Singing for Cages: The Use and Trade of Passeriformes as Wild Pets in an Economic Center of the Amazon—NE Brazil Route

Authors: Souto, Wedson Medeiros Silva, Torres, Mauro Aparecido Ribeiro, Sousa, Breno Fernando Cunha Freitas, Carvalho Lima, Katyelle Gonçalves Guimarães, Vieira, Lorena Tupinambá Serra, et al.

Source: Tropical Conservation Science, 10(1)

Published By: SAGE Publishing

URL: https://doi.org/10.1177/1940082917689898

Research Article

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
Volume 10: 1–19

DOI: 10.1177/1940082917689898
journals.sagepub.com/home/trc
SAGE

Wedson Medeiros Silva Souto[1,2,3], Mauro Aparecido Ribeiro Torres[2], Breno Fernando Cunha Freitas Sousa[2], Katyelle Gonçalves Guimarães Carvalho Lima[2], Lorena Tupinambá Serra Vieira[3], Glauco Alves Pereira[4], Anderson Guzzi[5], Mateus Vieira Silva[3], and Bruno Gabriel Nunes Pralon[1,3]

Abstract

Illegal bird-keeping and pet trade are some of the major threats to Neotropical birds. The aim of the present study was to detail aspects of the use and trade of wild Passeriformes as pets in an ecotonal zone of Caatinga-Cerrado domains in middle-north of Brazil, a western subregion of northeastern (NE) Brazil which also is a road hub interconnecting this region to the Amazon and other Brazilian areas. Information on the use of avifauna was obtained through semistructured interviews with 61 bird-keepers or trappers and investigations in the municipal market of Floriano, Piauí State. Our results reveal that at least 39 passerine species are targeted as pets in surveyed areas. Based on Use-Value (UV) index, the main recorded species were *Sporophila lineola*, *Charitospiza eucosma*, *Sporophila nigricollis*, *Sporophila plumbea*, *Paroaria dominicana*, *Sicalis flaveola*, *Gnorimopsar chopi*, *Sicalis columbiana*, *Mimus saturninus*, and *Turdus rufiventris*. In general, younger respondents (<30 years old) trapping more species than older persons (≥50 years old), as well as trappers engaged in wild pet trade explored a higher species richness by respondents. The regional bird market chain was typically performed outside municipal market of Floriano and facilitated by popularization of technological improvements (motorcycles, smartphones, and social media). New strategies urgently need to be developed to improve bird conservation, including establishment and maintenance of environmental education programs, media campaigns and development of a well-monitored system for captive breeding, and reproduction of wild birds exploited as pets.

Keywords

ethno-ornithology, ethnozoology, bird trade, wildlife conservation, pet-keeping, cage bird

Introduction

Humans use wild animals for many different purposes, but especially as food resources, traditional medicines, hunting trophies, and pets (Alonso-Castro, 2014; Barboza, Lopes, Souto, Fernandes-Ferreira, & Alves, 2016; Lindsey et al., 2013; Van Vliet et al., 2015). The capture of legal and illegal trade of wild animals as pets is an especially widespread practice throughout the tropics, with uncounted millions of specimens belonging to all vertebrate taxa being captured annually (Alves, Lopes, & Alves, 2016; Jepson & Ladle, 2009;

[1]Federal University of Piauí (UFPI), Department of Biology, Teresina, Piauí, Brazil
[2]Laboratory of Ethnobiology and Conservation, UFPI, Floriano, Piauí, Brazil
[3]Laboratory of Zoology, Use and Conservation of Ecotonal Fauna from South America, Federal University of Piauí, Teresina, Piauí, Brazil
[4]Post-Graduation Program in Ethnobiology and Nature Conservation (PPGEtno), Department of Biology, Federal Rural University of Pernambuco (UFRPE), Recife, Pernambuco, Brazil
[5]Departamento de Biologia, UFPI, Campus Ministro Reis Velloso, Centro de Ciências do Mar, Parnaíba, Piauí, Brazil

Received 12 November 2016; Revised 22 December 2016; Accepted 27 December 2016

Corresponding Author:
Wedson Medeiros Silva Souto, Federal University of Piauí, Campus Ministro Petrônio Portella, Department of Biology, Ininga, Teresina 64049-550, Brazil.
Email: wedson@ufpi.edu.br

Nascimento, Czaban, & Alves, 2015; Nijman, Shepherd, Mumpuni, & Sanders, 2012; Sodhi, Sekercioglu, Barlow, & Robinson, 2011).

The monetary figures involved in the wild pet trade and the numbers of species taken from nature in tropical regions are alarmingly high. The legalized international trade of live specimens for pet purposes handled 3.9 million songbirds, 2.5 million parrots, and earned USD $85 million by trading birds, reptiles, and amphibians from 2000 to 2005 (Roe, 2008). An older estimate dating from the mid-1980s indicated that bird trappers annually earned an average of USD $6.6 million per year (adjusted value for 2016: USD $14.5 million) with annual exports of 280,000 parrots in Neotropical countries alone, with middlemen receiving USD $22.8 million (~BRL $50.14 million) by reselling them (Freese, 1998). However, species richness, the numbers of specimens, the total money earned, and other impacts of the illegal pet trade are underestimated or poorly tallied as a result of the clandestine nature of that trade (Destro, Pimentel, Sabaini, Borges, & Barreto, 2012; WWF, 2012).

The trapping and trading of live wild animals are serious problems in countries with high biodiversity such as Brazil and its Neotropical neighbors (Cruz-Antia, 2010; Nascimento et al., 2015), and these activities are usually in violation of the Convention on International Trade in Endangered Species of Wild Fauna and Flora treaty and national laws (BirdLife International, 2008). Aves is the main taxon exploited for pets for illegal domestic and international trading in South American countries (Alves et al., 2016; Cruz-Antia, 2010; Daut, Brightsmith, Mendoza, Puhakka, & Peterson, 2015; Fernandes-Ferreira, Mendonça, Albano, Ferreira, & Alves, 2012; Neme, 2015). Until the late 1970s and early 1980s, ''feiras de passarinhos'' (passerines markets) were common in almost all Brazilian cities, with wild animals being openly sold in large numbers (Sick & Teixeira, 1979; Souza, Vilela, & Câmara, 2014). Although Brazil is an international supplier for illegal pet markets, the domestic pet market is the primary driving force for their trapping and commercialization (Destro et al., 2012), with birds representing nearly 80% of trafficked animals in that country (Neme, 2015).

Due to their gorgeous colors and singing abilities, birds of the order Passeriformes (passerines) are extensively trapped and traded in Latin America. According to Convention on International Trade in Endangered Species, passerines represent 70% of all specimens traded internationally as pets in Latin American countries (FAO, 2011), and although cultural factors and local biodiversity affect the illegal domestic use and trading of birds as pets (Alves et al., 2016; Roldán-Clarà, López-Medellín, Espejel, & Arellano, 2014), it is well known that passerines are the main species group sold as pets throughout Brazil (Destro et al., 2012; Fernandes-Ferreira et al., 2012; Nascimento et al., 2015; Regueira & Bernard, 2012). Based on data from the Brazilian Institute of Environment and Renewable Natural Resources (IBAMA) from the late 1990s and early 2000s, Godoy and Matushima (2010) determined that passerines represent 9 of the 10 bird species most commonly trafficked, and that the principal geographic area of their commercial distribution was Northeastern (NE) Brazil.

Concerns about the illegal domestic market for wild birds have been repeatedly expressed by conservationists. Extensive removal of Neotropical birds has led to decrease in their natural populations and, in several instances, has driven species to critical conservation levels or even to extinction (Cruz-Antia, 2010; Fernandes-Ferreira et al., 2012). It is well documented that their capture as a hobby or to support the illegal domestic trade in wild pets, in synergism with habitat loss, has led to severe population reductions and the contraction of the areas of distribution of the once-abundant passerines Buffy-fronted Seedeater *Sporophila frontalis* (Verreaux, 1869) and Saffron-cowled Blackbird *Xanthopsar flavus* (Gmelin, 1788) in southeastern and southern Brazil, respectively (BirdLife International, 2012).

To achieve sustainability in the use of wild species, it is necessary to know which species are being captured and the socioeconomic and cultural significance of their use (Alves, Nogueira, Araujo, & Brooks, 2010). This information can only be obtained through ethno-ornithological studies focusing on the target species of hunters and local traders, the dynamics of illegal markets, and drivers that lead people to trap and sell wild birds (Alves et al., 2016; Fernandes-Ferreira et al., 2012; Shepherd, 2006). Studies examining use and trade of wild birds by human populations are essential to developing effective strategies for bird conservation and management, as they take into consideration local realities and identify possible solutions to specific social, economic, and environmental contexts in different regions (Alves et al., 2016; Jepson & Ladle, 2009; Licarião, Bezerra, & Alves, 2013).

Many studies on the use and trading of terrestrial vertebrates exploited as pets in Brazil have been published in recent years, although they have largely focused on data obtained from traders or end-consumers in major metropolitan areas and regional economic centers (Alves et al., 2016; Costa, 2005; Regueira & Bernard, 2012). Wildlife seizure data have also been published (Destro et al., 2012; Souza et al., 2014), but there is a lack of available information concerning bird-keeping, trapping, their trading routes, and the dynamics of trading in wild birds in several parts of Brazil, including ecotones or remote zones. Many distant regions are considered important wildlife sources or likely places of intense trading activities in wild animals (RENCTAS, 2001).

The present study evaluates the use and trading of wild Passeriformes as pets in urban and peri-urban settings in an ecotone region and an important economic center and road hub in southern Piauí State, in NE Brazil. We provide here data concerning the diversity and trade dynamics of wild passerines captured in the western region of NE Brazil (also known as the Middle-Northern region) and record the techniques and strategies used for trapping and selling wild passerines. Our hypothesis is that socioeconomic factors (income, age, education level, and involvement in the trade of wild birds) influence the bird richness exploited by bird trappers.

Methods

Study Area

The field research was undertaken in urban and peri-urban areas in the municipality of Floriano, Piauí State, Brazil, as well as in and around the community of Manga (Figure 1). The municipality of Floriano is located in southwestern Piauí State (UN-PNUD, 2013), covers 3,423 km^2, with less than 30 km^2 representing urban areas (UN-PNUD, 2013); the total population of the municipality is approximately 58,800, with 85% of the inhabitants being urban residents (IBGE, 2016). The human development index (HDI) of Floriano was 0.7 in 2010 (high human development) (UN-PNUD, 2013), although there are noticeable social inequalities in different regions (Ferasso, Melo Júnior, Magalhães, & Schröeder, 2016).

Floriano is the fifth largest city in Piauí and an emerging regional development center (Santos & Rathmann, 2009; World Bank, 2003), with three major highways crossing it: Federal Highways BR-230 and BR-343 and State Highway PI-140 (CECI, 2007). BR-230 is the famous Transamazonian highway linking the metropolitan regions of the city of João Pessoa in Paraíba State (NE Brazil) with Lábrea in Amazonas State (Amazon region) (Walker, Perz, Arima, & Simmons, 2011). Studies have shown that wild animals are trapped and heavily traded (by wildlife traffickers or by local residents of several nearby areas) along the BR-230 highway (Bonaudo, Le Pendu, Faure, & Quanz, 2005; RENCTAS, 2001; Sills et al., 2014; Smith, 1976), while the Transamazonian and BR-153 highways are probably the principal routes used for wildlife trafficking in Brazil (Hernandez & Carvalho, 2006). The BR-343 highway connects northern Piauí State (the Parnaíba River Delta, a region with a rich biological diversity) to the southern part of that state, and then junctions with other routes to central-western and southeastern Brazil (RENCTAS, 2001).

Manga is a border community 55 km from Floriano (Google Maps©, 2016) that encompasses two sister villages, Manga-Piauí and Manga-Maranhão, which are

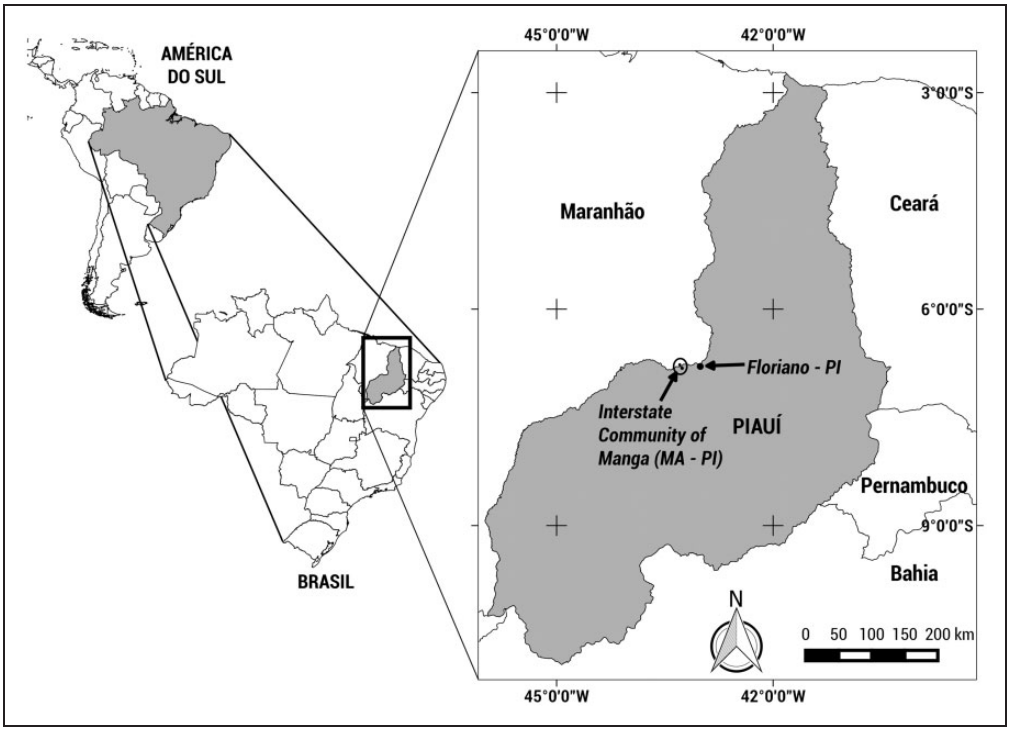

Figure 1. Study area: Municipality of Floriano (Piauí State) and interstate community of Manga (Maranhão and Piauí States).

parts of the municipalities of Floriano-PI and Barão de Grajaú-MA. These two towns have populations of approximately 700 inhabitants (Community Association estimates), and their economic activities include fishing, livestock raising (cattle, goats, and chickens), and subsistence agriculture (cassava, beans, and several fruits) (Google Maps©, 2016). Local residents also engage in bushmeat hunting for food and medicinal purposes (W. M. S. Souto, personal observations, 2016).

The regional climate is semiarid, with mean monthly temperatures between 25°C and 28°C (CECI, 2007). The study area is located in an ecotone region between Cerrado (Neotropical savanna) and Caatinga (deciduous thorny dryland) vegetations (Castro, 2003), with a mean annual rainfall of 1,100 mm (Viana, Vasconcelos, Azevedo, & Souza, 2002).

Data Collection

Data collection was undertaken from August 2015 to May 2016. As in previous ethnozoological studies (e.g., Souto et al., 2011; Souza & Alves, 2014), data were collected using semistructured questionnaires complemented with unstructured interviews and informal conversations. The questionnaires covered the following key points: (a) socioeconomic aspects; (b) if interviewees trapped wild animals to capture pets; (c) (illegal) trade aspects of live wild animals; (d) trapping techniques and strategies; (e) means of transportation to preferred trapping areas; and (f) reasons for capturing wild animals.

Data collection followed a convenience-sampling procedure (Kamins et al., 2011) that considered people encountered in the study areas with native wild pets in their homes or transporting or selling live wild animals as pets. Only people who acknowledged capturing wild animals were considered in this sample. All interviews were conducted by a single researcher (M. A. R. T.), while other workers (W. M. S. S., B. F. C. F. S., and K. G. G. C. L.) contributed by locating participants for the study. This sampling procedure was adopted because the hunting or trapping of native species is illegal in Brazil (Federal Law No. 9.605/98) and most people tend to be reluctant to (or refuse to) participate in this type of research (Alves & Souto, 2010).

Rapport was the most important element in this study, enabling us to undertake interviews with goodwill. Once a potential interviewee was identified, we scheduled a meeting location for further conversations. During the first, more informal, conversations, we addressed aspects of the local biodiversity and provided information concerning the research project itself. The meeting localities were always chosen by the participants, generally their residences or workplaces.

Additionally, two local residents were recruited (by WMSS) to voluntarily check whether wild pets were being sold in the Floriano Municipal Market, and the relationships of this market with the live wild animal trade chain. The volunteers acted as if they were customers interested in purchasing wild pet animals during three visits to the local market (December 2015, and February and April 2016). The volunteers asked local merchants where they could acquire specimens or find wild animals traders, and also attempted to buy songbirds, mammals, or chelonian species (popular pets in Brazil) at the market (Alves et al., 2016; Destro et al., 2012; Fernandes-Ferreira et al., 2012). The information obtained from the market traders was compared with data provided by the trappers who were interviewed to elucidate the local trade chain. This strategy was a simplification of the procedures used by TRAFFIC© to investigate the wildlife trade for pet and medicine purposes in Southeast Asia (Nowell, 2000; Shepherd & Magnus, 2004; Shepherd, Sukumaran, & Wich, 2004). More detailed data (e.g., the numbers of specimens sold by market traders) was not sought in this study as it is virtually impossible to obtain reliable information concerning this highly local and secretive trade, and it would have exposed the volunteers and researchers to certain risks.

The research was approved by the Ethics Committee of the Federal University of Piauí, Campus Ministro Petrônio Portella (CMPP; Protocol number CAAE 47887015.9.0000.5214). Prior to each interview with the pet trappers, they were asked to sign a Free Consent and Understanding Agreement (TCLE).

Species Identifications, Food Habits, and Conservation Aspects

Passeriformes identifications were based on: (a) specimens held by the trappers or traders themselves; (b) photographic records of specimens obtained during guided tours with some interviewees or other local residents; and (c) through the identification of vernacular names (with the help of taxonomists who were familiar with the local wildlife; WMSS, AG, BFCFS, GAP). Birds were also identified with aid of specialized literature (Sigrist, 2009) and reliable digital sources (WikiAves, 2016). The classification and nomenclature used followed the determinations of the Brazilian Committee of Ornithological Registration for Birds (CBRO; Piacentini et al., 2015). The conservation status of the recorded species follows IUCN Red List version 2016.1 (IUCN, 2016). The food habitats of the passerines were based on Myers et al. (2016), Santos (2004), and WikiAves (2016).

Data Analysis

UV, an ethnobiological index adapted from Phillips and Gentry (1993) by Rossato, Leitão-Filho, and

Begossi (1999), was employed for quantifying the relative importance of each species reported. UV was calculated as follows: $UV = \sum U/n$, where U is the number of citations per species; and n is the number of informants or interviewees.

Incidence-based data (such as Alves et al., 2016) were used to quantify the number of species reported by the interviewees (samples). The sampling effort was evaluated using species accumulation curves, computed as the average of 1,000 randomized species accumulation curves based on a species-by-sample incidence-based matrix (Colwell & Coddington, 1994). The nonparametric species richness estimators Chao 2 and Jackknife 2 were used to estimate sampling completeness (Gotelli & Colwell, 2011). Chao 2 and Jackknife 2 have been successfully used in ethnobiological research (Alves, Gonçalves, & Vieira, 2012; Bonifácio, Freire, & Schiavetti, 2016; Ferreira, Fernandes-Ferreira, & Léo Neto, 2013; Whiting, Williams, & Hibbitts, 2011). EstimateS version 9.1.0 software (Colwell, 2013) was used to calculate both Chao 2 and Jackknife 2, in addition to the species accumulation curves.

Nonparametric univariate statistics were utilized to assess the influence of socioeconomic factors (age, education level, residence zone, trade in zootherapeutic species) on the species richness exploited by hunters. All statistical tests were performed using IBM SPSS version 23 (IBM© Corp., 2014) or BioEstat version 5.3 software (Ayres, Ayres Jr., Ayres, & Santos, 2005). The level of significance adopted was 5% ($p < .05$) in all cases.

Results

Trapper Profiles

A total of 67 local residents consented to participate in this study. Of that total, 61 admitted to participating in the trapping or trading of passerines and composed the effective research sample. Table 1 summarizes the socioeconomic aspects of interviewees. In general, bird trappers were men ($n = 52$; 85.25%) with low education levels, but often with personal incomes higher than the minimum wage and owned motor vehicles (Table 1).

Mobile phone (or smartphone) ownership, access to tap water, and electricity were universal among the interviewees, and are not itemized in Table 1.

Table 1. Key Socioeconomic Profiles of Bird-Trappers Interviewed.

Socioeconomic aspect	*n*	%
Locality		
Community of Manga (Piauí and Maranhão States)	4	6.56%
Floriano (urban and peri-urban (except Manga residents))	57	93.44%
Gender		
Female	9	14.75%
Male	52	85.25%
Age group		
Less than 30 years old (y.o)	21	34.43%
≥30 y.o. e < 50 anos y.o.	22	36.07%
≥50 y.o.	18	29.51%
Schooling		
A—Very low (Illiterate or semi-literate)	9	14.75%
B—Low (incomplete or complete elementary school "ensino fundamental")	31	50.82%
C—Medium (incompleteor complete secondary school "ensino médio")	21	34.43%
Personal income		
A—Low	16	26.23%
≤minimum wage (BRL $ 788/ USD $ 229.4)	16	26.23%
B—Medium-high	45	73.77%
>1 e ≤2 minimum wage (USD $ 229.4–$ 458.8)	43	70.49%
>2 minimum wage (USD $ 458.8)	2	3.28%
Internet access daily		
Yes	32	52.46%
No	29	47.54%
Motorized vehicle(s) at home		
A—Yes	39	63.93%
Motorcycle	23	37.70%
Car	8	13.11%
Both	8	13.11%
B—No	22	36.07%
Sell wild Passeriformes		
Yes	25	40.98%
No	36	59.02%

Sampling Effort and Target Species

Thirty-nine bird species were reported as being targeted by trappers (Table 2). Only one species was not native to the Brazilian fauna: the Common Waxbill *Estrilda astrild* (Linnaeus, 1758)—a bird that was apparently introduced into Brazil with the slave trade in the first half of the 19th century (Fontoura, Dyer, Blackburn, & Orsi, 2013). *E. astrild* now has well-established populations throughout Brazil that are exploited in the wild pet trade (Rocha, Bergallo, & Mazzocchi, 2011; Silva & Oren, 1990).

Chao 2 estimated 47.2 ± 6.8 (*SD*) passerine species targeted by trappers in the study region, whereas Jackknife 2 estimated 52.8 species. Consequently, our sampling effort ranged from 73.6%, Richness species observed

Table 2. Passeriformes Species Reported by Bird-Keepers or Trappers of Floriano Region, Piauí State, Middle-North of NE Brazil.

Family or species—local name (in portuguese), English name	UV	IUCN Red List 2016-1	Food habits	Prices
Estrildidae				
Estrilda astrild (Linnaeus, 1758)—bico-de-lata/bico-de-lacre, Common Waxbill	0.03	LC	gr	$[a]
Corvidae				
Cyanocorax cyanopogon (Wied, 1821)—cancão, White-naped Jay	0.06	LC	om	$[a]
Cardinalidae				
Cyanoloxia brissonii (Lichtenstein, 1823)—azulão, Ultramarine Grosbeak	0.04	LC	pgr	$[a]
Fringillidae				
Euphonia chlorotica (Linnaeus, 1766)—vim-vim, Purple-throated Euphonia	0.07	LC	fr	BRL 5 (USD 1.45) (sm)
Spinus yarrellii (Audubon, 1839)—pintassilva, Yellow-faced Siskin	0.04	VU	gr	BRL 200–500 (USD 58.14–145.35) (sm), BRL 100–300 (USD 29–87.21) (f, nsm)
Icteridae				
Chrysomus ruficapillus (Vieillot, 1819)—casaca, Chestnut-capped Blackbird	0.04	LC	om	$[a]
Gnorimopsar chopi (Vieillot, 1819)—chico-preto, Chopi Blackbird	0.25	LC	om	BRL 300–1,000 (USD 87.21–290.7) (sm), BRL 10–50 (USD 2.91–14.53) (nsm)
Icterus jamacaii (Gmelin, 1788)—sofreu (or concriz), Campo Troupial	0.15	LC	om	BRL 20 (USD 5.81) (m), "very cheap" (< BRL 5) (< USD 1.45) (f)
Icterus pyrrhopterus (Vieillot, 1819)—pega (or xexéu-de-bananeira), Variable Oriole	0.1	LC	om	BRL 15–60 (m) (USD 4.36–17.44), "very cheap" (< BRL 5) (f)
Cacicus cela (Linnaeus, 1758)—xexéu-de-bananeira, Yellow-rumped Cacique	0.1	LC	om	$[a] ("expensive")
Psarocolius decumanus (Pallas, 1769)—rei-congo (or japu), Crested Oropendola	0.01	LC	fr	$[a] ("expensive"; BRL > 200, > USD 58.14)
Mimidae				
Mimus saturninus (Lichtenstein, 1823)—sabiá-do-campo, Chalk-browed Mockingbird	0.21	LC	om	$[a]
Passerellidae				
Zonotrichia capensis (Statius Muller, 1776)—tico-tico, Rufous-collared Sparrow	0.03	LC	om	$[a] ("very cheap")
Polioptilidae				
Polioptila plumbea (Gmelin, 1788)—gatinha, Tropical Gnatcatcher	0.01	LC	in	$[a] ("very cheap")

(continued)

Table 2. Continued

Family or species—local name (in portuguese), English name	UV	IUCN Red List 2016-1	Food habits	Prices
Thraupidae				
Charitospiza eucosma (Oberholser, 1905)—papa-capim-amarelo, Coal-crested Finch	0.42	NT	gr	BRL 20–50 (USD 5.81–USD 14.53) (ms), BRL 2–15 (USD 0.58–4.36) (nsm, f)
Coryphospingus pileatus (Wied, 1821)—sítio (or maria-fita), Pileated Finch	0.01	LC	gr	BRL 30–50 (USD 8.72–14.53) (ms), BRL 5 (USD 1.45) (nsm, f)
Paroaria dominicana (Linnaeus, 1758)—galo-de-campina, Red-cowled Cardinal	0.33	LC	pgr	BRL 30–500 (ms) (USD 8.72–145.35), BRL 5–30 (nsm, f) (USD 1.45–8.72)
Porphyrospiza caerulescens (Wied, 1830)—azulão-pequeno, Blue Finch	0.04	NT	pgr	$[a]
Saltator similis (d'Orbigny & Lafresnaye, 1837)—trinca-ferro, Green-winged Saltator	0.01	LC	om	$[a]
Saltator maximus (Statius Muller, 1776)—trinca-ferro, Buff-throated Saltator	0.01	LC	om (pfr)	$[a]
Sicalis columbiana (Cabanis, 1851)—canário-cochicho (or cochicho), Orange-fronted Yellow-Finch	0.24	LC	gr	BRL 40–100 (sm) (USD 11.63–29.07), BRL 10–30 (USD 2.91–8.72) (nsm, f)
Sicalis flaveola (Linnaeus, 1766)—canário-da-terra, Saffron Finch	0.31	LC	gr	BRL 50–300 (USD 14.53–87.21) (sm), BRL 10–100 (USD 2.91–29.07) (nsm, f), > BRL 500 (> USD 145.35) (mbf)
Sicalis luteola (Sparrman, 1789)—gaturamo, Grassland Yellow-Finch	0.04	LC	pgr	BRL 15 (USD 4.36) (sm), BRL 5 (USD 1.45) (f, nsm)
Sporophila angolensis (Linnaeus, 1766)—curió, Chestnut-bellied Seed-Finch	0.12	LC	pgr	BRL 80–200 (USD 23.26–58.14) (sm), BRL 20–100 (USD 5.81–29.07) (nsm, f)
Sporophila bouvreuil (Statius Muller, 1776)—caboclinho, Copper Seedeater	0.03	LC	gr	$[a]
Sporophila leucoptera (Vieillot, 1817)—chorona, White-bellied Seedeater	0.01	LC	gr	$[a]
Sporophila lineola (Linnaeus, 1758)—bigode, Lined Seedeater	0.49	LC	gr	BRL 20–200 (USD 5.81–58.14) (sm) BRL 5–25 (USD 1.45–7.27) (nsm, f)
Sporophila maximiliani (Cabanis, 1851)—bicudo, Great-billed Seed-Finch	0.03	VU	gr	$[a] ("expensive")
Sporophila nigricollis (Vieillot, 1823)—papa-capim, Yellow-bellied Seedeater	0.42	LC	gr	BRL 20–150 (USD 5.81–43.06) (sm) BRL 2–15 (USD 0.58–4.36) (nsm, f)
Sporophila plumbea (Wied, 1830)—patativa, Plumbeous Seedeater	0.39	LC	gr	BRL 50–300 (USD 14.53–87.21) (sm), BRL 5–50 (USD 1.45–14.53) (nsm)
Sporophila albogularis (Spix, 1825)—coleiro (or golado), White-throated Seedeater	0.12	LC	gr	BRL 50–250 (sm) (USD–14.53–72.68), BRL 20–50 (USD 5.81–14.53) (nsm, f)

(continued)

Table 2. Continued

Family or species—local name (in portuguese), English name	UV	IUCN Red List 2016-1	Food habits	Prices
Tangara palmarum (Wied, 1821)—pipira-verda (or sanhaçu-verde), Palm Tanager	0.03	LC	om	$[a] ("cheap")
Tangara sayaca (Linnaeus, 1766)—pipira-azul, SayacaTanager	0.1	LC	om	$[a] ("cheap")
Tachyphonus rufus (Boddaert, 1783)—pipira-preta, White-lined Tanager	0.01	LC	pfr	$[a] ("cheap")
Volatinia jacarina (Linnaeus, 1766)—tiziu, Blue-black Grassquit	0.01	LC	pgr	$[a] ("cheap")
Tyrannidae				
Pitangus sulphuratus (Linnaeus, 1766)—bem-te-vi, Great Kiskadee	0.01	LC	om	$[a]
Turdidae				
Turdus amaurochalinus (Cabanis, 1850)—sabiá-bico-de-osso, Creamy-bellied Trush	0.01	LC	om	$[a]
Turdus leucomelas (Vieillot, 1818)—sabiá-pardo (or barranco), Pale-breasted Trush	0.03	LC	om	$[a]
Turdus rufiventris (Vieillot, 1818)—sabiá-laranjeira (or sabiá-verdadeiro), Rufous-bellied Trush	0.21	LC	om	BRL 15–200 (USD 4.36–58.14) (sm, nsm, f)

Note. UV = Use-value; Red List Categories: LC = Least Concern; NT = Near Threatened; VU = Vulnerable. Food habits of Passeriformes: fr = frugivorous; gr = granivorous; in = insectivorous; om = omnivorous; pfr = predominantly frugivorous; pgr = predominantly granivorous. About prices: $[a] = bird known as sold, but without a specified price; sm = singing male; f = female; nsm = not singing male; m = male; mbf = male for bird fights ("*rinhas*"). Currencies: BRL = Brazilian Real; USD = United States Dollar.

(Sobs)/Jack 2, to 82.98%, Sobs/Chao 2. The sampling effort was high because the Chao 2 species accumulation curve reached its asymptote, while the Jack 2 curve was close to stabilization (Figure 2).

The average number of bird species reported per trapper was 5.16 ± 4.22. Some socioeconomic factors influenced the numbers of species reported by the interviewees. The numbers of species reported by each trapper were significantly different according to the interviewee's age group (Kruskal–Wallis $H = 9.16$, $gl = 2$, $p = .01$), with younger participants (<30 years old) trapping more different species than older individuals (≥50 years old; post hoc Dunn test, $p < .05$; mean ranking young trappers = 38.45; mean ranking most older trappers = 21.19). Our results also showed that the engagement of hunters in the wild pet trade encourages the exploitation of greater passeriform species richness (Mann–Whitney $U = 628.5$, $n_{(\text{sell pets})} = 25$, $n_{(\text{doesn't sell pets})} = 36$, mean ranking$_{(\text{sell})} = 38.14$, mean ranking$_{(\text{doesn't sell pets})} = 26.04$, $p = .008$). Personal income (Mann–Whitney U, $p > .05$), on the other hand, and education levels (Kruskal–Wallis H, $p > .05$) did not influence the number of species reported by the trappers.

Thraupidae ($n = 21$ spp.), Icteridae (6 spp.), Fringillidae, and Turdidae (both 3 spp.) were the most important families in terms of species richness. The major target birds recorded by trappers, based on UV, were the Lined Seedeater *Sporophila lineola* (UV = 0.49), the Coal-crested Finch *Charitospiza eucosma* and the Yellow-bellied Seedeater *Sporophila nigricollis* (both with UV = 0.42), the Plumbeous Seedeater *Sporophila plumbea* (0.39), the Red-cowled Cardinal *Paroaria dominicana* (0.33), the Saffron Finch *Sicalis flaveola* (0.33), the Chopi Blackbird *Gnorimopsar chopi* (0.25), the Orange-fronted Yellow-Finch *Sicalis columbiana* (0.24), and the Chalk-browed Mockingbird *Mimus saturninus* and the Rufous-bellied Thrush *Turdus rufiventris* (0.21; Table 2). Most species are granivorous ($n = 18$ spp.; 46.15%) or omnivorous ($n = 16$; 41.03%). One species targeted by bird trappers (The Tropical Gnatcatcher *Polioptila plumbea*), however, is insectivorous. Examples of illegally trapped and traded passerines in southern Piauí are shown in Figure 3.

In addition to trapping for household pets, some bird species are used in bird fights, locally known as *rinhas*. According to interviewees, the "*canário-da-terra*" *Sicalis*

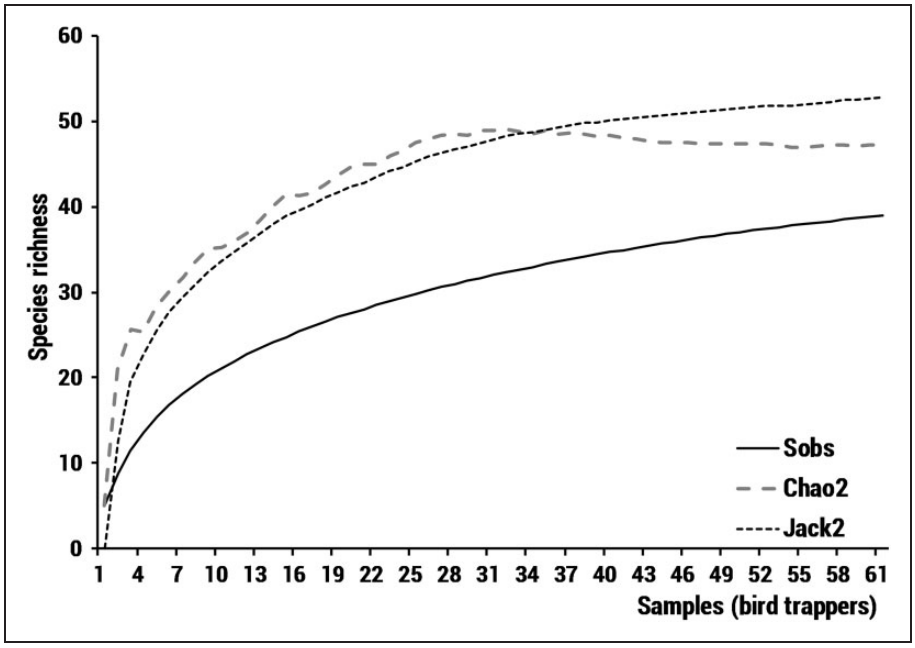

Figure 2. Species accumulation curve (Chao 2 and Jackknife 2 estimators), comparing the number of observed species (Sobs) and the estimated richness of Passeriformes species exploited as wild pets in surveyed area.

flaveola is the most commonly used passerine for bird fights, in addition to *Paroaria dominicana*, *Sicalis columbiana*, and *Sporophila* spp. Trappers reported that *rinhas* are usually held on weekends at clandestine venues at the organizers' or trappers' homes. During these bird fight events, two or three adult males of a single species are put in a cage adjacent to a cage containing a female of the same species (to encourage sexual fights between males). The male bird most seriously injured by the end of the combat is considered the loser. The interviewees noted that bird deaths were common in *rinhas* fights, especially among *S. flaveola* males. Our interviews and observations of caged birds indicated that many of the birds not immediately dying in *rinhas* bouts can nonetheless be seriously injured or blinded.

Trapping and Bird-Keeping

Passerine trapping occurs mainly in the months of December ($n = 39$; 63.93%), January ($n = 44$; 72.13%), February ($n = 37$; 60.66%), and March ($n = 30$; 49.18%). These are the rainiest months in the region (Medeiros, Azevedo, Saboya, & Francisco, 2013), and practically all of the interviewees reported an abundance of passerines during this period. All of the interviewees indicated that at least three species (*Sporophila albogularis*, *Sporophila angolensis*, and *Sporophila lineola*) were only encountered in the rainy season.

The trappers captured birds mainly during the day. Trapping expeditions normally start in the early morning hours (between 3 a.m. and 5 a.m.) and terminate by late afternoon. Only seven trappers (11.47%) reported a preference for capturing birds at night. Bird trapping at night requires the use of rechargeable LED flashlights (which can be purchased locally for about BRL $20.00 [USD $5.81; April 2016]). Night time trapping excursions do not use traps and are designed to take young passerines in their nests or sleeping adults. Daylight trapping excursions, on the other hand, are more diverse in terms of their capture strategies and target species. In addition to the direct capture of young passerines in their nests, the interviewees reported three other popular techniques or strategies for harvesting birds during the daytime: *gaiolas assaprão* (trap-door type cages), *visgo* (glue sticks), and *arapuca* traps.

The trap-door cage (*assaprão*) was the technique most frequently mentioned by the interviewees ($n = 41$; 67.21%) and they were used to capture all of the target-passerines in the study areas. The trappers will bait the cages with fruits, seeds, or other items selected according to the target-species. Trap-door cages are extremely effective for capturing species of the families Icteridae and Thraupidae; females can be used as bait ("*chamas*") to attract males to the cages. Trap-door cages can be readily purchased at local markets, with different prices and of different sizes depending on the customer's purchasing power. The poorest trappers, for example, can buy small wooden trap-door cages at the Floriano Municipal Market that can be attached to common, larger cages.

Visgo ($n = 40$; 65.57%) is a passive technique for trapping small birds using natural or industrial adhesives.

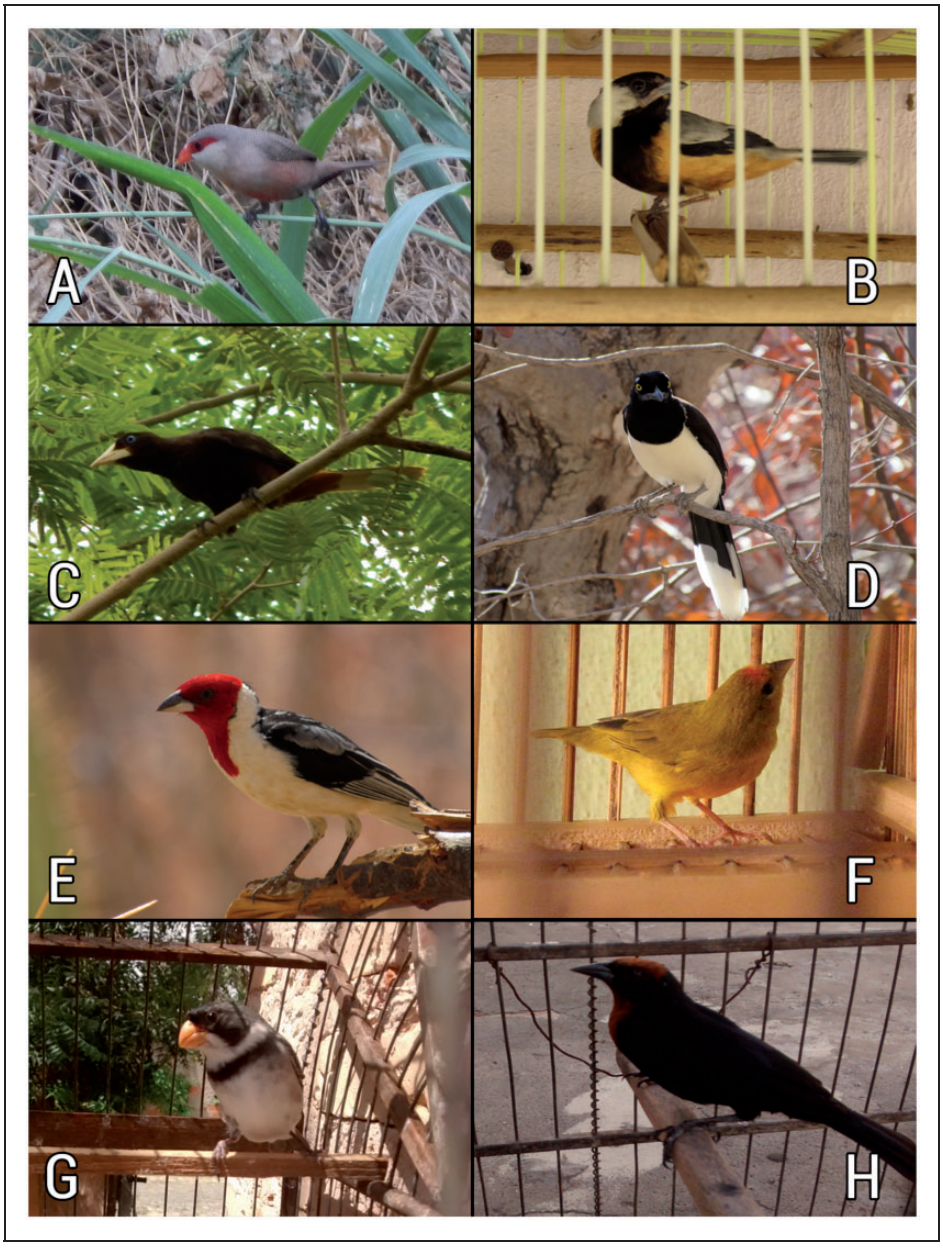

Figure 3. Examples of Passeriformes trapped for pet purposes in middle-north region, NE Brazil. (a) *Estrilda astrild*, (b) *Charitospiza eucosma*, (c) *Psarocolius decumanus*, (d) *Cyanocorax cyanopogon*, (e) *Paroaria dominicana*, (f) *Sicalis flaveola*, (g) *Sporophila albogularis*, (h) *Chrysomus ruficapillus*. Credits: (a, c) Mateus Silva; (b, f) Wedson Souto; (d, e, g, h) Mauro Torres.

According to the interviewees, the glue is usually made from mangabeira latex, *Hancornia speciosa* Gomes (Apocynaceae), harvested in Southern Piauí. We found mangabeira latex spheres with diameters of 5 to 8 cm being sold for BRL $10.00 (~USD $2.90) in exotic pet stores or in stalls at the Floriano Municipal Market. *Visgo* has been described being used in various cultures, indicating that the strategy is effective and has ancient roots (Bezerra, Araujo, & Alves, 2012; Platt et al., 2012; Shepherd et al., 2004). The glue is spread on the branches of fruiting shrubs or trees to capture omnivores, granivorous, or frugivorous passerines. As described by Fernandes-Ferreira et al. (2012) in Ceará State, local trappers also apply lime to small branches near the cages with the "*chamas*" females. The *arapuca*, another popular technique used by bird catchers ($n = 6$; 9.84%), is a pyramid-shaped cage or trap held open by a pressure trigger, as previously described by Bezerra et al. (2012). These traps are baited with corn bran, fruits, or both, depending on the target-species.

The use of motor vehicles for bird trapping journeys is a common practice in the study areas. At least 18

interviewees (29.5%) reported to employ motorcycles, cars, and buses as exclusive transport resources to access preferred wildlife resource areas. All other interviewees reported to use vehicles, especially motorcycles to cover long distances (> 5 km) between the trapper's residence and the trapping areas. Travelling distances were influenced by the interviewees' areas of preference for capturing birds, by target-species rarity, and by passerine habitats. Some Thraupidae species (e.g., *Paroaria dominicana*, *Sporophila lineola*, and *Tangara* spp.), for example, can be trapped even in peri-urban areas, whereas other tanagers (e.g., *Charitospiza eucosma*, *Saltator* spp., *Sporophila* spp.), as well as all Icteridae species, are mainly captured in rural areas, particularly in *matas* (islands of Cerrado-Caatinga ecotone vegetation) or fruit orchards. There was a unanimous perception that passerine trapping now occurs in areas increasingly distant from the urban center of Floriano. A total of 26 hunters (42.62%) reported the need to travel more than 10 km to trap wild animals.

We observed that birds were usually kept in small cages (~60 cm (length) × 40 cm (width) × 40 cm (height)), probably because larger cages are more expensive and more difficult to transport. The cages can be made of metal or wood, and both types were easily found for sale in specialized shops in Floriano at prices ranging from BRL $40 to BRL $500. Based on information provided by the interviewees, the diets of captured birds are restricted to a very limited number of food items, with omnivorous or frugivorous birds being fed with fruits, while granivorous birds are kept with commercial birdseed or corn bran. *Polioptila plumbea* (Gmelin, 1788), an insectivorous bird, is fed with a mixture of fruits and a few insects.

The Local and Regional Market Chain of Passeriformes, Prices, and Conservation Status

At least 40.98% of the interviewees (three from the Manga community and 22 from Floriano, Table 1) assumed their involvement in the illegal passerines trade. Based on interviews with trappers and information from market traders, our results suggest a direct market chain with a rapid local turnover of passerines, operationalized mainly outside the Floriano Municipal Market.

Trappers from the Manga community indicated that they are contacted by residents of Floriano (and other urban centers in the states of Piauí and Maranhão) to obtain wild specimens for pet purposes. They also reported contacts from pet buyers from the urban zone of Floriano through indications by acquaintances or friends. Contacts between trappers from Manga and local end-consumers are arranged through mobile phone contacts or brokered by third parties. Trade operations are often carried out at the homes of the trappers or those of the end-consumers. Similar strategies were reported by interviewees from the Floriano urban area. Trappers from Floriano also pointed out the use of social networks (Facebook™ and Whatsapp™) to find customers. Contacts with carriers, the people who move the purchased specimens from the trapper's home to the buyers, were reported by only six interviewees (9.83%).

The Floriano Municipal Market seems to be a less significant, although persistent, outlet for the wild pet trade. None of the trappers engaged in the passerine trade reported selling birds to final consumers in the public market, although at least four urban interviewees from Floriano did so. The interviewees could not directly identify buyers of native passerines in the Floriano Municipal Market, although four vendors at that market reported that some traders and owners of neighboring stores (unidentified persons) sell live wild animals. The market vendors also reported that sales of Passeriformes species by store owners never occur in the market itself, but rather in the store owner's or market trader's home (or other locations used as illegal trade points).

Connections between the local and regional market chains of wild passerines were identified. Urban interviewees from Floriano indicated that buyers from at least three municipalities (Teresina [the capital of Piauí State], Barão de Grajaú-MA, and Imperatriz-MA [the second largest city of Maranhão State]) and imprecise numbers of communities and municipalities in the vicinity of Floriano travel to the study areas to acquire pets.

All passerine species reported in this study are illegally traded in South of Piauí. The interviewees accurately reported the prices of 18 species (Table 2). Some species (e.g., the White-naped Jay *Cyanocorax cyanopogon*, the Rufous-collared Sparrow *Zonotrichia capensis*, and the Great-billed Seed-Finch *Sporophila maximiliani*) had no specified prices, or were generically considered "very cheap" or "expensive."

We identified a pattern of bird prices. Juvenile male and adult songbirds that do not sing in captivity (locally known as "*brabo*" birds) are sold at relatively low prices, usually between BRL $2 and BRL $30 (USD $0.58–USD $8.72). Females are sold at equivalent "*brabo*" prices, or even less. Adult males with captive singing abilities are known as "*cantador*" and command the highest commercial prices. Rarity is a second determinant factor for passerines prices. Adult males of *Gnorimopsar chopi* were sold for approximately BRL $1,000 (~USD $290.7), due to both its admired singing and the difficulty in finding and capturing this species. The prices of Saffron Finches *Sicalis flaveola* (Linnaeus, 1766) used in "*rinhas*" are influenced mainly by their "fight records." The trappers spoke of "champion" *S. flaveola* specimens that sold for more than BRL $ 5,000 (~USD $1,455).

Another difficult component to evaluate, but which greatly influences bird prices, is the trapper's perception of the customer's social or economic level. Members of the elite or upper middle class will often spend large sums to purchase wildlife products, so that some trappers (or vendors) raise their prices for well-off buyers. One interviewee, for example, reported the sale of one "*xexéu*" (the Yellow-rumped Cacique) *Cacicus cela* for BRL $3,000 (USD $872.09) to a local politician.

All of the species mentioned by the trappers are listed on the IUCN Red List, although most of them (35 spp., 89.74%) are classified as LC and not endangered (Table 2). Two species—the Coal-crested Finch *Charitospiza eucosma* and the Blue Finch *Porphyrospiza caerulescens*—are classified as near threatened. Two other species, the Yellow-faced Siskin *Spinus yarrellii* and the Great-billed Seed-Finch *Sporophila maximiliani*, are considered Vulnerable.

Discussion

Species Richness

Twenty-one passerine species were found for sale in the Campina Grande public market, the largest inland city in NE Brazil (Rocha, Cavalcanti, Sousa, & Alves, 2006). Likewise, Licarião et al. (2013) found 20 bird species with illegal bird-keepers in Campina Grande. A recent study performed in the Amazon, summarizing data of seizures over a period of 10 years, recorded a total of 23 native passerines species traded as wild pets (Nascimento et al., 2015). Our results represent one of the most complete records of the use and trading in Passeriformes in Northern and NE Brazil (see Alves et al., 2010; Fernandes-Ferreira et al., 2012; Licarião et al., 2013; Nascimento et al., 2015; Regueira & Bernard, 2012; Souza & Alves, 2014).

The species richness reported by trappers reinforces the view that Passeriformes are the pets preferred by trappers and the general population throughout Brazil (as well as other tropical areas; Alves et al., 2010; Pereira & Brito, 2005; Shepherd et al., 2004). The capture and trading of passerines is probably favored due to the fact that these birds are easy (and inexpensive) to maintain in captivity (Alves et al., 2010; Fernandes-Ferreira et al., 2012). The geographical location of the study area (an ecotone zone) also influenced the species richness of the caged birds, as all of the species reported (except *E. astrild*) are native to the Caatinga and Cerrado domains (see Sigrist, 2009; WikiAves, 2016).

Roads and highways have been identified as facilitators of trapping and trading in live animals around the world—particularly in areas with rich biological diversities (Nascimento et al., 2015; RENCTAS, 2001; Shepherd, 2006). Alves et al. (2010) noted that it is common for people to sell wild animals along highways in Brazil, and they serve as access routes to preferential trapping zones in the semiarid region of NE Brazil. This was likewise observed in the present study, as the PI-140 and BR-324 highways were used by the trappers as their principal routes for harvesting several bird species, including *Spinus yarrellii*, which is caught further South in Piaui State, in the region encompassing the *Serra das Confusões* (PNSC) and *Serra da Capivara* (PNSCa) National Parks. According to at least two trappers, passerines are more easily caught in both the PNSC as PNSCa. Additional reports of bird buyers coming from Maranhão State to the region around Floriano suggests that the BR-230 highway is a frequent route for moving wild pets taken in southern Piauí; this illegal trade works in both directions, with individuals engaged in bird trapping being able to obtain native Passeriformes in both areas (Roe, 2008). In line with this perspective, the interviewees pointed out that the Great-billed Seed-Finch, *Sporophila maximiliani*, is mainly obtained by exchanges with other bird-keepers, wildlife traders, or truck drivers.

The predominance of Thraupidae and Icteridae species as caged passerines corroborates the results of other studies carried out in other regions of the Neotropics, showing these families to be the most popular passerines among bird-keepers and traders (Alves et al., 2016; Daut et al., 2015; Marín-Espinoza, Guevara-Vallera, Prieto-Arcas, Muñoz-Gil, & Carvajal-Moreno, 2011). Although intra- and interspecific factors (e.g., sex and the age of the bird, species type, and local demand) have been identified as drivers of trapper and consumer preferences (Alves, Lima, & Araujo, 2012), tropical passerines are known to be favored for their remarkable songs or as ornamental birds with beautiful plumage (Jepson & Ladle, 2005; Licarião et al., 2013; Shepherd et al., 2004). The Thraupidae and Icteridae families are potential targets for trappers as they combine both attributes, as noted by Sick (2001) and Regueira and Bernard (2012).

The high representation and popularity of *Sporophila* species ($n = 8$ spp., 20.51% of the total species richness) corroborates data from environmental agencies and various studies of the wild pet trade in Brazil. *Sporophila* spp. lead in terms of the numbers of birds seized from trappers or bird-keepers in the states of Amazonas (northern Brazil) (Nascimento et al., 2015) and Minas Gerais (southeastern Brazil; Souza et al., 2014), and research undertaken in major urban markets and in metropolitan areas of NE Brazil has indicated a similar trend. Costa (2005) reported that *Sporophila* species were the most commercialized birds in Fortaleza markets (Ceará State), while Regueira and Bernard (2012) found the highest abundance of *Sporophila* spp. in street markets in the metropolitan area of Recife (Pernambuco State). *Sporophila* species are favored due to their ease of

breeding in cages, because they are territorial and defend their territories by singing and quickly become docile in cages with proper care just a few weeks after capture (A. Guzzi, personal observation, 2016). Our results suggest that these birds are among the species that suffer the highest trapping pressure from the pet trade in different parts of Brazil, even in areas where few studies have yet been performed.

Which Factors Drive the Exploitation of Wild Passerines as Pets in the Floriano Region in Southern Piauí?

Cultural, sporting, commercial, and subsistence factors were found to drive the trapping of Passeriformes in the region around Floriano in southern Piauí State. As for other uses of wild animals (Duffy, St John, Büscher, & Brockington, 2016; Roe, 2008), the synergy of different drivers, rather than the effect of any single one, acted to promote the exploitation of wild pets in the ecotone study areas. For example, capturing passerines can be a weekend sport for some bird trappers, as well as a source of extra cash for luxury items (e.g., beverages, cigarettes, motorcycle equipment) or provide support for subsistence items (e.g., food purchases or school fees).

Cultural factors motivating bird trapping were directly or indirectly expressed by the interviewees, with the terms "culture," "tradition," or "popularity" often being used by the hunters. Additionally, the main species or genera reported in this study are common cage birds in other, more distant, regions of NE Brazil (Alves et al., 2016; Regueira & Bernard, 2012), demonstrating that accessibility and cultural tradition are linked drivers of bird exploitation for pet purposes, as observed by Jepson and Ladle (2009) in Indonesia.

Trapping activities and pet-keeping have often been associated with sporting activities (Jepson & Ladle, 2009; Techachoochert & Round, 2013), and, in many ways, the trapping and trading of Passeriformes in the ecotone areas of Floriano are boosted by their sporting aspects. Sporting activities ($n = 50$; 81.92%), more than subsistence ($n = 9$; 14.75%), were reported as the primary reasons for capturing birds, and some sporting elements were closely associated with trapping and keeping passerines, especially (a) fun during trapping outings; (b) the challenge of capturing a variety of species; and (c) enjoyment in watching and wagering on bird fights.

Although none of the interviewees indicated the monetary rewards of trading in Passeriformes as the main reason for their capture, there is substantial evidence that commercial interests are a major driver for trapping wild passerines in the study areas. Wildlife trading is a huge and growing business (Baker et al., 2013), with low risks as compared with other illegal activities (e.g., drug trafficking) but high profits (BirdLife International, 2013; Roe, 2008). Not coincidentally, bird trappers of Floriano region involved in commercializing wild passerines capture, on the average, more species than those who claim it to be a hobby and rarely sell their birds. A larger repertoire of target species favors greater profitability and ensures a constant supply of pets for the illegal market throughout the year. A similar strategy has been adopted by hunters and users of zootherapeutic species in NE Brazil as a response to the variable availability or accessibility of wild animals in any given season (Souto et al., 2011).

Prices of wild passerines were generally high in comparison to the minimum wage (BRL \$788 (~USD \$229.06)) at the time of data collection. According to the interviewees, one *Sicalis flaveola* "*cantador*" could easily be sold for BRL \$500 (USD \$145.34) in the urban area of Floriano. Even species considered locally abundant (with low prices) can provide relevant profits. Ten singing males of *Paroaria dominicana* sold for BRL \$600 would provide an increase in income almost equivalent to another minimum wage—reinforcing the observations of Regueira and Bernard (2012) and Alves, Lima, et al. (2012) that the profits generated by people involved in trapping and trading wildlife are generally very difficult to estimate, although those monetary rewards can often be very high.

Bird fights were also an additional component of the capture and trading of some species, especially *Sicalis flaveola* and *Paroaria dominicana*. In open interviews, trappers reported that "*rinhas*" organized by economic middle or lower class individuals have low betting levels (about BRL \$50–100) compared with bird fights held by upper middle class residents (approximately BRL \$1,000 or more). In both cases, part of the money wagered at the "*rinhas*" goes to the owner of the victorious bird.

The wildlife trade is recognized as providing additional income sources to families in tropical regions (Davies & Brown, 2007; González-Marín, Moreno-Casasola, Castro-Luna, & Castillo, 2016), and Passeriformes were locally perceived as sources of cash for such items as drinks, cell phones, and car or motorcycle parts, as any income from the sale of those birds "avoids spending one's salary," as was clearly stated by an interviewee. This data, along with the small number of trappers who stated their dependence on commercializing wild animals for subsistence income, probably reflects a recent shift in the economic and social scenario in Brazil. From 2003 to 2014, Brazil experienced a period of economic and political stability, with the implementation of income transfers and significant improvements in the HDI (which reached its highest level in 2007; UN-PNUD, 2013). The illegal trade of passerines appears to have evolved into a means of purchasing nonessential items more than subsistence products by trapper families, although further studies will be needed for a better assessment of the social, cultural,

and economic roles of trapping and trading in live wild animals. The continuous harvesting of wild animals by urban and peri-urban communities around the world highlights the need for further interdisciplinary research in ethnozoology which can be used in strategies to conserve biodiversity (Alves, Oliveira, Rosa, & Cunningham, 2013). Understanding the contexts of wildlife uses of animals is central for elucidating their potential impact on biodiversity conservation. In this sense, interdisciplinary research with integrated methods, collaborative work, and participatory decisions (see Broto, Gislason, & Ehlers, 2009) provides an accurate analysis of the social, ecological, and economic scenarios related to bird-keeping and pet trade.

Implications for Conservation

Although few species reported in present study are threatened, we cannot conclude that local bird harvesting does not generate consequences for wildlife populations. The trapping and trading of wild animals for pet purposes is recognized as one of the greatest threats to tropical faunas (Daut et al., 2015; Sodhi et al., 2011), and the trapping of live animals has led to the elimination of several populations of *Sicalis flaveola*, *Gnorimopsar chopi*, and *Icterus jamacaii* in some regions of NE Brazil (Fernandes-Ferreira et al., 2012; Olmos, Silva, & Albano, 2005)—and the harvesting of Spix's Macaw *Cyanopsitta spixii* (Wagler, 1832) as pets is considered the main cause of their extinction in the wild (Alves, Lima, et al., 2012). To know exactly the ecological consequences of the bird trade, it is necessary to carry out local and regional bird population studies for the species most harvested.

High mortality rates are associated with the capture and transport of wild animals (Alves, Lima, et al., 2012; Baker et al., 2013), and this is probably also true in the region around Floriano, since trapped birds are usually kept in small cages, and often shown signs of injuries or malnutrition, with insectivorous and some omnivores species having especially high rates of mortality—becoming disposable elements in this type of wildlife use (Shepherd et al., 2004).

Bird-keeping has cascading effects not only on populations of the target species but also in the ecosystems in which those birds naturally occur (Chng, Eaton, Krishnasamy, Shepherd, & Nijman, 2015; Harris et al., 2016). As pointed out by other studies (e.g., Gilbert, Sokha, Joyner, Thomson, & Poole, 2012; Harrison et al., 2013), the exploitation of wild birds has serious consequences—directly through local declines and extinctions and indirectly by impacting important ecological processes such as seed dispersal and pollination.

Biological invasion is another phenomenon that concerns conservationists throughout the world, provoking ecosystem changes and disruptions of interspecific relationships established between the local biota (García-Díaz, Ross, Ayres, & Cassey, 2015). Bird-keeping and trading in wild species have been responsible for major biological invasions, with Silva and Oren (1990) reporting the introduction of *Aratinga jandaya*, *Icterus jamacaii*, *Paroaria dominicana*, and *Sporophila albogularis* in Belém city, Pará State (Amazon region). Due to wild animal trafficking from NE Brazil to other regions, *Paroaria dominicana* can now be found in southern (Porto Alegre city) and southeastern (São Paulo) Brazil (Ferreira & Glock, 2004; Godoy & Matushima, 2010). As the Floriano region is a major road hub, the wildlife traded there will surely be distributed to other regions in Brazil.

Strategies for bird conservation are urgently needed, with monitoring, enforcement, and effective sanctions (Alves, Lima, et al., 2012; Regueira & Bernard, 2012) . Effective enforcement will require new strategies, as trappers (and wildlife traders) are aware of the everyday efforts of federal and state agencies to combat wildlife trafficking. Given the clandestine nature of bird-keeping and wildlife trading, as well as the availability of technological resources for communication and trapper mobility, it is essential that environmental agencies adopt better intelligence measures and patrol local roads and the main highways more intensively (Alves, Lima, et al., 2012).

Law enforcement, however, is only one aspect of combating illegal wildlife exploitation (Daut et al., 2015), as one of the most serious challenges to bird conservation in the Neotropics is integrating human needs and wildlife conservation (Alves et al., 2010). The clandestine perpetuation of trapping and bird-keeping, even after decades of prohibition, highlights the inefficiency of environmental actions exclusively directed toward law enforcement and control (Alves et al., 2016). Integrated conservation and intervention plans must consider both trappers and local or regional demand for wild pets. Environmental education programs in schools, media campaigns exposing animal cruelty, and the mortality rates involved in trapping and in wildlife transport, as well as the risks of disease transmission to humans could reduce the demand for wild animals on a medium-term basis (Kuhnen & Kanaan, 2014; Nascimento et al., 2015).

Based on other studies (Daut et al., 2015; Jepson & Ladle, 2005), the regulation and implementation of systems for captive breeding and reproduction of species popularly exploited by trappers or bird-keepers and illegal trade networks, together with effective systems for monitoring and recording native specimens born in captivity, could represent a feasible manner of generating income for people involved in the trapping and trading of wild animals—at least partially filling the demand for passerines.

In another perspective, regulation of trapping and trade of wild-caught birds could be considered as a

strategy to reconcile cultural and economic demands of the people involved in these activities. This, however, is a new scenario that deserves careful analysis and ecological, legal, and social studies with broad and effective engagement of environmental agencies for implementation. In important Latin American countries with megadiversity of birds, such as Brazil, Peru (Law 30407/ January 2016), and Argentina (Law 22421/ March 1981), the removal of birds from the natural environment for trade and pet purposes is currently strictly prohibited. In turn, there is a complex social and legal system in Mexico, with legalized trappers and sellers (''*pajareros*''), which are organized in associations (''*unions*'') and have legal permits of the ''*Dirección Geral de la Vida Silvestre*'' for trapping and trade of a certain limit of specimens (Roldán-Clarà, 2015). The Mexican model has contributed to provide income to a representative number of families with scarce resources (Roldán-Clarà, 2015). Nonetheless, it is limited to a very restricted number of target species (see SEMARNAT, 2016), and illegal capture of birds is still widespread throughout the country (Guzmán, Saldaña, Grosselet, & Gamez, 2007). In any case, there is no doubt that strategies for bird conservation will only be effective when considering local realities and integrating human populations in a participatory way.

Author Contributions

Wedson M. S. Souto planned the research, analyzed the data, identified species, and also wrote the article. Mauro A. R. Torres collected the data. Breno F. C. F. Sousa contributed to the data collection and he identified species. Katyelle G. G. C. Lima contributed to the data collection. Lorena R. S. Vieira and Mateus V. Silva performed guided tours to take photographic records and identify species. Glauco A. Pereira and Anderson Guzzi critically revised this manuscript and identified species. Bruno G. N. Pralon identified species and also wrote the article.

Acknowledgments

The authors thank the renowned professor, and authority on the use and trade of Neotropical fauna, PhD Rômulo Romeu Nóbrega Alves (State University of Paraíba—UEPB) for useful comments on the manuscript. Authors are indebted to the American, and professor at the State University of Feira de Santana, PhD. Roy Richard Funch for the English language revision this article. Special thanks are due to all interviewees, who kindly shared their knowledge with us.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) disclosed receipt of the following support for the research, authorship, and/or publication of this article: The authors would like to thank the university campus Amílcar Ferreira Sobral (CAFS) and NEDET (*Núcleo de Pesquisa e Extensão em Desenvolvimento Territorial*) of Federal University of Piauí for providing logistical support (vehicles). We are grateful to CNPq (Brazilian National Council for Scientific and Technological Development) for the PIBIC fellowship granted to the second author.

References

Alonso-Castro, A. J. (2014). Use of medicinal fauna in Mexican traditional medicine. *Journal of Ethnopharmacology*, *152*, 53–70. doi:10.1016/j.jep.2014.01.005.

Alves, R. R. N., Gonçalves, M. B. R., & Vieira, W. L. S. (2012). Caça, uso e conservação de vertebrados no semiárido Brasileiro [Hunting, use and conservation of wild vertebrates in Brazilian semiarid]. *Tropical Conservation Science*, *5*, 394–416. doi:10.1177/194008291200500312.

Alves, R. R. N., Lima, J. R. F., & Araujo, H. F. P. (2012). The live bird trade in Brazil and its conservation implications: an overview. *Bird Conservation International*, *1*, 1–13. doi:10.1017/S095927091200010X.

Alves, M. M., Lopes, S. F., & Alves, R. R. N. (2016). Wild vertebrates kept as pets in the semiarid region of Brazil. *Tropical Conservation Science*, *9*, 354–368. doi:10.1177/194008291600900119.

Alves, R. R. N., Nogueira, E., Araujo, H., & Brooks, S. (2010). Bird-keeping in the Caatinga, NE Brazil. *Human Ecology*, *38*, 147–156. doi:10.1007/s10745-009-9295-5.

Alves, R. R. N., Oliveira, T. P. R., Rosa, I. L., & Cunningham, A. B. (2013). Marine invertebrates in traditional medicines. In: R. R. N. Alves, & I. L. Rosa (Eds.). *Animals in traditional folk medicine: Implications for conservation* (pp. 263–287). Heidelberg, Germany: Springer-Verlag. doi:10.1007/978-3-642-29026-8_1.

Alves, R. R. N., & Souto, W. M. S. (2010). Alguns desafios e dificuldades associadas as pesquisas etnozoológicas no Brasil [Some challenges and difficulties associated with ethnozoological research in Brazil]. In: R. R. N. Alves, W. M. S. Souto, & J. S. Mourão (Eds.). *A Etnozoologia no Brasil: Importância, Status atual e Perspectivas* (pp. 57–66). Recife, Brazil: NUPEEA. Retrieved from https://is.gd/TNDNwF.

Ayres, M., Ayres, M., Jr., Ayres, D. L., & Santos, A. A. S. (2005). *BioEstat: Aplicações Estatísticas nas Áreas das Ciências Biomédicas* [BioEstat: Statistical applications for biological sciences]. *Version 5.3*. Belém, Brazil: Sociedade Civil Mamirauá. Retrieved from http://www.mamiraua.org.br/pt-br/downloads/programas/bioestat-versao-53/

Baker, S. E., Cain, R., van Kesteren, F., Zommers, Z. A., D'Cruze, N., & Macdonald, D. W. (2013). Rough trade: Animal welfare in the global wildlife trade. *BioScience*, *63*, 928–938. doi:10.1525/bio.2013.63.12.6.

Barboza, R. R. D., Lopes, S. F., Souto, W. M. S., Fernandes-Ferreira, H., & Alves, R. R. N. (2016). The role of game mammals as bushmeat in the Caatinga, northeast Brazil. *Ecology and Society*, *21*, 1–11. doi:10.5751/ES-08358-210202.

Bezerra, D. M. M., Araujo, H. F. P., & Alves, R. R. N. (2012). Captura de aves silvestres no semiárido brasileiro: Técnicas cinegéticas e implicações para conservação [Capturing of wild birds in Brazilian semiarid: Hunting and trapping techniques

and implications for conservation]. *Tropical Conservation Science*, *5*, 50–66. doi:10.1177/194008291200500106.

BirdLife International. (2008). *The illegal parrot trade remains a problem in Latin America (Presented as part of the BirdLife State of the world's birds website)*. Retrieved from http://www.birdlife.org/datazone/sowb/casestudy/165.

BirdLife International. (2012). *Sporophila frontalis* (In: The IUCN Red List of Threatened Species 2012). Retrieved from http://dx.doi.org/10.2305/IUCN.UK.2012-1.RLTS.T22723399A38203530.en.

BirdLife International. (2013). *Cyanopsitta spixii* (In: The IUCN Red List of Threatened Species 2013). 1. Retrieved from http://dx.doi.org/10.2305/IUCN.UK.2013-2.RLTS.T22685533A49809312.en.

Bonaudo, T., Le Pendu, Y., Faure, J. F., & Quanz, D. (2005). The effects of deforestation on wildlife along the transamazon highway. *European Journal of Wildlife Research*, *51*, 199–206. doi:10.1007/s10344-005-0092-1.

Bonifácio, K. M., Freire, E. M. X., & Schiavetti, A. (2016). Cultural keystone species of fauna as a method for assessing conservation priorities in a Protected Area of the Brazilian semiarid. *Biota Neotropica*, *16*, 1–16. doi:10.1590/1676-0611-BN-2014-0106.

Broto, V. C., Gislason, M., & Ehlers, M.-H. (2009). Practising interdisciplinarity in the interplay between disciplines: Experiences of established researchers. *Environmental Science & Policy*, *12*, 922–933. doi:https://doi.org/10.1016/j.envsci.2009.04.005.

Castro, A. A. J. F. (2003). Survey of the vegetation in the State of Piaui. In: T. Gaiser, M. Krol, H. Frischkom, & J. C. Araújo (Eds.). *Global change and regional impacts: Water availability and vulnerability of ecosystems and society in the semiarid northeast of Brazil* (pp. 117–123). Berlin, Germany: Springer. Retrieved from http://dx.doi.org/10.1007/978-3-642-55659-3_9.

CECI. (2007). Centro de Estudos Avançados da Conservação Integrada - Relatório Final do Plano Diretor de Floriano (PI) [Center of Advanced Studies for Integrated Conservation—Final Report of the Floriano Master Plan]. Retrieved from http://www.floriano.pi.gov.br/a-cidade/.

Chng, S. C. L., Eaton, A. D., Krishnasamy, K., Shepherd, C. R., & Nijman, V. (2015). *In the market for extinction: An inventory of Jakarta's bird markets*. Petaling Jaya, Malaysia: TRAFFIC Southeast Asia.

Colwell, R. K. (2013). *EstimateS: Statistical estimation of species richness and shared species from samples (Version 9.1.0)—User's guide and application*. Storrs, CT: Department of Ecology and Evolutionary Biology, University of Connecticut. Retrieved from http://viceroy.eeb.uconn.edu/estimates/EstimateSDownload/EstimateS_910_Windows.zip.

Colwell, R. K., & Coddington, J. A. (1994). Estimating terrestrial biodiversity through extrapolation. *Philosophical Transactions of the Royal Society of London B*, *345*, 101–118. doi:10.1098/rstb.1994.0091.

Costa, R. G. A. (2005). Comércio ilegal de aves silvestres em Fortaleza, Ceará [Illegal trade of wild birds in Fortaleza, Ceará State]. *Atualidades Ornitológicas*, *125*, 3.

Cruz-Antia, D. (2010). Aproximación al uso y tráfico de fauna silvestre en Puerto Carreño, Vichada, Colombia [Wildlife use and trafficking in Puerto Carreño, Vichada-Colombia: An overview]. *Ambiente y Desarrollo*, *14*, 63–94. Retrieved from http://revistas.javeriana.edu.co/index.php/ambienteydesarrollo/article/view/1094.

Daut, E. F., Brightsmith, D. J., Mendoza, A. P., Puhakka, L., & Peterson, M. J. (2015). Illegal domestic bird trade and the role of export quotas in Peru. *Journal for Nature Conservation*, *27*, 44–53. doi:10.1016/j.jnc.2015.06.005.

Davies, G., & Brown, D. (2007). *Bushmeat and Livelihoods: Wildlife Management and Poverty Reduction*. Malden, MA: Blackwell Publishing/Zoological Society of London. doi:10.1002/9780470692592.

Destro, G. F. G., Pimentel, T. L., Sabaini, R. M., Borges, R. C., & Barreto, R. (2012). Efforts to combat wild animals trafficking in Brazil. In: G. A. Lameed (ed.) *Biodiversity enrichment in a diverse world* (pp. 421–436). New York, NY: InTech. Retrieved from http://www.ibama.gov.br/sophia/cnia/periodico/effortstocombatwildanimalstraffick.pdf.

Duffy, R., St John, F. A. V., Büscher, B., & Brockington, D. (2016). Toward a new understanding of the links between poverty and illegal wildlife hunting. *Conservation Biology*, *30*, 14–22. doi:10.1111/cobi.12622.

FAO. (2011). *International trade in wild birds, and related bird movements, in Latin America and the Caribbean (Animal Production and Health Paper No. 166)* (1 ed.). Rome, Italy: United Nations. Retrieved from http://www.fao.org/3/a-i0708e.pdf.

Ferasso, M., Melo Júnior, A. S., Magalhães, A., & Schröeder, C. S. (2016). Qualification in entrepreneurship in extremely poor regions: An experience on Brazil's Northeast. *Revista Livre de Sustentabilidade e Empreendedorismo*, *1*, 3–22. Retrieved from http://www.relise.eco.br/index.php/relise/article/view/1/1.

Fernandes-Ferreira, H., Mendonça, S. V., Albano, C., Ferreira, F. S., & Alves, R. R. N. (2012). Hunting, use and conservation of birds in Northeast Brazil. *Biodiversity and Conservation*, *21*, 221–244. doi:10.1007/s10531-011-0179-9.

Ferreira, F. S., Fernandes-Ferreira, H., & Léo Neto, N. A. (2013). The trade of medicinal animals in Brazil: Current status and perspectives. *Biodiversity and Conservation*, *22*, 839–870. doi:10.1007/s10531-013-0475-7.

Ferreira, C. M., & Glock, L. (2004). Diagnóstico preliminar sobre a avifauna traficada no Rio Grande do Sul, Brasil [Preliminar diagnosis of the trafficked avifauna in the state of Rio Grande do Sul, Brazil]. *Biociências (On-line)*, *12*, 21–30. Retrieved from http://revistaseletronicas.pucrs.br/ojs/index.php/fabio/article/view/151.

Fontoura, P. M., Dyer, E., Blackburn, T. M., & Orsi, M. L. (2013). Non-native bird species in Brazil. *Neotropical Biology and Conservation*, *8*, 165–175. doi:10.4013/nbc.2013.83.07.

Freese, C. H. (1998). A global overview. In: C. H. Freese (ed.) *Wild species as commodities: Managing markets and ecosystems for sustainability* (pp. 19–32). Washington, DC: Island Press. .

García-Díaz, P., Ross, J. V., Ayres, C., & Cassey, P. (2015). Understanding the biological invasion risk posed by the global wildlife trade: Propagule pressure drives the introduction and establishment of Nearctic turtles. *Global Change Biology*, *21*, 1078–1091. doi:10.1111/gcb.12790.

Gilbert, M., Sokha, C., Joyner, P. H., Thomson, R. L., & Poole, C. (2012). Characterizing the trade of wild birds for merit release in Phnom Penh, Cambodia and associated risks to health and ecology. *Biological Conservation*, *153*, 10–16. doi:10.1016/j.biocon.2012.04.024.

Godoy, S. N., & Matushima, E. R. (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. doi:10.1647/2009-029.1.

González-Marín, R. M., Moreno-Casasola, P., Castro-Luna, A. A., & Castillo, A. (2016). Regaining the traditional use of wildlife in wetlands on the coastal plain of Veracruz, Mexico: Ensuring food security in the face of global climate change. *Regional Environmental Change.* Advance online publication. doi:10.1007/s10113-016-0955-x.

Google Maps©. (2016). Traveling distance beetwen Manga community and Floriano city. 1 ed. Retrieved from https://goo.gl/thbZLr.

Gotelli, N. J., & Colwell, D. J. (2011). Estimating species richness. In: A. E. Magurran, & B. J. McGill (Eds.). *Biological diversity: Frontiers in measurement and assessment* (pp. 39–54). Oxford, England: Oxford University Press. .

Guzmán, J. C. C., Saldaña, M. E. S., Grosselet, M., & Gamez, J. S. (2007). *The illegal parrot trade in Mexico: A comprehensive assessment*. Washington, DC: Defenders of Wildlife. Retrieved from https://www.defenders.org/publications/the_illegal_parrot_trade_in_mexico.pdf.

Harris, J. B. C., Tingley, M. W., Hua, F., Yong, D. L., Adeney, J. M., Lee, T. M., . . . Wilcove, D. S. (2016). Measuring the impact of the pet trade on indonesian birds. *Conservation Biology*. Advance online publication. doi:10.1111/cobi.12729.

Harrison, R. D., Tan, S., Plotkin, J. B., Slik, F., Detto, M., Brenes, T., . . . Davies, S. J. (2013). Consequences of defaunation for a tropical tree community. *Ecology Letters*, *16*, 687–694. doi:10.1111/ele.12102.

Hernandez, E. F. T., & Carvalho, M. S. (2006). O tráfico de animais silvestres no Estado do Paraná [The traffic of wild animals in the state of Paraná]. *Acta Scientiarum Human and Social Sciences*, *28*, 257–266. doi:10.4025/actascihumansoc.v28i2.168.

IBGE. (2016). Canal Cidades—município de Floriano [Cities channel—municipality of Floriano]. Retrieved from http://cod.ibge.gov.br/4DG.

IBM© Corp. (2014). *IBM SPSS Statistics for Windows Version 23*. Armonk, NY: Author.

IUCN. (2016). The IUCN Red List of Threatened Species (version 2016-1). Retrieved from http://www.iucnredlist.org/.

Jepson, P., & Ladle, R. J. (2005). Bird-keeping in Indonesia: Conservation impacts and the potential for substitution-based conservation responses. *Oryx*, *39*, 442–448. doi:10.1017/S0030605305001110.

Jepson, P., & Ladle, R. J. (2009). Governing bird-keeping in Java and Bali: Evidence from a household survey. *Oryx*, *43*, 364–374. doi:0.1017/S0030605309990251.

Kamins, A. O., Restif, O., Ntiamoa-Baidu, Y., Suu-Ire, R., Hayman, D. T. S., Cunnigham, A. A., . . . Rowcliffe, J. M. (2011). Uncovering the fruit bat bushmeat commodity chain and the true extent of fruit bat hunting in Ghana, West Africa. *Biological Conservation*, *144*, 3000–3008. doi:10.1016/j.biocon.2011.09.003.

Kuhnen, V. V., & Kanaan, V. T. (2014). Wildlife trade in Brazil: A closer look at wild pets welfare issues. *Brazilian Journal of Biology*, *74*, 124–127. doi:10.1590/1519-6984.18912.

Licarião, M. R., Bezerra, D. M. M., & Alves, R. R. N. (2013). Wild birds as pets in Campina Grande, Paraíba State, Brazil: An ethnozoological approach. *Anais da Academia Brasileira de Ciências*, *85*, 201–213. doi:10.1590/S0001-37652013000100011.

Lindsey, P. A., Balme, G., Becker, M., Begg, C., Bento, C., Bocchino, C., . . . Zisadza-Gandiwa, P. (2013). The bushmeat trade in African savannas: Impacts, drivers, and possible solutions. *Biological Conservation*, *160*, 80–96. doi:10.1016/j.biocon.2012.12.020.

Marín-Espinoza, G., Guevara-Vallera, S., Prieto-Arcas, A., Muñoz-Gil, J., & Carvajal-Moreno, Y. (2011). Comercialización ilegal de aves silvestres: Un caso en Venezuela [Illegal trade of wild birds: A case study in Venezuela]. *Biologist (Lima)*, *9*, 38–52. Retrieved from https://dialnet.unirioja.es/descarga/articulo/3888254.pdf.

Medeiros, R. M., Azevedo, P. V., Saboya, L. M. F., & Francisco, P. R. M. (2013). Classificação climática e zoneamento agroclimático para o município de Amarante–PI [Climate classification and agroclimatic zoning for the municipality of Amarante-PI]. *Revista Brasileira de Agricultura Irrigada*, *7*, 170–180. doi:10.7127/rbai.v7n200011.

Myers, P., Espinosa, R., Parr, C. S., Jones, T., Hammong, G. S., & Dewey, T. A. (2016). The animal diversity web (online). Retrieved from http://animaldiversity.org.

Nascimento, C. A. R., Czaban, R. E., & Alves, R. R. N. (2015). Trends in illegal trade of wild birds in Amazonas state, Brazil. *Tropical Conservation Science*, *8*, 1098–1113. doi:10.1177/194008291500800416.

Neme, L. A. (2015). Latin American illegal wildlife trade exploding in scope and scale. Retrieved from https://news.mongabay.com/2015/11/latin-american-illegal-wildlife-trade-exploding-in-scope-and-scale/.

Nijman, V., Shepherd, C. R., Mumpuni, & Sanders, K. L. (2012). Over-exploitation and illegal trade of reptiles in Indonesia. *Herpetological Journal*, *22*, 83–89. Retrieved from https://is.gd/V5T4Gg.

Nowell, K. (2000). *Far from a cure: The tiger trade revisited* (1 ed.). Kuala Lumpur, Malaysia: TRAFFIC Southeast Asia. Retrieved from Retrieved from https://portals.iucn.org/library/node/7661.

Olmos, F., Silva, W. A. G., & Albano, C. G. (2005). Aves em oito áreas de caatinga no sul do Ceará e oeste de Pernambuco, Nordeste do Brasil: Composição, riqueza e similaridade [Birds in eight areas of Caatinga domain from Southern Ceará and Weastern Pernambuco, Northeastern Brazil]. *Papéis Avulsos de Zoologia (São Paulo)*, *45*, 179–199. doi:10.1590/S0031-10492005001400001.

Pereira, G. A., & Brito, M. T. (2005). Diversidade de aves silvestres brasileiras comercializadas nas feiras livres da Região Metropolitana do Recife, Pernambuco [Diversity of Brazilian wild birds traded in open markets from Metropolitan Region of Recife, Pernambuco State]. *Atualidades Ornitológicas*, *126*, 14–20. Retrieved from http://www.ao.com.br/download/glauco.pdf.

Phillips, O., & Gentry, A. H. (1993). The useful plants of Tambopata, Peru: I. Statistical hypotheses tests with a new quantitative technique. *Economic Botany*, *47*, 15–32. doi:10.1007/BF02862203.

Piacentini, V. Q., Aleixo, A., Agne, C. E., Maurício, G. N., Pacheco, J. F., Brito, G. R. R., . . . Cesari, E. (2015). Annotated checklist of the birds of Brazil by the Brazilian Ornithological Records Committee. *Revista Brasileira de*

Ornitologia, *23*, 91–298. Retrieved from http://www4.museu-goeldi.br/revistabrornito/revista/index.php/BJO/article/view/1263/pdf_905.

Platt, S. G., Platt, K., Naing, T. Z., Meng, H., Ko, W. K., Lin, N., . . . Rainwater, T. R. (2012). Birdlime in Western Myanmar: Preparation, use, and conservation implications for an endemic bird. *Ethnobiology Letters*, *3*, 68–75. doi:10.14237/ebl.3.2012.38.

Regueira, R. F. S., & Bernard, E. (2012). Wildlife sinks: Quantifying the impact of illegal bird trade in street markets in Brazil. *Biological Conservation*, *149*, 16–22. doi:10.1016/j.biocon.2012.02.009.

RENCTAS. (2001). *1st National Report on the Traffic of Wild Animals (Brazil)* (1 ed.). Brasília, Brazil: RENCTAS. Retrieved from https://is.gd/renctas.

Rocha, C. F. D., Bergallo, H. G., & Mazzocchi, R. (2011). Invasive vertebrates in Brazil. In: D. Pimentel (ed.) *Biological invasions: Economic and enviromental costs of alien plant, animal, and microbe species* (pp. 53–106). Boca Raton, FL: CRC Press. doi:10.1201/b10938-7.

Rocha, M. S. P., Cavalcanti, P. C. M., Sousa, R. L., & Alves, R. R. N. (2006). Aspectos da comercialização ilegal de aves nas feiras livres de Campina Grande, Paraíba, Brasil [Aspects of Illegal bird trade at open markets of Campina Grande, Paraíba State, Brazil]. *Revista de Biologia e Ciências da Terra*, *6*, 204–221. Retrieved from http://www.redalyc.org/articulo.oa?id=50060213.

Roe, D. (2008). *Trading nature: A report, with case studies, on the contribution of wildlife trade management to sustainable livelihoods and the Millennium Development Goals* (1 ed.). Cambridge, England: TRAFFIC International and WWF International.. Retrieved from https://portals.iucn.org/library/node/9614.

Roldán-Clarà, B. (2015). *Diagnóstico del uso de las aves canoras y de ornato en México desde la mirada de los actores* [Diagnosis of the use of songbirds and ornamental birds in Mexico in the actors' perspective] (PhD Thesis). Ensenada, Mexico: Instituto de Investigaciones Oceanológicas, Universidad Autónoma del Estado de Baja California.

Roldán-Clarà, B., López-Medellín, X., Espejel, I., & Arellano, E. (2014). Literature review of the use of birds as pets in Latin America, with a detailed perspective on Mexico. *Ethnobiology and Conservation*, *3*, 1–18. doi:10.15451/ec2014-10-3.5-1-18.

Rossato, S. C., Leitão-Filho, H., & Begossi, A. (1999). Ethnobotany of caiçaras of the Atlantic Forest coast (Brazil). *Economic Botany*, *53*, 387–395. doi:10.1007/bf02866716.

Santos, M. P. D. (2004). As comunidades de aves em duas fisionomias da vegetação de Caatinga no estado do Piauí, Brasil [Bird communities in two distinct physiognomy in the Caatinga domain of Piauí State, Brazil]. *Ararajuba*, *12*, 113–123. Retrieved from https://is.gd/EoS4RA.

Santos, O. I. B., & Rathmann, R. (2009). Identification and analysis of local and regional impacts from the introduction of biodiesel production in the state of Piauí. *Energy Policy*, *37*(10): 4011–4020. doi:10.1016/j.enpol.2009.05.002.

SEMARNAT. (2016). *Calendario de épocas hábiles y lista de especies de aves canoras y de ornato para captura con fines de subsistencia—Temporada 2016–2017* [Calendar for permitted hunting/trapping season and list of songbirds and ornamental birds species for capture with subsistence purposes—Season 2016–2017]. Retrieved from http://www.gob.mx/cms/uploads/attachment/file/115665/TEMPORADAS_HABILES_2016-2017-ACO.pdf.

Shepherd, C. R. (2006). The bird trade in Medan, north Sumatra: An overview. *BirdingASIA*, *5*, 16–24. Retrieved from https://is.gd/medanshepherd.

Shepherd, C. R., & Magnus, N. (2004). *Nowhere to hide: The trade in Sumatran Tiger*. Petaling Jaya, Selangor, Malaysia: TRAFFIC Southeast Asia. Retrieved from https://portals.iucn.org/library/node/8429.

Shepherd, C. R., Sukumaran, J., & Wich, S. A. (2004). *Open season: An analysis of the pet trade in Medan, Sumatra 1997–2001*. Petaling Jaya, Malaysia: TRAFFIC Southeast Asia. Retrieved from https://portals.iucn.org/library/node/8668.

Sick, H. (2001). *Ornitologia Brasileira* (Edição revista e ampliada por José Fernando Pacheco) [Brazilian Ornitology, Revised and expanded edition by José Fernando Pacheco]. Rio de Janeiro, Brazil: Editora Nova Fronteira.

Sick, H., & Teixeira, D. M. (1979). Notas sobre as aves brasileiras e raras ou ameaçadas de extinção [Notes about rare and endangered Brazilian birds]. *Publicação Avulsa do Museu Nacional*, *62*, 1–39.

Sigrist, T. (2009). *Avifauna Brasileira: The avis brasilis field guide to the birds of Brazil*. São Paulo, Brazil: Editora Avis Brasilis.

Sills, E. O., Atmadja, S. S., de Sassi, C., Duchelle, A. E., Kweka, D. L., Resosudarmo, I. A. P., . . . Sunderlin, W. D. (2014). *REDD + on the groud: A case book of subnational initiatives across the globe*. Bogor Barat, Indonesia: CIFOR. Retrieved from http://www.cifor.org/library/5202/redd-on-the-ground-a-case-book-of-subnational-initiatives-across-the-globe/.

Silva, J. M. C., & Oren, D. C. (1990). Introduced and Invading Birds in Belém, Brazil. *The Wilson Bulletin*, *102*, 309–313. Retrieved from http://www.jstor.org/stable/4162868.

Smith, N. J. H. (1976). Utilization of game along Brazil's transamazon highway. *Acta Amazonica*, *6*, 455–466. Retrieved from https://is.gd/smith_hunting.

Sodhi, N. S., Sekercioglu, C. H., Barlow, J., & Robinson, S. K. (2011). The state of tropical bird biodiversity. In: N. S. Sodhi, C. H. Sekercioglu, J. Barlow, & S. K. Robinson (Eds.). *Conservation of tropical birds* 1 ed. (pp. 1–26). West Sussex, England: Blackwell Publishing Ltd. doi:10.1002/9781444342611.ch1.

Souto, W. M. S., Mourão, J. S., Barboza, R. R. D., Mendonça, L. E. T., Lucena, R. F. P., Confessor, M. V. A., . . . Alves, R. R. N. (2011). Medicinal animals used in Ethnoveterinary practices of the 'Cariri Paraibano', NE Brazil. *Journal of Ethnobiology and Ethnomedicine*, *7*, 1–46. doi:10.1186/1746-4269-7-30.

Souza, J. B., & Alves, R. R. N. (2014). Hunting and wildlife use in an Atlantic Forest remnant of northeastern Brazil. *Tropical Conservation Science*, *7*, 145–160. doi:10.1177/194008291400700105.

Souza, T. O., Vilela, D. A. R., & Câmara, B. G. O. (2014). Pressões sobre a avifauna brasileira: Aves recebidas pelo CETAS/IBAMA, Belo Horizonte, Minas Gerais [Pressures on the Brazilian avifauna: Birds received by CETAS / IBAMA, Belo Horizonte, Minas Gerais]. *Ornithologia*, *7*, 1–11. Retrieved from http://cemave.net/publicacoes/index.php/ornithologia/article/viewFile/117/144.

Techachoochert, S., & Round, P. D. (2013). Red-whiskered Bulbul: Are trapping and unregulated avicultural practices pushing this

species towards extinction in Thailand. *BirdingASIA*, *20*, 49–52. http://orientalbirdclub.org/wp-content/uploads/2014/03/Red-whiskered-Bulbul.pdf.

UN-PNUD. (2013). Atlas do Desenvolvimento Humano no Brasil 2013 [United Nations' Atlas of Human Development in Brazil]. Retrieved from http://www.atlasbrasil.org.br/2013/home/.

Van Vliet, N., Quiceno-Mesa, M. P., Cruz-Antia, D., Telles, D., Martins, C., Haiden, E., . . . Nasi, R. (2015). From fish and bushmeat to chicken nuggets: The nutrition transition in a continuum from rural to urban settings in the Colombian Amazon region. *Ethnobiology and Conservation*, *4*, 1–12. doi:10.15451/ec2015-7-4.6-1-12.

Viana, T. V. A., Vasconcelos, D. V., Azevedo, B. M., & Souza, V. F. (2002). Estudo da aptidão agroclimática do Estado do Piauí para o cultivo da aceroleira [Study of the agroclimatic vocation of Piauí State for cultivation of aceroleira]. *Revista Ciência Agronômica*, *33*, 5–12. Retrieved from http://www.ccarevista.ufc.br/site/down.php?arq=09rca33-2.pdf.

Walker, R., Perz, S., Arima, E., & Simmons, C. (2011). The Transamazon highway: Past, present, future. In: D. S. Brunn (ed.) *Engineering Earth: The impacts of megaengineering projects* (pp. 569–599). Dordrecht, The Netherlands: Springer Netherlands. doi:10.1007/978-90-481-9920-4_33.

Whiting, M. J., Williams, V. L., & Hibbitts, T. J. (2011). Animals traded for traditional medicine at the Faraday market in South Africa: species diversity and conservation implications. *Journal of Zoology*, *284*, 84–96. doi:10.1111/j.1469-7998.2010.00784.x.

WikiAves. (2016). Wikiaves—a Enciclopédia de Aves do Brasil. Retrieved from http://www.wikiaves.com.br/.

World Bank. (2003). *Brazil—Piauí State Economic Memorandum: Managing a Natural Inheritance* (1 ed.). Washington, DC: Author. Retrieved from http://documents.worldbank.org/curated/pt/543071468769204628/pdf/244840BR.pdf.

WWF. (2012). *Fighting illicit wildlife trafficking: A consultation with governments* (1 ed.). Cambridge, England: WWF/Dalberg Global Development Advisors. Retrieved from http://www.wwf.de/fileadmin/fm-wwf/Publikationen-PDF/FightingIllicitWildlifeTrafficking_KeyFindings.pdf.