC = null model AIC – model AIC) (Harrison et al. 2018; Richards 2008). All analyzes were performed in the R version 4.0.5 program (R Core Team 2021) based on MASS (Venables and Ripley 2022), lme4 (Bates et al. 2015), and Broom.mixed (Bolker and Robinson 2022). Significant values were considered based on the 95% confidence interval ($p \leq 0.05$).

RESULTS AND DISCUSSION

The literature search returned 30,507 studies including full articles, theses, dissertations and reports. After a screening through keyword identification and implementing inclusion and exclusion criteria, 36 works on the trade of wild birds for pet purposes were selected for this analysis (Figure 1). Of these studies, 21 were carried out in the Northeast region, four in the North region, three in the South region, eight in the Southeast region and one in the Center-West region of Brazil (Figure 2). The list of works included in the analysis can be found in the Table 1.

Literature data indicated a total of 411 species of birds traded in Brazil, while the list of birds seized by IBAMA included 180 species. The sum of these two sets of data excluding species in common (n=165) totaled 426 bird species, 411 native species and 16 exotic species. The compiled species belong to 69 families and 28 orders. The most representative orders were Passeriformes and Psittaciformes (Figure 3), whose Families with the most recorded species were Thraupidae (20%), Psittacidae (12%) and Icteridae (5%), the first and last belonging to the Suborder Passeri, a group of songbirds which represented more than 30% of the recorded species richness (n= 161). Regarding

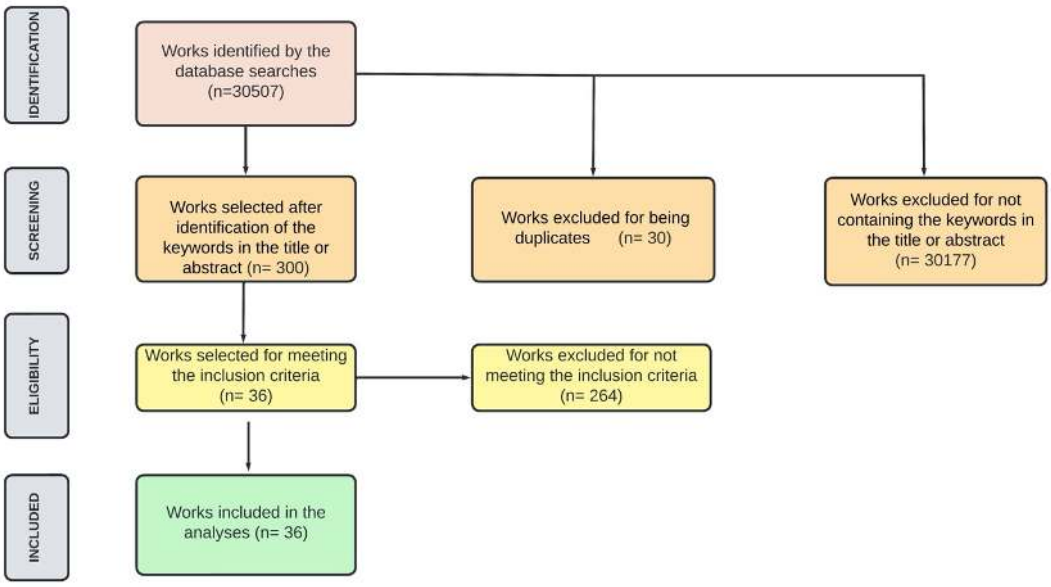

Figure 1. Flowchart of the screening process and selection of works on the commercialization of wild birds for pet purposes in Brazil.

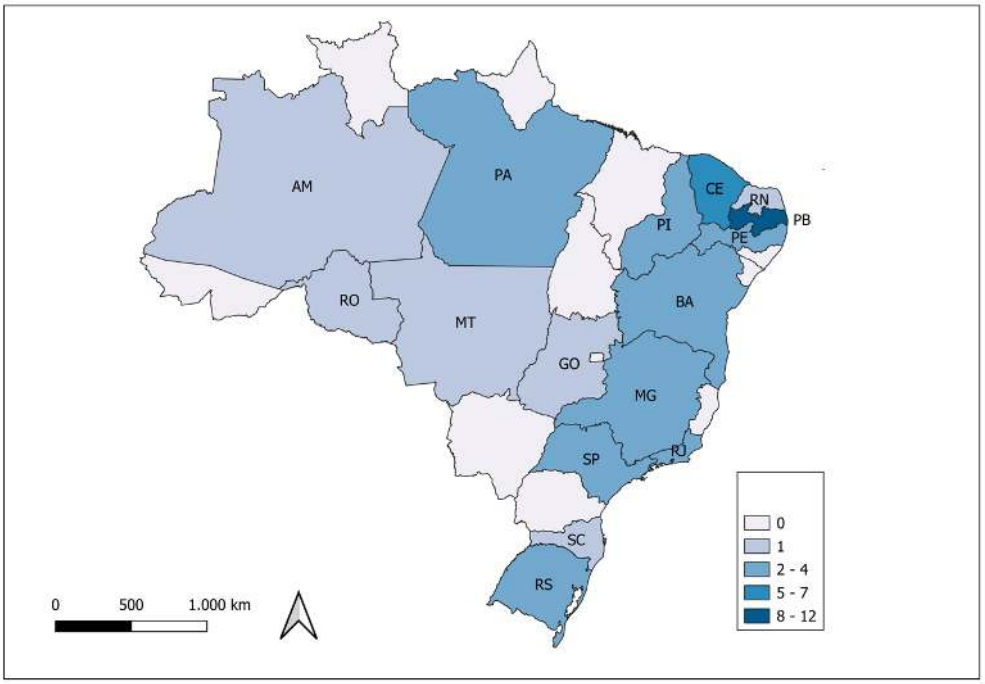

Figure 2. Distribution of published works on the commercialization of wild birds for pet purposes in Brazil by state.

the threaten degree, 384 bird species appear on the IUCN list in the "Least Concern (LC)" category, 20 as "Near Threatened (NT)", 14 as "Vulnerable (VU)" and 8 as "Endangered" (EN)".

Despite the expressive number of species registered as commercialized, it was possible to obtain information about bird prices only for 122 species. Prices ranged from R30.00*toR*8,000.00 (US5.80*toUS*1547.38; US1.00 = *R*5.14 in September 2021). Data regarding longevity were obtained for 151 species, with most of the data referring to the parrot group. The life expectancy of the species ranged from 3 years (*Myophobus fasciatus*) to 63.04 years (*Ara chloropterus*).

Positive correlations were found between data on species seized by *IBAMA* and public interest on the internet (Spearman: Rho=0.322; p< 0.001), as well as between commercialized species (recorded in the literature) and public interest on the internet (Spearman: Rho=0.387; p<0.001). The correlation between the seized species and the species registered as commercialized also showed a positive value (Spearman: Rho= 0.667; p<0.001).

The Google Trends tool returned values for 278 species, while 148 species had very low search volumes, to the point that no search value was returned at a national level. Thus, such values were counted as zero, indicating a low public interest in these species. Furthermore, songbirds made up a representative part of the sample, with 106 species returning search values. Public interest at the regional level has shown that interest in birds on the internet is greater in the regions of their natural occurrence (Wilcoxon-paired: V = 1715.5, p = 0.04503; Inside: 38±17.12 / Outside: 29±46.62). A total of 161 native bird species with occurrences more restricted to just a few regions of the country were used in this analysis (Additional File 1). However, from an exploratory point of view, we were able to observe that the regions of Brazil that most showed interest in birds from other locations were the south and southeast regions, with a preferential search profile for species residing in the north and northeast regions as demonstrated in Figure 4 (see Additional File 2 for check Google Trends values). No influence was observed on the public interest in birds with respect to the different threatened degrees of the species (F= 1.719; gl= 5/426; p= 0.129).

Regarding the attributes that can influence people's interest in wild pet birds, we found that granivorous and omnivore diet, and semi-open habitats positively influence interest in wild birds. In addition, the public showed greater interest in songbirds. In turn, price had a negative influence on public interest (Tables 2 and 3). Thus, our results indicate that the greatest public interest is in songbirds which have a generalist diet, live in more open habitats, are

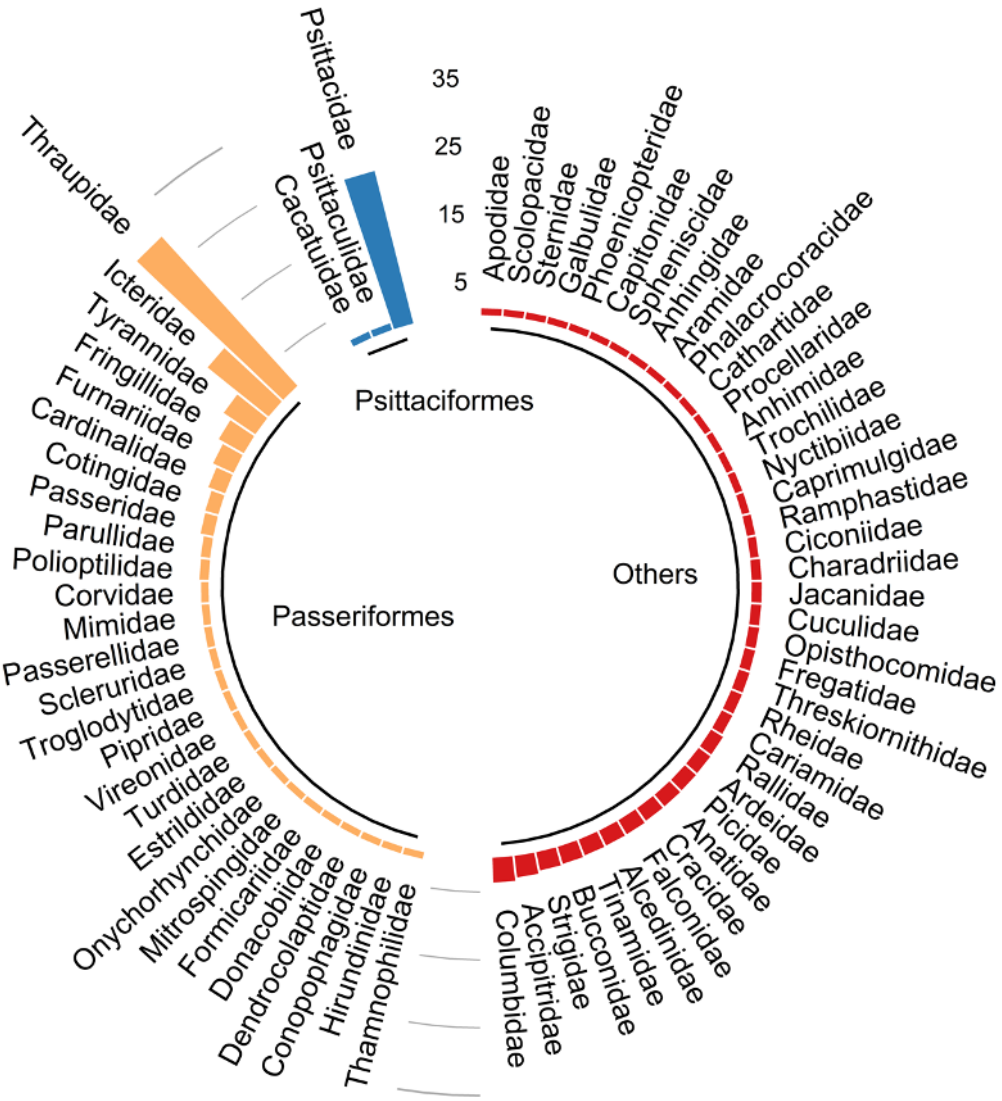

Figure 3. Public interest in wild birds according to each Family. The bars are arranged in ascending order, with emphasis on the most representative orders: Passeriformes (orange) and Psittaciformes (blue).

widely distributed, and are traded at lower prices. We did not find a significant result regarding body mass, brood size, and longevity in this analysis.

About 17 bird species presented occurrence points outside their natural distribution, 48% of which belong to the group of songbirds (see Additional File 3). We found a positive relationship between the birds that presented new occurrences and the public's interest. Regarding the factors that could be associated with those bird species, we found that the price presented a negative value, while semi-open habitat type, songbirds and the omnivorous food guild presented positive values (Table 3). Therefore, the birds that presented new occurrences outside their natural distributions are mostly songbirds, omnivorous and inhabiting more open environments. Thus, we see that the public interest is related to the occurrences of birds outside their natural range, and that the semi-open environment and the omnivorous diet were also factors which presented significant relationships for these new occurrences.

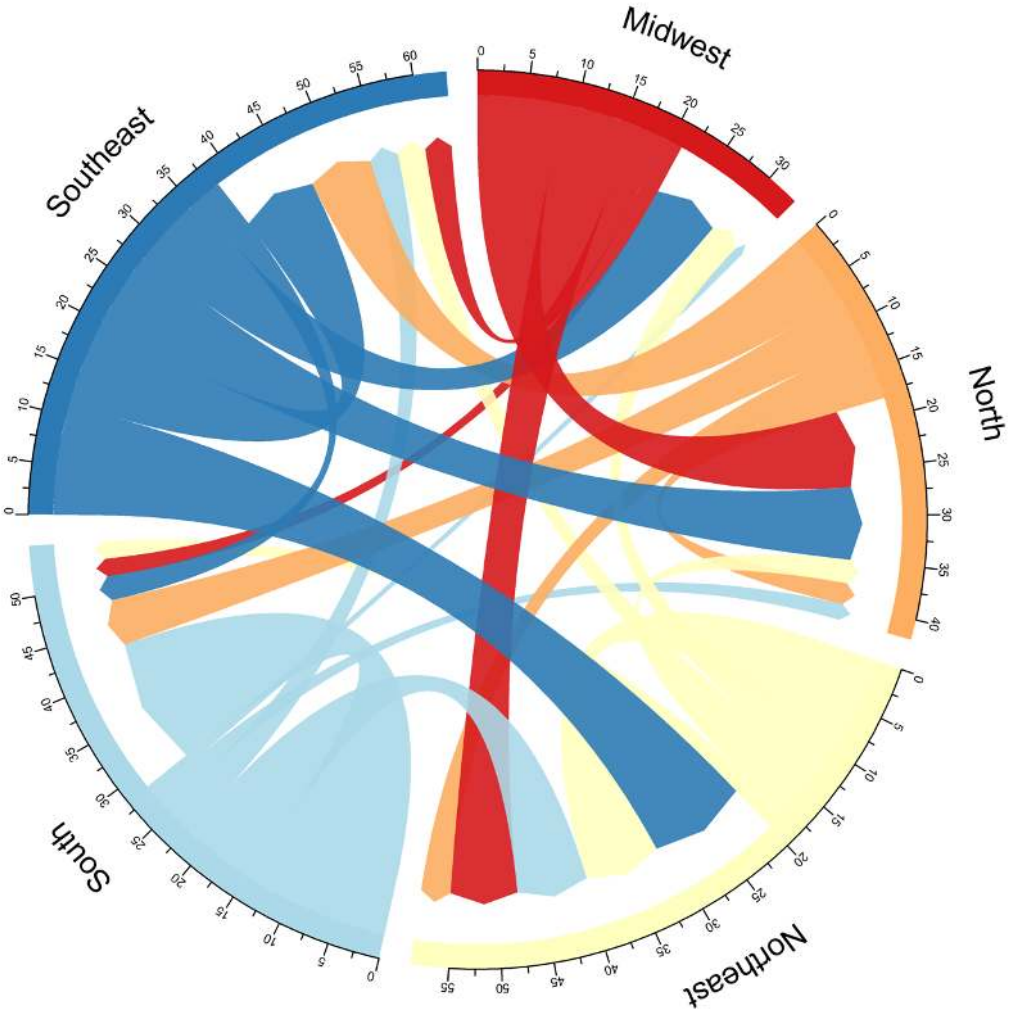

Figure 4. Public interest separated by regions of Brazil. The arrows depart from the search locations and point to the regions where the species of interest resides.

Table 1. List of published works that described the trade of wild birds as pets in Brazil, from 1997 to 2021.

	City/State	Region	Registered species	Source
1	Manaus, AM	North	40	(Nascimento et al. 2015)
2	Abaetetuba, PA	North	8	(Farias et al. 2019)
3	Belém, PA	North	60	(Moreira 1997)
4	Candeias do Jamari, RO	North	38	(Silva and Lima 2014)
5	Teresina, PI	Northeast	83	(Moura et al. 2012)
6	Floriano, PI	Northeast	39	(Souto et al. 2017)
7	CE	Northeast	44	(Fernandes-Ferreira et al. 2012)
8	Fortaleza, CE	Northeast	29	(Batista 2010)
9	Fortaleza, CE	Northeast	57	(Costa et al. 2017)
10	Itapipoca, CE	Northeast	30	(Assis and Lima 2007)
11	RN	Northeast	152	(Oliveira et al. 2020a)
12	Campina Grande, PB	Northeast	21	(Rocha et al. 2006)
13	Catolé do Rocha, PB	Northeast	38	(Alves et al. 2010)
14	PB	Northeast	98	(Pagano et al. 2009)
15	PB	Northeast	13	(Pessoa et al. 2013)
16	João Pessoa, PB	Northeast	20	(Gama and Sassi 2008)
17	Lagoa seca, PB	Northeast	32	(Oliveira et al. 2020b)
18	Patos, PB	Northeast	21	(Soares et al. 2020)
19	Queimadas, PB	Northeast	31	(Barbosa et al. 2010)
20	Santana dos Garrotes, PB	Northeast	13	(Alves et al. 2016)
21	São João do Cariri e Cabaceiras, PB	Northeast	30	(Alves et al. 2012)
22	Recife, PE	Northeast	106	(Pereira and Brito 2005)
23	Recife, PE	Northeast	55	(Regueira and Bernard 2012)
24	Feira de Santana, BA	Northeast	72	(Santos and Costa-Neto 2007)
25	Cabaceiras do Paraguaçu, BA	Northeast	38	(Souza and Soares Filho 1998)
26	GO	Midwest	78	(Bastos et al. 2008)
27	Belo Horizonte, MG	Southeast	34	(Souza and Vilela 2013)
28	Belo Horizonte, MG	Southeast	162	(Souza et al. 2014)
29	Cuiabá, MT	Southeast	16	(Pinho and Nogueira 2000)
30	Rio de Janeiro, RJ	Southeast	50	(Padrone 2004)
31	Seropédica, RJ	Southeast	28	(Matias et al. 2016)
32	Araras, SP	Southeast	61	(Brito 2017)
33	São Paulo, SP	Southeast	23	(Godoy and Matushima 2010)
34	São Miguel do Oeste, SC	South	16	(Preuss and Schaedler 2011)
35	RS	South	93	(Ferreira and Glock 2004)
36	Santa Maria, RS	South	77	(Zago 2008)

Table 2. Summary of generalized models generated to assess the main factors related to public interest about birds commercialized as pets.

Response variable	Explanatory variables		Est.	Std. Error	t value	pr(>|t|)		AIC	AIC Null-model	ΔAIC
Public's Interest	Diet	Invert.	3.74e-01	3.14e-01	1191	233		10772.8	60933.2	50160.4
		Omni.	2.20e-01	1.14e-01	1923	0.0406	*			
		Plants	-2.98e-01	2.35e-01	-1264	0.2062				
		Seeds	5.06e-01	1.56e-01	3242	0.0011	**			
	Brood size		-3.99e-02	4.75e-02	-841	0.4004				
	Longevity		5.83e-03	7.60e-03	767	0.4428				
	Habitat	Open	-1.62e-01	1.97e-01	-821	0.4118				
		Semi-open	4.54e-01	1.38e-01	2895	0.0037	**			
	Distribution area		2.26e-04	2.22e-04	-1016	0.3096				
	Body mass		-2.89e-04	2.49e-04	-1159	0.2463				
	Songbirds	Yes	3.52e-01	1.84e-01	-1913	0.0442	*			
	Price		-2.42e-05	9.67e-06	-2502	0.0123	*			

Table 3. Summary of generalized models generated to assess the factors related to the birds that presented new occurrences of outside their natural range. * = p<0.05; ** = p< 0.01; *** = p<0.001. (Exponentiated coefficients are described in Additional File 4). Invert= Invertebrates; Omni= Omnivores

Response variable	Model	Explanatory variables		Est.	Std. Error	t-value	pr(>|t|)		AIC	AIC Null-model	ΔAIC
New occurrences outside Natural range	1	Public's interest		0.28e+02	9.66+e03	2985	0.0028	*	6973.1	6980.2	7.1
		Diet	Invert.	3.69e+01	6.64e+05	0	0.9999		229.3	6980.2	6751
			Nectar	-2.01e+06	6.74e+06	-299	0.7650				
			Omni.	3.46e+01	6.64e+05	0	0.0099	**			
			Plants	5.06+e06	1.05e+07	482	0.6295				
			Seeds	3.20e+01	6.64e+05	0	0.9999				
	2	Habitat	Open	3.33e+06	6.71e+07	50	0.9603				
			Semi-open	9.46e-01	5.96e-01	-1588	0.0112	*			
		Songbird	yes	2.79e+00	1.07e+00	2613	0.0089	**			
		Price		-2.15e-03	4.50e-04	4792	0.0000	***			

DISCUSSION

Our results revealed an expressive richness of wild bird species sold as pets in Brazil, especially birds from the Thraupidae and Psittacidae families, reinforcing a trend already reported in previous studies (for example, Araujo et al. (2010) and Nascimento et al. (2015) who recorded the popularity of these birds as pets in the country and indicate that most of the animals targeted for pet trafficking in Brazil are birds. We recorded that at least 426 species are traded in Brazil, constituting higher numbers than those recorded in previous surveys (Alves et al. (2013)= 295 species; Costa et al (2018)= 383 bird species). We found that the birds which arouse greater public interest are related to the attributes of granivorous and omnivorous diet, semi-open habitats, and lower prices. Such attributes, except for the granivorous diet, also showed a relationship with the new occurrences of birds. Therefore, we can relate commercialization with the occurrences of birds in new environments.

The positive correlations between the three datasets demonstrated that the values measured by Google trends can be used to assess public interest in birds on a national scale. An indication of this is that the preferences of the public on the internet do not differ significantly from what was recorded in works carried out at smaller geographical scales (Oliveira et al. 2018, 2020b; Regueira and Bernard 2012; Silva et al. 2022). However, despite being significant, the correlations showed a weak relationship with each other, which may be associated with the fact that several species showed low interest values at the national level returned by Google. Therefore, despite the large number of birds that are commercialized, there is probably a limited profile of species that are known nationally. This result is reinforced when we observe that, on a regional scale, there is a greater interest in birds which naturally occur in the areas from which internet searches start.

The greater interest in species from the North and Northeast regions, starting mainly from the Southeast, Midwest and South regions, shows a pattern already seen in other works, demonstrating that the Northeast region is the place with the largest trade in wild animals in the country (Alves et al. 2013; Godoy and Matushima 2010; Oliveira et al. 2020a; Regueira and Bernard 2012), while the southern regions of the country are the regions with the greatest demand for these species (Destro et al. 2012; Freitas et al. 2021; Zardo et al. 2014). This result may indicate that the data returned by Google Trends can be used to assess large-scale trade issues, at least for more popular species, since it was possible to demonstrate a correlation with other data already published. Considering these variations, it appears that scale is a factor that must be considered when analyzing public interest in themes associated with nature, as shown by previous studies (Fukano and Soga 2019; Funk and Rusowsky 2014). Thus, it is evident that local and easily accessible species tend to be perceived by people, allowing their eventual use as pets, especially when compared to allochthonous species, which tend to have higher prices.

In general terms, the selling price of animals is a factor that influences public interest (Ribeiro et al. 2019; Sung and Fong 2018). When analyzing both the public's interest and the birds that presented new occurrences, we observed that both showed to be influenced by lower prices. As commercial theories already point out, lower prices tend to be related to species that are more common in the market (Su et al. 2015). Thus, the interest in cheaper birds highlights the issue of the population's familiarity with the species, indicating that the preference is for more common birds. Since the birds that presented new occurrences are also related to public interest, the negative relationship with the price may indicate that the most popular species on the market are also more likely to be released into the wild. Similar results in relation to low price and possible introductions were also found in studies for both birds and other taxonomic groups (Duggan et al. 2006; Stringham and Lockwood 2018; Su et al. 2016).

A lower price to acquire birds species can favor their acquisition as well as their release into nature, since the investment tends to be small, and their release tends to be more common. The relationship between the low price and the new occurrences of birds recorded in our study may be related to the positive interest of public in songbirds. Some works show that the value of a bird is proportional to its ability to sing for hours in competitions, so that very young birds or adults that do not sing in captivity (captured in the wild or born in captivity) are sold at lower prices (Costa et al. 2017; Oliveira et al. 2020b; Souto et al. 2017). In addition, other studies have demonstrated that these birds can undergo a training process to acquire the ability to sing and participate in competitions, becoming more valuable (Oliveira et al. 2020b; Silva et al. 2022). Therefore, it is possible that species which do not meet the expectation of singing or winning singing competitions are abandoned in nature by their buyers, as they will not produce the expected return. Similarly, the work by Su et al. (2016) observed a positive relationship between songbirds and their introduction into new environments. Therefore, although our data do not directly indicate that the new occurrences were due to introductions, it is likely that the songbird trade is associated with the release of species into new environments, considering that birds

that do not have as much vocal capacity tend to be abandoned by their owners/breeders.

The greater interest in granivorous and omnivorous birds is consistent with what is described in several works on the trade and breeding of wild pet birds, since seeds are part of the natural diet of most commercialized birds (Alves et al. 2010; Destro et al. 2012; Oliveira et al. 2020b; Cruz et al. 2022; Bezerra et al. 2023). However, it is worth noting that traders and breeders do not necessarily provide the species with a natural diet, since several studies describe that the birds are basically fed with small grains such as millet or birdseed for adults and some fruits for the young (Fernandes-Ferreira et al. 2012; Neto et al. 2022). Thus, the interest in generalist species is probably due to the high availability of these species in the market, in addition to the ease of finding suitable food for birds in captivity. Regarding the new occurrences of birds, our data corroborate the premise that a broader diet tends to favor species' survival in new environments (Blackburn et al. 2009; Lockwood et al. 2019).

The positive influence of more open habitats, both on public interest and on new occurrences of birds, was the factor the best expressed the relationship between the popularity of the species and their occurrence in areas outside their natural range. Based on this result, we can suggest that more open environments are the most used to capture birds for trade, as they are probably more accessible to the population, which influences the public's familiarity with the species (Alves et al. 2010; Bonifácio et al. 2016; Destro et al. 2020b; Oliveira et al. 2020b). In addition, the presence of birds from more open environments in new areas demonstrate that they have greater environmental tolerance, being able to establish themselves in different environments from which they are commonly associated. Not surprisingly, many species located further to the North and Northeast of Brazil have shown new occurrences in the south in the country, more than 800 km from their natural range (BirdLife International 2019). For example, *Paroaria coronata and Paroaria dominicana*, whose original distributions did not have records and occurrences in the Northeast and South regions of Brazil, respectively (BirdLife International 2019; Klemann-Junior et al. 2017). Similar results are also described in the work by Davis et al. (2014) who coined the concept of 'substitutable habitats', associated with the fact that species from more open environments can make use of other habitats, including anthropized environments, in the absence of their original habitat, with greater ease.

CONCLUSION

The positive relationship of public interest with birds that presented new occurrences may indicate the influence of trade on possible introductions of wild birds into new areas in Brazil. Although we cannot affirm that the new occurrences are the result of species abandonment or escape from captivity, we observed that the birds of greatest interest to the public have characteristics that favor them in new environments. However, further studies that consider other variables such as climatic factors and land vegetation cover are necessary to improve this discussion, because factors such as deforestation and climate change may also be responsible for the occurrence of birds in other regions (Destro et al. 2019; Fletcher et al. 2018). For example, the advance of deforestation has increased the number of anthropic areas, which has possibly facilitated the new occurrences of species from more open environments (Zurita and Bellocq 2010). In turn, climate change can also be an indication that such species are changing their environment, as observed in other works (Green and Pearce-Higgins 2014; Maggini et al. 2011).

We demonstrate that the profile of people searching for wild birds on the internet can be guided by sociocultural factors in each location, and it is important to know the public's preference to outline actions aimed at the conservation of the species sold in each region to avoid or at least reduce the trade of species outside their natural habitat. We also found that birds from more open environments and with a generalist diet arouse greater interest from the public and at the same time present occurrences in areas outside their natural distribution. Thus, it is likely that species releases or escape from captivity, combined with their life history attributes, may favor the establishment of allochthonous species in new environments. Therefore, it is important that these factors be considered in association with environmental factors, such as deforestation and climatic parameters, to support policies on the trade of birds outside their natural range and to assess the possibility of establishing these species in new environments.

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DATA AVAILABILITY

The data used to support the findings of this study are available from the corresponding author upon reasonable request. Some details about analyses are described in our additional files.

CONFLICT OF INTEREST

The authors have no conflicts of interest to declare.

CONTRIBUTION STATEMENT

Conceived of the presented idea: LMMA, RRNA.
Carried out the experiment: LMMA.
Carried out the data analysis: LMMA.
Wrote the first draft of the manuscript: LMMA, RRNA.
Review and final write of the manuscript: LMMA, RRNA.
Supervision: RRNA.

REFERENCES

Alves RRN, Gonçalves MBR, Vieira WLS (2012) **Caça, uso e conservação de vertebrados no semiárido Brasileiro.** *Tropical Conservation Science* 5:394–416.

Alves MM, Faria Lopes S, Alves RRN (2016) **Wild Vertebrates Kept as Pets in the Semiarid Region of Brazil.** *Tropical Conservation Science* 9:354–368.

Alves RRN, Araújo BMC, Policarpo IS, Pereira HM, Borges AKM, Vieira WLS, Vasconcellos A (2019) **Keeping reptiles as pets in Brazil: Ethnozoological and conservation aspects.** *Journal for Nature Conservation* 49:9–21.

Alves RRN, Lima JRF, Araujo HFP (2013) **The live bird trade in Brazil and its conservation implications: an overview.** *Bird Conservation International* 23:53–65.

Alves RRN, Nogueira EEGG, Araujo HFP, Brooks SE (2010) **Bird-keeping in the Caatinga, NE Brazil.** *Human Ecology* 38:147–156.

Alves RRN, Silva JS, Chaves LS, Albuquerque UP (2018) **Ethnozoology and Animal Conservation.** Ethnozoology. Elsevier, pp. 481–496.

Araujo ACB, Behr ER, Longhi SJ, Menezes PTS, Kanieski MR (2010) **Diagnóstico sobre a avifauna apreendida e entregue espontaneamente na Região Central do Rio Grande do Sul, Brasil.** *Revista Brasileira de Biociências* 84849:279–284.

Assis IA, Lima DC (2007) **Uma Introdução Ao Comércio Ilegal De Aves Em Itapipoca, Ceará.** *Anais do VIII Congresso de Ecologia do Brasil* 1–3.

Barbosa AJA, Nobrega WA, Alves RRN (2010) **Aspectos da caça e comércio ilegal da avifauna silvestre por populações tradicionais do semiárido paraibano**. *Revista de Biologia e ciências da terra* 10:39–49.

Bastos LF, Ferreira Luz VL, Reis JI, Souza VL (2008) **Apreensão de espécimes da fauna silvestre em Goiás – situação e destinação.** *Revista de Biologia Neotropical* 5:51–63.

Bates D, Mächler M, Bolker B, Walker S (2015) **"Fitting Linear Mixed-Effects Models Using lme4."** *Journal of Statistical Software* 67:1–48.

Batista LAO (2010). **O Tráfico de Aves Silvestres em Fortaleza: Implicações Bioéticas e Vivências de Compradores.** MSc. dissertation, Universidade Federal do Ceará, Fortaleza – CE, Brazil.

Brito MCR (2017) **Diagnóstico, registro e destinação da avifauna recebida no pró-arara centro de reabilitação de animais silvestres, Araras-SP**. MSc. dissertation, Universidade Federal de São Carlos, São Carlos -SP, Brasil.

Becerra S, Marinero J, Borghi CE (2022). **Poaching and illegal wildlife trade in western Argentina.** *Ethnobiology and Conservation* 11. https://doi.org/10.15451/ec2022-01-11.05-1-15

Bezerra DMM, Araujo HFP, Alves ÂGC, Alves RRN (2013) **Birds and people in semiarid northeastern Brazil: Symbolic and medicinal relationships.** *Journal of Ethnobiology and Ethnomedicine* 9:1–11.

Bezerra DMM, Araujo HFP, Alves RRN (2020) **Understanding the use of wild birds in a priority conservation area of Caatinga, a Brazilian tropical dry forest.** *Environment, Development and Sustainability* 22:5297–5316.

BirdLife International and Handbook of the Birds of the World (2019) **Bird species distribution maps of the world. Version 2019.1.** Available at `http://datazone.birdlife.org/species`.

Blackburn TM, Cassey P, Lockwood JL (2009) **The role of species traits in the establishment suc-**

cess of exotic birds. *Global Change Biology* 15:2852–2860.

Bolker B, Robinson D (2022) **broom.mixed: Tidying Methods for Mixed Models.** *R package version 0.2.9.4*.

Bonifácio KM, Schiavetti A, Freire EMX (2016) **Fauna used by rural communities surrounding the protected area of Chapada do Araripe, Brazil.** *Journal of Ethnobiology and Ethnomedicine* 12:41.

Borges AKM, Oliveira TPR, Rosa IL, Braga-Pereira F, Ramos HAC, Rocha LA, Alves RRN (2021) **Caught in the (inter)net: Online trade of ornamental fish in Brazil.** *Biological Conservation* 263:109344.

Bregman TP, Sekercioglu CH, Tobias JA (2014) **Global patterns and predictors of bird species responses to forest fragmentation: Implications for ecosystem function and conservation.** *Biological Conservation* 169:372–383.

Burivalova Z, Lee TM, Hua FY, Lee JSH, Prawiradilaga DM, Wilcove DS (2017) **Understanding consumer preferences and demography in order to reduce the domestic trade in wild-caught birds.** *Biological Conservation* 209:423–431.

Carrete M, Tella JL (2008) **Wild-bird trade and exotic invasions: a new link of conservation concern?** *Frontiers in Ecology and the Environment* 6:207–211.

Choi H, Varian H (2012) **Predicting the Present with Google Trends.** *Economic Record* 88:2–9.

Costa F, Ferreira J, Monteiro K, Mayrink R (2017) **Fortalecendo Parcerias a Favor da Biodiversidade.** Ciência contra o tráfico: Avanços no Combate ao Comércio Ilegal de Animais Silvestres. pp. 17–22.

Costa FJ, Ribeiro RE, Albuquerque De Souza C, Navarro RD (2018) **Espécies de Aves Traficadas no Brasil: Uma Meta-Análise com Ênfase nas Espécies Ameaçadas.** *Journal of Social, Technological and Environmental Science* 324–346.

Cruz CEFD, Soares CEDS, Hirt GB, Wagner PGC, Andretta I, Castro Neto WDN (2022). **Wild animals housed at the IBAMA triage center in Southern Brazil, 2005–2021: a glimpse into the endless conflicts between man and other animals.** *Ethnobiology and conservation* 11 10.15451/ec2022-09-11.28-1-29.

Davies T, Cowley A, Bennie J, Leyshon C, Inger R, Carter H, Robinson B, Duffy J, Casalegno S, Lambert G, Gaston K (2018) **Popular interest in vertebrates does not reflect extinction risk and is associated with bias in conservation investment.** *PLoS ONE* 13:e0203694.

Davis AY, Malas N, Minor ES (2014) **Substitutable habitats? The biophysical and anthropogenic drivers of an exotic bird's distribution.** *Biological Invasions* 16:415–427.

Destro GFG, Andrade AFA, Fernandes V, Terribile LC, De Marco P (2020a) **Climate suitability as indicative of invasion potential for the most seized bird species in Brazil.** *Journal for Nature Conservation* 58:125890.

Destro GFG, Fernandes V, Andrade AFA, De Marco P, Terribile LC (2019) **Back home? Uncertainties for returning seized animals to the source-areas under climate change.** *Global Change Biology* 25:3242–3253.

Destro GFG, Lucena T, Monti R, Cabral R, Barreto R (2012) **Efforts to Combat Wild Animals Trafficking in Brazil.** Biodiversity Enrichment in a Diverse World. InTech, pp. 421–436 .

Destro GFG, De Marco P, Terribile LC (2020b) **Comparing environmental and socioeconomic drivers of illegal capture of wild birds in Brazil.** *Environmental Conservation* 47:46–51.

Ducatez S, Shine R (2019) **Life-history traits and the fate of translocated populations.** *Conservation Biology* 33:853–860.

Duggan IC, Rixon CAM, MacIsaac HJ (2006) **Popularity and propagule pressure: Determinants of introduction and establishment of aquarium fish.** *Biological Invasions* 8:377–382.

Dunning JB (2007) **CRC Handbook of Avian Body Masses.** 2th ed. CRC Press, Boca Raton, Florida .

El Bizri HR, Morcatty TQ, Lima JJS, Valsecchi J (2015) **The thrill of the chase: uncovering illegal sport hunting in Brazil through YouTubeTM posts.** *Ecology and Society* 20:art30.

eBird (2021) **eBird: An online database of bird distribution and abundance.** [http://www.ebird.org].

Farias TC, Belo RP, Silva SR, Júnior PCB (2019) **Comércio ilegal de aves silvestres em feiras livres da Amazônia: Um estudo de caso no Município de Abaetetuba, Pará, Brasil.** *Biota Amazônia* 9:24–28.

Fernandes-Ferreira H, Mendonça SV, Albano C, Ferreira FS, Alves RRN (2012) **Hunting, use and conservation of birds in Northeast Brazil.** *Biodiversity and Conservation* 21:221–244.

Ferreira CM, Glock L (2004) **Diagnóstico preliminar sobre a avifauna traficada no Rio Grande do Sul, Brasil.** *Biociências* 12:21–30.

Ficetola GF (2013) **Is interest toward the environment really declining? The complexity of analysing trends using internet search data.** *Biodiversity and Conservation* 22:2983–2988.

Fletcher RJ, Didham RK, Banks-Leite C, Barlow J, Ewers RM, Rosindell J, Holt RD, Gonzalez A, Pardini R, Damschen EI, Melo FPL, Ries L, Prevedello JA, Tscharntke T, Laurance WF, Lovejoy T, Haddad NM (2018) **Is habitat fragmentation good for biodiversity?** *Biological Conservation* 226:9–15.

Freitas TC de, Gadotti GI, Beltrame R, Guarino E de SG, Gomes GC, Molina AR (2021) **Comércio ilegal de aves nativas em plataforma social virtual: Subsídios para a perícia ambiental.** *Revista Brasileira de Engenharia e Sustentabilidade* 9:8–15.

Fukano Y, Soga M (2019) **Spatio-temporal dynamics and drivers of public interest in invasive alien species.** *Biological Invasions* 21:3521–3532.

Funk SM, Rusowsky D (2014) **The importance of cultural knowledge and scale for analysing internet search data as a proxy for public interest toward the environment.** *Biodiversity and Conservation* 23:3101–3112.

Gama TF, Sassi R (2008) **Aspectos do comércio ilegal de pássaros silvestres na cidade de João Pessoa, Paraíba, Brasil.** *Gaia Scientia* 2:1–20.

Godoy SNSN, Matushima ERER (2010) **A survey of diseases in passeriform birds obtained from illegal wildlife trade in São Paulo City, Brazil.** *Journal of Avian Medicine and Surgery* 24:199–209.

Green RE, Pearce-Higgins JW (2014) **Birds and Climate Change: Impacts and Conservation Responses.** Cambridge University Press, Cambridge .

Harrison XA, Donaldson L, Correa-Cano ME, Evans J, Fisher DN, Goodwin CED, Robinson BS, Hodgson DJ, Inger R (2018) **A brief introduction to mixed effects modelling and multi-model inference in ecology.** *PeerJ* 2018:e4794.

IUCN (2023) **The IUCN Red List of Threatened Species. Version 2023-1.** [https://www.iucnredlist.org] Accessed December 12, 2023.

Jepson P, Ladle RJ (2005) **Bird-keeping in Indonesia: Conservation impacts and the potential for substitution-based conservation responses.** *ORYX* 39:442–448.

Jetz W, Sekercioglu CH, Böhning-Gaese K (2008) **The worldwide variation in avian clutch size across species and space.** *PLoS Biology* 6:2650–2657.

Klemann-Junior L, Vallejos MAV, Scherer-Neto P, Vitule JRS (2017) **Traditional scientific data Vs. Uncoordinated citizen science effort: A review of the current status and comparison of data on avifauna in Southern Brazil.** *PLoS ONE* 12:e0188819.

Ladle RJ, Correia RA, Do Y, Joo G-J, Malhado AC, Proulx R, Roberge J-M, Jepson P (2016) **Conservation culturomics.** *Frontiers in Ecology and the Environment* 14:269–275.

Le Nghiem TP, Papworth SK, Lim FKS, Carrasco LR (2016) **Analysis of the capacity of google trends to measure interest in conservation topics and the role of online news.** *PLoS ONE* 11:e0152802.

Licarião MR, Bezerra DMM, Alves RRN (2013) **Wild birds as pets in Campina Grande, Paraíba State, Brazil: An Ethnozoological Approach.** *Anais da Academia Brasileira de Ciências* 85:201–213.

Lockwood JL, Welbourne DJ, Romagosa CM, Cassey P, Mandrak NE, Strecker A, Leung B, Stringham OC, Udell B, Episcopio-Sturgeon DJ, Tlusty MF, Sinclair J, Springborn MR, Pienaar EF, Rhyne AL, Keller R (2019) **When pets become pests: the role of the exotic pet trade in producing invasive vertebrate animals.** *Frontiers in Ecology and the Environment* 17:323–330.

Lopes OS, Sacchetta LA, Dente E (1980) **Longevity of wild birds obtained during a banding program in S‹o Paulo, Brazil.** *J. of Field Ornithology* 51(2):144–148.

Magalhães ALB, Jacobi CM (2010) **Comércio eletrônico de peixes ornamentais de água doce: Potencial dispersor de espécies exóticas no Brasil.** *Acta Scientiarum - Biological Sciences* 32:243–248.

Magalhães JP, Costa JJ (2009) **A database of vertebrate longevity records and their relation to other life-history traits.** *Journal of Evolutionary Biology* 22:1770–1774.

Maggini R, Lehmann A, Kéry M, Schmid H, Beniston M, Jenni L, Zbinden N (2011) **Are Swiss birds tracking climate change?. Detecting elevational shifts using response curve shapes.** *Ecological Modelling* 222:21–32.

Matias CAR, Pereira IA, Reis EMF, Rodrigues DP, Siciliano S (2016) **Frequency of zoonotic bacteria among illegally traded wild birds in Rio de Janeiro.** *Brazilian Journal of Microbiology*

47:882–888.

Mazza G, Aquiloni L, Inghilesi A, Giuliani C, Lazzaro L, Ferretti G, Lastrucci L, Foggi B, Tricarico E (2015) **Aliens just a click away: the online aquarium trade in Italy.** *Management of Biological Invasions* 6:253–261.

Minin E Di, Fink C, Hiippala T, Tenkanen H, Di Minin E, Fink C, Hiippala T, Tenkanen H (2019) **A framework for investigating illegal wildlife trade on social media with machine learning.** *Conservation Biology* 33:210–213.

Moher D, Liberati A, Tetzlaff J, Altman DG (2009) **Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement.** *BMJ* 339:b2535–b2535.

Moura SG, Pessoa FB, Oliveira FF (2012) **Animais silvestres recebidos pelo centro de triagem do IBAMA no Piauí no ano de 2011.** *Enciclopédia Biosfera* 8:1748–1762.

Moreira CF (1997) **Comércio ilegal das aves silvestres vivas nas principais feiras da cidade de Belém, Pará, Brasil.** Undergraduate thesis, Universidade Federal Rural da Amazônia, Belém, PA, Brazil.

Morcatty TQ, Feddema K, Nekaris KAI, Nijman V (2021) **Online trade in wildlife and the lack of response to COVID-19.** *Environmental Research* 193:110439.

Myhrvold NP, Baldridge E, Chan B, Sivam D, Freeman DL, Ernest SKM (2015) **An amniote life-history database to perform comparative analyses with birds, mammals, and reptiles.** *Ecology* 96:3109–000.

Nascimento CAR, Czaban RE, Alves RRN (2015) **Trends in illegal trade of wild birds in Amazonas state, Brazil.** *Tropical Conservation Science* 8:1098–1113.

Neto AIS, Fraga RE, Schiavetti A (2022) **Tradition and trade: culture and exploitation of avian fauna by a rural community surrounding protected areas in the south of Bahia's State, Northeastern Brazil.** *Journal of Ethnobiology and Ethnomedicine* 18:1–14.

Oliveira ES, Torres DF, Alves RRN (2020a) **Wild animals seized in a state in Northeast Brazil: Where do they come from and where do they go?** *Environment, Development and Sustainability* 22:2343–2363.

Oliveira WSL, Borges AKM, Lopes SDF, Vasconcellos A, Alves RRN (2020b) **Illegal trade of songbirds: An analysis of the activity in an area of northeast Brazil.** *Journal of Ethnobiology and Ethnomedicine* 16:1–14.

Oliveira WSL, Lopes SF, Alves RRN (2018) **Understanding the motivations for keeping wild birds in the semi-arid region of Brazil.** *Journal of Ethnobiology and Ethnomedicine* 14:1–14.

Pacheco JF, Silveira LF, Aleixo A, Agne CE, Bencke GA, Bravo GA, Brito GRR, Cohn-Haft M, Maurício GN, Naka LN, Olmos F, Posso RS, Lees AC, Figueiredo LFA, Carrano, Eduardo, Guedes RC, Cesari E, Ismael F, Schunck F, Piacentini VQ (2021) **Annotated checklist of the birds of Brazil by the Brazilian Ornithological Records Committee-second edition.** *Ornithology Research* 29: 94–105.

Padrone JMB. (2004). **O comércio ilegal de animais silvestres: avaliação da questão ambiental no estado do Rio de Janeiro**. Msc. Dissertation, Universidade Federal Fluminense, Rio de Janeiro – RJ, Brazil.

Pagano IS de A, Sousa AEBADS, Wagner PGC, Ramos RT da C (2009) **Aves depositadas no Centro de Triagem de Animais Silvestres do IBAMA na Paraíba: uma amostra do tráfico de aves silvestres no estado.** *Ornithologia* 3:132–144.

Pereira GA, Brito MT de (2005) **Diversidade de aves silvestres brasileiras comercializadas nas feiras livres da Região Metropolitana do Recife, Pernambuco.** *Atualidades Ornitológicas* 126:7.

Pessoa TSA, Wagner PGC, Langguth A (2013) **Captura e comercialização de animais silvestres no semiárido da paraiba , Brasil , sob a perspectiva de crianças e adolescentes.** *Revista Nordestina de Biologia* 21:79–100.

Pinho JB, Nogueira M de B (2000) **Mostra da retirada de psitacídeos em cativeiro na cidade de Cuiabá e Pantanal de Poconé, Mato Grosso, no período 1995-1997.** *Ararajuba* 8:51–53.

Preuss JF, Schaedler PF (2011) **Diagnóstico da fauna silvestre apreendida e resgatada pela polícia militar ambiental de São Miguel do Oeste, Santa Catarina, Brasil.** *Unoesc & Ciência* 2:141–150.

Proulx R, Massicotte P, Pépino M (2014) **Googling Trends in Conservation Biology.** *Conservation Biology* 28:44–51.

R Core Team (2021) **R: A Language and Environment for Statistical Computing.**.

Regueira RFS, Bernard E (2012) **Wildlife sinks:**

Quantifying the impact of illegal bird trade in street markets in Brazil. *Biological Conservation* 149:16–22.

Ribeiro J, Reino L, Schindler S, Strubbe D, Vall-llosera M, Araújo MB, Capinha C, Carrete M, Mazzoni S, Monteiro M, Moreira F, Rocha R, Tella JL, Vaz AS, Vicente J, Nuno A (2019) **Trends in legal and illegal trade of wild birds: a global assessment based on expert knowledge.** *Biodiversity and Conservation* 28:3343–3369.

Richards SA (2008) **Dealing with overdispersed count data in applied ecology.** *Journal of Applied Ecology* 45:218–227.

Roldán-Clarà B, Leyva C, Espejel I, López-Medellín X (2021) **The complex social and legal context of the use of live birds in Mexico.** *Ethnobiology and Conservation*, 10. https://doi.org/10.15451/ec2021-09-10.30-1-14

Roldán-Clarà B, Hinojosa REH (2022). **Fruits used in two rural communities of the Sierra Madre Oriental region, Mexico to feed captive *Myadestes* spp. birds for their acclimation.** *Ethnobiology and Conservation* 11. https://doi.org/10.15451/ec2022-12-11.29-1-16

Samia DSM, Nakagawa S, Nomura F, Rangel TF, Blumstein DT (2015) **Increased tolerance to humans among disturbed wildlife.** *Nature Communications* 6:8877.

Santos IB, Costa-Neto EM (2007) Estudo etnoornitológico em uma região do semi-árido do Estado da Bahia. Sitientibus Série Ciências Biológicas 7:273–288.

Sick H (1997) **Ornitologia brasileira.** Nova Fronteira, Rio de Janeiro.

Sigrist T (2009) **Guia de Campo Avis Brasilis - Avifauna Brasileira: Pranchas e Mapas.** 1o ed. Avis Brasilis Editora, Vinhedo, SP -Brasil.

Silva SM, Lima RA (2014) **Levantamento da fauna silvestre no centro de reabilitação do batalhão da polícia militar ambiental nos anos de 2010, 2011 e 2013 no município de Candeias do Jamari-RO.** *Revista Eletrônica em Gestão, Educação e Tecnologia Ambiental* 18:296–311.

Silva S, Braga B, Brasil L, Baía-Júnior P, Guimarães D (2022) **The use of Passeriformes in the eastern Amazonia of Brazil: culture encourages hunting and profit encourages trade.** *Oryx* 56:218–227.

Silva-Jr EF, Kajiki LN, Diniz P, Kanegae MF (2020) **Longevity records for some passerines of central Brazil.** *Ornithology Research* 28:258–262].

Silva SR, Braga B, Silva Costa J., Costa Ribeiro M, Cardoso DL, Zangeronimo MG., Baía Júnior, PC, Araújo Guimarães DA (2023). **Management of captive Passeriformes in eastern Amazonia: the bird keepers.** *Ethnobiology and Conservation* 12. https://doi.org/10.15451/ec2023-07-12.16-1-144.

Siriwat P, Nekaris KAI, Nijman V (2019) **The role of the anthropogenic Allee effect in the exotic pet trade on Facebook in Thailand.** *Journal for Nature Conservation* 51:125726.

Soares HKL, Soares VMS, Lopes SF, Lucena RFP, Barboza RRD (2020) **Rearing and trade of wild birds in a semiarid region of Brazil.** *Environment, Development and Sustainability* 22:4323–4339.

Souto WMS, Torres MAR, Sousa BFCF, Lima KGGC, Vieira LTS, Pereira GA, Guzzi A, Silva MV, Pralon BGN (2017) **Singing for Cages: The Use and Trade of Passeriformes as Wild Pets in an Economic Center of the Amazon—NE Brazil Route.** *Tropical Conservation Science* 10:194008291768989.

Souza GM, Soares Filho A (1998) **Comércio ilegal de aves silvestres na região do Paraguaçu e sudoeste da Bahia.** *Enciclopédia Biosfera* 1:1–11.

Souza TO, Vilela DAR (2013) **Espécies ameaçadas de extinção vítimas do tráfico e criação ilegal de animais silvestres.** *Atualidades Ornitológicas* 176:64–68.

Souza TO, Vilela DAR, Câmara BGO (2014) **Pressões sobre a avifauna brasileira: Aves recebidas pelo CETAS/IBAMA, Belo Horizonte, Minas Gerais.** *Ornithologia* 7:1–11.

Stotz DF, Fitzpatrick JW, Parker III TA, Moskovits DK (1996) **Neotropical Birds Ecology and Conservation.** The University of Chicago Press, Chicago

Stringham OC, Lockwood JL (2018) **Pet problems: Biological and economic factors that influence the release of alien reptiles and amphibians by pet owners.** *Journal of Applied Ecology* 55:2632–2640.

Su S, Cassey P, Blackburn TM (2016) **The wildlife pet trade as a driver of introduction and establishment in alien birds in Taiwan.** *Biological Invasions* 18:215–229.

Su S, Cassey P, Vall-llosera M, Blackburn TM (2015) **Going Cheap: Determinants of Bird Price in the Taiwanese Pet Market.** *PLOS ONE* 10:e0127482-.

Sung Y-HH, Fong JJ (2018) **Assessing consumer trends and illegal activity by monitoring the**

online wildlife trade. *Biological Conservation* 227:219–225.

Svensson MS, Ingram DJ, Nekaris KAI, Nijman V (2015) **Trade and ethnozoological use of African lorisiforms in the last 20 years.** *Hystrix, the Italian Journal of Mammalogy* 26:153–161.

Sy EY (2018) **Trading Faces: Utilisation of Facebook to Trade Live Reptiles in the Philippines.** TRAFFIC, United Kingdom.

Tobias JA, Sheard C, Seddon N, Meade A, Cotton AJ, Nakagawa S (2016) **Territoriality, Social Bonds, and the Evolution of Communal Signaling in Birds.** *Frontiers in Ecology and Evolution* 4:74.

Troumbis AY, Iosifidis S (2020) **A decade of Google Trends-based Conservation culturomics research: A critical evaluation of an evolving epistemology.** *Biological Conservation* 248:108647.

Vall-llosera M, Cassey P (2017) **'Do you come from a land down under?' Characteristics of the international trade in Australian endemic parrots.** *Biological Conservation* 207:38–46.

Venables WN, Ripley BD (2022) **Modern Applied Statistics with S.** 4th ed. Springer, New York .

Wikiaves (2021) **A enciclopédia de aves do Brasil.** [www.wikiaves.com.br] .

Wilman H, Belmaker J, Simpson J, De C, Rosa LA, Rivadeneira MM, Jetz W (2014) **EltonTraits 1.0: Species-level foraging attributes of the world's birds and mammals Ecological Archives E095-178.** [http://esapubs.org/archive].

Young AM, Hobson EA, Lackey LB, Wright TF (2012) **Survival on the ark: life-history trends in captive parrots.** *Animal Conservation* 15:28–43.

Zago DC (2008) **Animais da fauna silvestre mantidos como animais de estimação.** Undergraduate thesis, Universidade Federal de Santa Maria, Santa Maria – RS, Brazil.

Zardo L, Behr R, Macedo A, Pereira L, Lovato M (2014) **Aves nativas e exóticas mantidas como animais de estimação em Santa Maria, RS, Brasil.** *Acta Ambiental Catarinense* 11:33–42.

Zurita GA, Bellocq MI (2010) **Spatial patterns of bird community similarity: Bird responses to landscape composition and configuration in the Atlantic forest.** *Landscape Ecology* 25:147–158.

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Additional Files

Add File 1. Species that do not have a range distribution throughout Brazil's territory, according to BirdLife International (2019).

Order	Family	*Species*
Anseriformes	Anatidae	*Anas versicolor*
Anseriformes	Anatidae	*Coscoroba coscoroba*
Anseriformes	Anatidae	*Cygnus melanocoryphus*
Apodiformes	Trochilidae	*Lophornis magnificus*
Columbiformes	Columbidae	*Columbina minuta*
Columbiformes	Columbidae	*Columbina passerina*
Falconiformes	Falconidae	*Milvago chimango*
Galliformes	Cracidae	*Aburria jacutinga*
Galliformes	Cracidae	*Crax alector*
Galliformes	Cracidae	*Crax blumenbachii*
Galliformes	Cracidae	*Ortalis guttata*
Galliformes	Cracidae	*Penelope jacquacu*
Galliformes	Cracidae	*Penelope jacucaca*
Galliformes	Cracidae	*Penelope marail*
Galliformes	Cracidae	*Penelope obscura*
Gruiformes	Rallidae	*Aramides mangle*
Gruiformes	Rallidae	*Rallus longirostris*
Passeriformes	Cardinalidae	*Amauropiza moesta*
Passeriformes	Cardinalidae	*Cyanoloxia glaucocaerulea*
Passeriformes	Conopophagidae	*Conopophaga lineata*
Passeriformes	Corvidae	*Cyanocorax chrysops*
Passeriformes	Corvidae	*Cyanocorax cyanopogon*
Passeriformes	Cotingidae	*Carpornis cucullata*
Passeriformes	Cotingidae	*Cotinga cotinga*
Passeriformes	Cotingidae	*Pyroderus scutatus*
Passeriformes	Cotingidae	*Rupicola rupicola*
Passeriformes	Estrildidae	*Estrilda astrid*
Passeriformes	Formicariidae	*Chamaeza campanisona*
Passeriformes	Fringillidae	*Chlorophonia cyanea*
Passeriformes	Fringillidae	*Euphonia chalybea*
Passeriformes	Fringillidae	*Euphonia chrysopasta*
Passeriformes	Fringillidae	*Euphonia laniirostris*
Passeriformes	Fringillidae	*Spinus yarrellii*
Passeriformes	Furnariidae	*Annumbius annumbi*
Passeriformes	Furnariidae	*Pseudoseisura cristata*
Passeriformes	Icteridae	*Agelaioides badius*
Passeriformes	Icteridae	*Agelaioides fringillarius*
Passeriformes	Icteridae	*Agelasticus cyanopus*
Passeriformes	Icteridae	*Agelasticus thilius*
Passeriformes	Icteridae	*Amblyramphus holosericeus*
Passeriformes	Icteridae	*Anumara forbesi*
Passeriformes	Icteridae	*Cacicus cela*
Passeriformes	Icteridae	*Cacicus chrysopterus*
Passeriformes	Icteridae	*Molothrus bonariensis*
Passeriformes	Icteridae	*Pseudoleistes guirahuro*
Passeriformes	Icteridae	*Pseudoleistes virescens*
Passeriformes	Icteridae	*Sturnella superciliaris*

Order	Family	*Species*
Passeriformes	Mimidae	*Mimus gilvus*
Passeriformes	Mimidae	*Mimus triurus*
Passeriformes	Mitrospingidae	*Mitrospingus oleagineus*
Passeriformes	Passerellidae	*Ammodramus aurifrons*
Passeriformes	Passerellidae	*Arremon flavirostris*
Passeriformes	Pipridae	*Antilophia galeata*
Passeriformes	Pipridae	*Ilicura militaris*
Passeriformes	Pipridae	*Pipra fasciicauda*
Passeriformes	Pipridae	*Tachyphonus coronatus*
Passeriformes	Scleruridae	*Sclerurus scansor*
Passeriformes	Thraupidae	*Catamenia homochroa*
Passeriformes	Thraupidae	*Chiroxiphia caudata*
Passeriformes	Thraupidae	*Compsothraupis loricata*
Passeriformes	Thraupidae	*Conothraupis speculigera*
Passeriformes	Thraupidae	*Coryphospingus pileatus*
Passeriformes	Thraupidae	*Cyanicterus cyanicterus*
Passeriformes	Thraupidae	*Embernagra longicauda*
Passeriformes	Thraupidae	*Embernagra platensis*
Passeriformes	Thraupidae	*Euphonia cayennensis*
Passeriformes	Thraupidae	*Gubernatrix cristata*
Passeriformes	Thraupidae	*Haplospiza unicolor*
Passeriformes	Thraupidae	*Orchesticus abeillei*
Passeriformes	Thraupidae	*Paroaria capitata*
Passeriformes	Thraupidae	*Paroaria coronata*
Passeriformes	Thraupidae	*Paroaria dominicana*
Passeriformes	Thraupidae	*Paroaria gularis*
Passeriformes	Thraupidae	*Pipraeidea bonariensis*
Passeriformes	Thraupidae	*Pipraeidea melanonota*
Passeriformes	Thraupidae	*Poospiza nigrorufa*
Passeriformes	Thraupidae	*Ramphocelus bresilius*
Passeriformes	Thraupidae	*Ramphocelus nigrogularis*
Passeriformes	Thraupidae	*Saltator aurantiirostris*
Passeriformes	Thraupidae	*Saltator fuliginosus*
Passeriformes	Thraupidae	*Saltator grossus*
Passeriformes	Thraupidae	*Saltator maxillosus*
Passeriformes	Thraupidae	*Sicalis citrina*
Passeriformes	Thraupidae	*Sporophila albogularis*
Passeriformes	Thraupidae	*Sporophila americana*
Passeriformes	Thraupidae	*Sporophila ardesiaca*
Passeriformes	Thraupidae	*Sporophila bouvreuil*
Passeriformes	Thraupidae	*Sporophila castaneiventris*
Passeriformes	Thraupidae	*Sporophila crassirostris*
Passeriformes	Thraupidae	*Sporophila falcirostris*
Passeriformes	Thraupidae	*Sporophila frontalis*
Passeriformes	Thraupidae	*Sporophila maximiliani*
Passeriformes	Thraupidae	*Sporophila melanogaster*
Passeriformes	Thraupidae	*Sporophila minuta*
Passeriformes	Thraupidae	*Sporophila ruficollis*
Passeriformes	Thraupidae	*Sporophila schistacea*
Passeriformes	Thraupidae	*Stephanophorus diadematus*
Passeriformes	Thraupidae	*Tangara cyanocephala*
Passeriformes	Thraupidae	*Tangara fastuosa*
Passeriformes	Thraupidae	*Tangara ornata*
Passeriformes	Thraupidae	*Tangara seledon*
Passeriformes	Thraupidae	*Tiaris fuliginosus*

Order	Family	*Species*
Passeriformes	Thraupidae	*Trichothraupis melanops*
Passeriformes	Troglodytidae	*Cistothorus platensis*
Passeriformes	Turdidae	*Turdus flavipes*
Passeriformes	Turdidae	*Turdus nudigenys*
Passeriformes	Turdidae	*Turdus subalaris*
Passeriformes	Tyrannidae	*Knipolegus lophotes*
Passeriformes	Tyrannidae	*Myiopagis caniceps*
Passeriformes	Vireonidae	*Cyclarhis gujanensis*
Pelecaniformes	Threskiornithidae	*Eudocimus ruber*
Phoenicopteriformes	Phoenicopteridae	*Phoenicopterus ruber*
Piciformes	Capitonidae	*Capito niger*
Piciformes	Picidae	*Melanerpes flavifrons*
Piciformes	Ramphastidae	*Pteroglossus bailloni*
Piciformes	Ramphastidae	*Ramphastos dicolorus*
Piciformes	Ramphastidae	*Ramphastos tucanus*
Piciformes	Ramphastidae	*Ramphastos vitellinus*
Piciformes	Ramphastidae	*Selenidera gouldii*
Piciformes	Ramphastidae	*Selenidera maculirostris*
Psittaciformes	Psittacidae	*Alipiopsitta xanthops*
Psittaciformes	Psittacidae	*Amazona brasiliensis*
Psittaciformes	Psittacidae	*Amazona festiva*
Psittaciformes	Psittacidae	*Amazona ochrocephala*
Psittaciformes	Psittacidae	*Amazona pretrei*
Psittaciformes	Psittacidae	*Amazona rhodocorytha*
Psittaciformes	Psittacidae	*Amazona vinacea*
Psittaciformes	Psittacidae	*Ara severus*
Psittaciformes	Psittacidae	*Aratinga auricapillus*
Psittaciformes	Psittacidae	*Aratinga jandaya*
Psittaciformes	Psittacidae	*Aratinga nenday*
Psittaciformes	Psittacidae	*Aratinga solstitialis*
Psittaciformes	Psittacidae	*Aratinga weddellii*
Psittaciformes	Psittacidae	*Brotogeris sanctithomae*
Psittaciformes	Psittacidae	*Brotogeris tirica*
Psittaciformes	Psittacidae	*Brotogeris versicolurus*
Psittaciformes	Psittacidae	*Deroptyus accipitrinus*
Psittaciformes	Psittacidae	*Eupsittula cactorum*
Psittaciformes	Psittacidae	*Graydidascalus brachyurus*
Psittaciformes	Psittacidae	*Guaruba guarouba*
Psittaciformes	Psittacidae	*Myiopsitta monachus*
Psittaciformes	Psittacidae	*Pionites leucogaster*
Psittaciformes	Psittacidae	*Pionopsitta pileata*
Psittaciformes	Psittacidae	*Pionus fuscus*
Psittaciformes	Psittacidae	*Primolius auricollis*
Psittaciformes	Psittacidae	*Pyrrhura cruentata*
Psittaciformes	Psittacidae	*Pyrrhura frontalis*
Psittaciformes	Psittacidae	*Pyrrhura gryseipectus*
Psittaciformes	Psittacidae	*Pyrrhura melanura*
Psittaciformes	Psittacidae	*Pyrrhura molinae*
Psittaciformes	Psittacidae	*Pyrrhura picta*
Psittaciformes	Psittacidae	*Triclaria malachitacea*
Psittaciformes	Pssitacidae	*Pyrilia caica*
Strigiformes	Strigidae	*Megascops atricapilla*
Suliformes	Phalacrocoracidae	*Nannopterum brasilianus*
Tinamiformes	Tinamidae	*Crypturellus cinereus*
Tinamiformes	Tinamidae	*Crypturellus noctivagus*

Order	Family	*Species*
Tinamiformes	Tinamidae	*Crypturellus obsoletus*
Tinamiformes	Tinamidae	*Nothura boraquira*
Tinamiformes	Tinamidae	*Tinamus solitarius*

Add File 2. Data returned by Google Trends by the regions of Brazil, for species of birds that have more restricted occurrences.

region_of_search (source)	region_of_birds_occurrence (target)	hit
Midwest	Midwest	0
Midwest	North	2
Midwest	Northeast	2,883333333
Midwest	Northeast	4,745714286
Midwest	South	8,636363636
Midwest	Southeast	3,005882353
North	Midwest	0
North	North	2,415217391
North	Northeast	3,344444444
North	South	5,266666667
North	Southeast	2,703636364
North	Southeast	4,367346939
Northeast	Midwest	0
Northeast	Midwest	3,48
Northeast	North	0,933333333
Northeast	North	1,745833333
Northeast	Northeast	3,182608696
Northeast	South	1,966666667
Northeast	Southeast	3,797142857
Northeast	Southeast	4,817757009
South	Midwest	1
South	North	1,816666667
South	Northeast	3,462162162
South	Northeast	4,534782609
South	South	3,48
South	South	4,915328467
South	South	6,015384615
South	Southeast	3,196666667
Southeast	Midwest	7,5
Southeast	North	2,734482759
Southeast	Northeast	4,030645161
Southeast	Northeast	4,5
Southeast	South	4,639354839
Southeast	South	6,55
Southeast	Southeast	3,385365854
Southeast	Southeast	4,883185841

Add File 3. Species that presented new occurrences outside their natural distribution area (about 800km away).

Ordem	Família	Espécies
Passeriformes	Thraupidae	*Paroaria coronata*
Passeriformes	Pipridae	*Tachyphonus coronatus*
Psittaciformes	Psittacidae	*Myiopsitta monachus*
Psittaciformes	Psittacidae	*Ara ararauna*
Passeriformes	Thraupidae	*Paroaria capitata*
Passeriformes	Thraupidae	*Sporophila albogularis*
Passeriformes	Thraupidae	*Paroaria dominicana*
Coraciiformes	Alcedinidae	*Chloroceryle aenea*
Psittaciformes	Psittacidae	*Ara chloropterus*
Passeriformes	Icteridae	*Amblyramphus holosericeus*
Passeriformes	Thraupidae	*Sporophila ardesiaca*
Passeriformes	Furnariidae	*Furnarius rufus*
Anseriformes	Anatidae	*Dendrocygna autumnalis*
Passeriformes	Cardinalidae	*Cyanoloxia glaucocaerulea*
Passeriformes	Passerellidae	*Ammodramus aurifrons*
Gruiformes	Rallidae	*Mustelirallus albicollis*
Passeriformes	Icteridae	*Cacicus cela*

Add File 4. Exponentiates coefficients (odds ratio) of the explanatory variables used to assess the factors related to the birds that presented new occurrences outside their natural range. (odds ratio >1 = greater chances of success; odds ratio <1 = smaller chances of success; odds ratio= 1 = no change).

Variables	Exponentiated coefficents (odds ratio)
Diet: Invertebrates	1.160207
Diet: Plants	0
Diet: Seeds	8.644882
Diet: Nectar	0
Diet: Omnivore	1.067479
Habitat: open	0
Habitat: semi-open	3.880126
Songbird:yes	1.639462
Price	1.002160