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Understanding the use of wild birds in a priority conservation area of Caatinga, a Brazilian tropical dry forest

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Abstract
The aim of the present study was to characterise the uses of bird species by hunters from a Brazilian tropical dry forest area to assess whether the choice of birds as a food resource is associated with the availability and body masses of those species. We have also analysed the conservation implications of using the birds in the area. Ethno-ornithological data were collected from rural areas in the immediate vicinity of Santa Catarina Mountain, in the state of Paraíba, using semi-structured interviews to local hunters and former hunters. Four use categories (food, pet, medicinal and symbolic uses) were identified. No correlation between the use value of the species used as a protein source and their relative abundance and body mass was found. These findings may support future environmental sustainability projects that focus on the human element and on conservation actions to protect the bird species that are exposed to high-use pressures in this region.

Keywords Avifauna · Ethno-ornithology · Hunting · Semiarid · Use value

1 Introduction

Ethno-zoological studies are important for understanding and integrating human dimensions to improve wildlife conservation (Roldán-Clarà et al. 2017; Alves et al. 2018; Camino et al. 2018; Gutiérrez-Santillán et al. 2018; van Vliet et al. 2018; Castillo and Ladio 2019; Alves and Souto 2015). Hunting for wild animals is stimulated by the many different

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human uses of faunal resources in local communities in the Brazilian semiarid region (Alves et al. 2009). In this region, the use and hunting of avifauna have been designated as key cultural and subsistence factors for human populations (Alves et al. 2010a). However, these uses have clear ecological implications, including population declines or the extinction of some species, decreased pollinators or seed dispersers that are important for plant diversity maintenance and a possible increase in insects that are considered pests (Alves et al. 2010b; Fernandes-Ferreira et al. 2012). Also, the populational decline of certain species due to hunting may favour non-hunted species, affecting the ecology of involved species. There may also be increase in certain species due to the predation of other species. The use of wild birds is a practice that is rooted in the culture of the local peoples of the north-east semiarid region (Fernandes-Ferreira et al. 2012) and involves different species that are used for various purposes (Bezerra et al. 2011a, b; Teixeira et al. 2014; Soares et al. 2018a).

Different types of interactions between human and bird populations have already been identified: the *social-affective* interaction, which corresponds to keeping birds as pets; the *trophic* interaction, which consists in using birds as a protein source; the *medicinal* interaction, which is related to using birds in folk medicine; and the *symbolic* interaction, which comprises the set of beliefs or superstitions concerning the birds cited by the respondents (Santos and Costa-Neto 2007). In addition to those use categories, these birds may also be used in craftwork (for example, feathers used in the manufacture of clothes and ornaments), recreational use, ornamental use (for example, feathers and eggshells as raw material for decorative items), to produce musical instruments (for example, using bones) and as bait for hunting other animals, which may involve mythological and historical issues linked to the culture of the human populations (Anderson 2010; Tidemann and Gosler 2010).

In ethno-biological studies, the potential use of natural resources has been analysed by calculating the use value (UV), which was first published by Phillips and Gentry (1993a, b), to estimate human knowledge of plant uses. This index has also been used frequently in ethno-ornithological studies (Texeira et al. 2014; Bezerra et al. 2017; Oliveira et al. 2018) to analyse the use of wild avifauna by local human populations. However, some authors (Albuquerque and Lucena 2005; Lucena et al. 2012a) have reported the shortcomings of this method because it fails to differentiate actual uses from the known or past uses of species. Therefore, Lucena et al. (2012a) recommended that the use value should consider three different types of calculations as follows: the general use value (which includes the known, current and past uses of species), current use value (which includes the current uses of species that are actually used) and potential use value (which includes the past uses of species).

The breakdown of the UV has been performed in several recent ethno-botanical studies (Lucena et al. 2012a, b; Ribeiro et al. 2014a, b). Some studies with an ethno-zoological focus on analysing these variations in the use values have been published (Soares et al. 2018a, b). The calculated use value of potentially useful and currently used species can be important for differentiating between historically used taxa and those that are now used. In the case of birds, it will be important to know which species are effectively used by local human populations—as some species may be known to have been used but are not currently sought after.

Another quantitative method used in ethno-biological studies is the conservation priority index, which was initially used in ethno-botanical studies (Dhar et al. 2000; Kala et al. 2004; Oliveira et al. 2007; Albuquerque et al. 2009, 2011; Lucena et al. 2013) to evaluate both the biological and cultural aspects related to the plant species in use and to contribute to species conservation strategies and their more sustainable use. Human use of natural

resources is also affected by ecological factors. Phillips and Gentry (1993a) suggest that the more easily found plants offer greater possibilities for local populations to experiment with their uses, thus increasing the likelihood that people will incorporate these resources into the local culture. In ethno-ornithological studies, a simple way to collect data on the relative abundance of species is to calculate the frequency of their occurrence from data gathered using the MacKinnon lists method (Mackinnon 1991; Herzog et al. 2002), and its results may be correlated with the species used by the local population. In this context, ethno-ornithological surveys that record and quantify the use pressure of human populations on avifauna resources are important for providing the necessary data for species management and conservation at local level.

The Serra de Santa Catarina mountains, the present study area, is considered a biologically important site and one of the few areas that still harbours seasonal deciduous forest formations within a Caatinga (dryland) matrix (Giulietti et al. 2003). It likewise represents an important area for wild bird conservation (Silva et al. 2003), as the avifauna there shows high species richness and the presence of species considered rare or threatened (Araujo and Mariano 2012).

The site is an ideal location to apply the ethno-biological techniques described above and gain a wider comprehension of the relationships between local human populations and the avifauna in a biologically well-preserved Caatinga environment (Gadellha-Neto et al. 2018; Lucena et al. 2018). As such, the following questions were posed to be addressed using ethno-biological and statistical tools: is there a correlation between the current use value and potential use value of the wild bird species now sought after? Do more locally abundant species tend to be better known and used by the local population? Which species have the highest conservation priority index? Have hunting of bird species as a food resource associated with the availability of these species in the area or with the body mass of these species? From a conservationist standpoint, these data may be valuable in guiding future environmental education and public policy studies with local populations. Additionally, our results can contribute to future research projects and conservation actions designed to protect local avifauna and conserving endangered bird species in the study area.

2 Materials and methods

2.1 Study area and characterisation of the study target population

Santa Catarina Mountain is located in the tropical dry forest Paraíba state, Brazil (approximate central point: 7°00′46″ South and 38°11′12″ West; Fig. 1). It extends for approximately 25 km and covers an area of approximately 112.1 km^2 (Brandão et al. 2009). This region is a key conservation area for wild birds in Paraíba state (Silva et al. 2003).

One of the largest centres of seasonally dry deciduous forests in South America is in Northeast Brazil, known as the Caatinga (Banda-R et al. 2016). The Caatinga has a semi-arid tropical climate with an unstable rainfall regime (Ab'Saber 1977), average annual temperature of approximately 26 °C (Nimer 1989) and precipitation varying between 240 and 1500 mm, with 50% of the region receiving less than 750 mm (Prado 2003). Thus, the vegetation shows adaptations to drought and is basically composed of species bearing thorns, tiny leaves and xerophilism with phytophysiognomies ranging from being dominated by open shrub vegetation to deciduous forests (Giulietti et al. 2004).

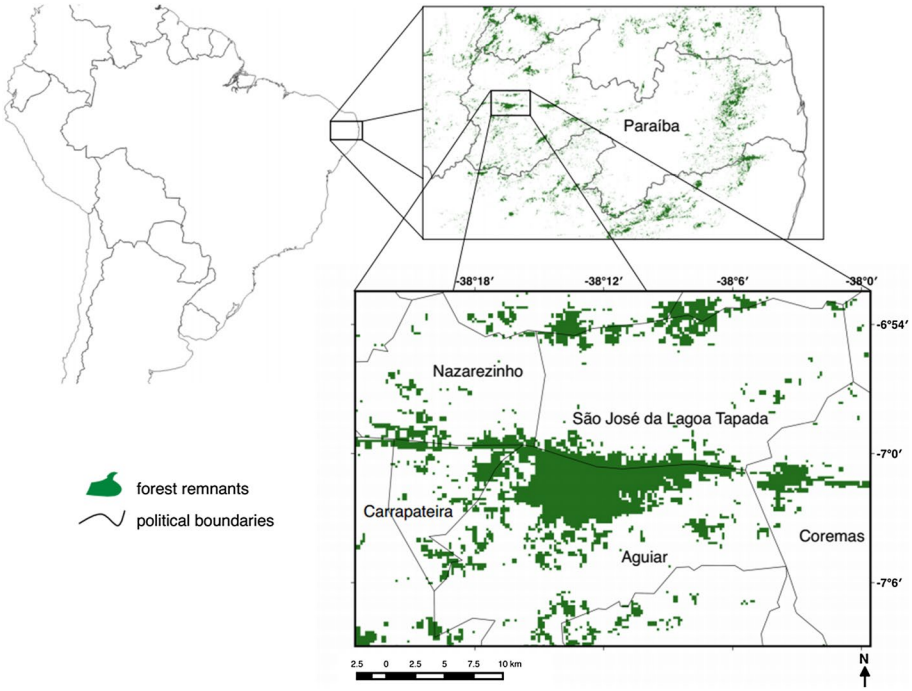

Fig. 1 Geographic location of the study areas: Nazarezinho, Carrapateira and São José da Lagoa Tapada (Paraíba State, Northeast Brazil) and forest remnants Santa Catarina Mountain

Ethno-ornithological data were collected in rural areas of the São José da Lagoa Tapada (06°56′27″ South, 38°09′43″ West), Nazarezinho (06°54′57″ South, 38°19′30″ West) and Carrapateira (07°02′20″ S, 38°20′38″ West) municipalities, which are located in the immediate vicinity of Santa Catarina Mountain. The rural areas located in the vicinity of the mountain have agriculture and livestock activities, and the logging, perceived uses and anthropogenic actions, and animal poaching are also performed.

2.2 Ethno-ornithological data collection

The interviews were performed during August and September of 2013, October 2014 and January 2015. Hunters/former hunters who were willing to participate and people who capture birds for use as pets were interviewed at each location. While the first local hunters were interviewed, the selection was performed using the snowball method (Bailey 1994). Thirty-three people (27 men and six women) with ages ranging from 10 to 87 years and a mean age of 46 years were interviewed. Most respondents were born at the study locations (63.6%, $N=21$) and lived in rural areas (93.93%, $N=31$).

Data on local avifauna knowledge and use were collected using semi-structured interviews, which were complemented by free interviews and informal conversations (Huntington 2000). The ethno-ornithological questionnaire addressed specific questions on birds that are known and used by residents and their use categories.

2.3 Species identification

The birds direct visualisation in the homes of the respondents, photographic records during interviews and the birds cited by respondent using the checklist-interview method (Alexiades 1996) were identified to the species level using field guides (for example, Ridgely and Tudor 2009; Sigrist 2014). The scientific nomenclature used in this research study followed the taxonomy suggested by the BirdLife International (2017).

2.4 Data analysis

2.4.1 Use value

The use value (UV) of each bird species cited here was calculated using the following formula: $VU = \Sigma Ui/n$, as reported by Rossato et al. (1999), where Ui = number of uses mentioned per informant and n = total number of informants.

The use value was calculated in the following four different ways: the current use value (UVc), based on citations of the bird uses that the respondents (hunters) reported using currently; the potential use value (UVp), corresponding to the use of birds that the respondents (former hunters) cited as knowing or having previously used; and the symbolic use value (UVs), based on citations of birds to which symbolic knowledge is assigned, albeit without actual use. Lastly, the general use value (UVg), which makes no distinction between current and past use and symbolic knowledge, was calculated.

2.4.2 Current and potential use value

Spearman's rank correlation coefficients were calculated to assess whether there was an association between the current (UVc) and potential (UVp) use value of the wild avifauna species used in the study area. The analysis was performed using BioEstat 5.0 software (Ayres et al. 2007) and adopting a 5% significance level ($p < 0.05$). The analyses indicated that the historically hunted species are the same as those currently hunted.

2.4.3 Conservation priority index

The Conservation Priority Index (CPI) of locally used animals was calculated with the method adapted from Oliveira et al. (2007). The following formula, the criteria of which are outlined in Table 1, was used: CPI = 0.5 (BS) + 0.5 (UR).

The Biological Score (BS) was calculated using the frequency of occurrence (FO) based on the MacKinnon lists, where $BS = A \times 10$, with A = the score for the occurrence frequency of each species.

The Use Risk (UR) value was calculated using the following formula: $UR = 0.5\ (H) + 0.5\ (U) \times 10$, where (H) = sampling risk score and (U) is the highest value found among the local importance (L) and use diversity (V) values which are detailed in Table 1. This approach was chosen because it combines biological and cultural aspects when determining the priority species for conservation.

Table 1 Criteria of the scores used to calculate the conservation priority index of birds cited by respondents in Santa Catarina Mountain, PB, Brazil, as adapted from Oliveira et al. (2007)

Criteria	Scores
A. Relative abundance was calculated using the frequency of occurrence (*FO*) *based on the MacKinnon lists* (*A*)	
Not registered—very low (0–3%)	10
Low (3 < 10%)	7
Medium (10 < 25%)	4
High (≥ 25%)	1
B. Use risk (*H*)	
Destructive capture of the animal, in which the obtaining of the animal product entails the death of the individual	10
Capture of the individual, without death of the animal and its breeding in captivity	7
Extraction of parts of animals that are collected without causing the individual's death	4
Extraction of metabolism products such as faeces and urine	1
There is no capture of the animal	0
C. Local importance (*L*)	
High (listed by > 20% dos of the local informants)	10
Moderately high (10 ≤ 20% of the local informants)	7
Moderately low (< 10% of the local informants)	4
D. Diversity of use (*V*)	
For each use is added a point	1–∞

2.4.4 Frequency of occurrence

The frequency of occurrence (FO) of the species cited by the respondents was calculated using the equation $FO = (P \times 100)/T$, where P is the number of records of the species in the 10-species lists (Herzog et al. 2002) and T is the total number of MacKinnon lists. The MacKinnon lists were compiled from Santa Catarina Mountain and its vicinity to cover different environments.

2.4.5 Use value, frequency of occurrence and body mass of birds

The Spearman's rank correlation coefficient was calculated to assess whether the current (UVc) and potential (UVp) use values are associated with the frequency of occurrence (FO) and to the body masses of wild bird species in Santa Catarina Mountain. The aim of these analyses was to assess whether the preference of hunters and former hunters for wild bird species is related to their availability in the environment and to the bird body mass, respectively. In this case, only bird species that were hunted or captured for food purposes were considered. These analyses were performed using BioEstat 5.0 software (Ayres et al. 2007) at a 5% significance level ($p < 0.05$).

The body mass data were collected from the literature (for example, Sick 2001; Piratelli et al. 2001; Sigrist 2014) and included morphometric data collected during field surveys.

3 Results

3.1 Bird species cited

Sixty-five wild bird species belonging to 27 families were cited (Table 2). All the bird species recorded here are native to Brazil, including four that are endemic to Caatinga (*Penelope jacucaca*, *Eupsittula cactorum*, *Paroaria dominicana* and *Sporophila albogularis*) and two that are endemic to Brazil (*Cyanocorax cyanopogon* and *Icterus jamacaii*). The Columbidae (eight species), Thraupidae (eight species) and Icteridae (seven species) families stood out with the highest number of cited species.

3.2 Use categories and use value

Four categories related to the use of wild birds were identified on the basis of respondent citations as follows: food use, use as a pet, medicinal use and symbolic knowledge (Fig. 2). Symbolic knowledge is the only category identified in this research study that required no specimen capture. The other categories require the capture of the bird in the wild, in some cases alive and in others dead, for actual use.

Although no commercial use of wild birds by the interviewed hunters was noted here, several respondents reported the existence of other hunters in the region and in other locations of the state of Paraíba who hunt birds on Santa Catarina Mountain for sale in a few urban centres.

Of all the respondents, 90.9% ($n=30$) cited at least one symbolic aspect related to avifauna. Regarding the remaining uses, 81.8% ($n=27$) of all the respondents mentioned using the birds for food, 54.5% ($n=18$) as pets, and only 18.2% ($n=6$) reported using birds as a zootherapeutic resource.

Symbolic knowledge related to wild avifauna was the category with the highest bird species richness ($n=35$, 53.8%) mentioned by the respondents. The food resource and pet uses had the same number of species cited ($N=24$, 36.9%). Conversely, the medicinal use of avifauna was the category with the lowest species richness ($N=7$, 10.8%). It is noteworthy that some species were cited in more than one use category (Table 2).

The birds commonly known as white-tipped dove (*Leptotila verreauxi*, UVg = 0.64), tataupa tinamou (*Crypturellus tataupa*, UVg = 0.61), white-browed guan (*Penelope jacucaca*, UVg = 0.61) and small-billed tinamou (*Crypturellus parvirostris*, UVg = 0.58) had the highest general use values (UVg), and they are birds that are typically hunted for use as food resources (see Table 2).

Six of the 37 species stood out for having the highest current use values (UVc) as follows: *L. verreauxi* and *P. dominicana* (UVc = 0.45), *C. parvirostris, Zenaida auriculata* (UVc = 0.40) and *C. tataupa* and *P. jacucaca* (UVc = 0.35). Among these birds, only the *P. dominicana* species is captured for use as a pet, whereas the others are used for food.

A total of 40 birds with potential use values (UVp) were recorded, and the species *P. jacucaca*, *C. tataupa* (UVp = 1.00), *L. verreauxi* and *Nothura boraquira* (UVp = 0.92) stood out for having the highest values and are commonly hunted for food.

Regarding the symbolic use value (UVs), 35 species were mentioned, and the laughing falcon (*Herpetotheres cachinnans*, UVs = 0.43), purple-throated euphonia (*Euphonia chlorotica*, UVs = 0.40) and American barn owl (*Tyto furcata*, UVs = 0.33) had the highest symbolic use values.

Table 2 List of species and use categories of the avifauna cited by respondents from the Santa Catarina Mountain region in the state of Paraíba, Brazil

Taxon	Common name [Portuguese]	Use	UVa	UVp	UVs	UVg	FO (%)	BM (g)	CPI
TINAMIDAE									
Crypturellus parvirostris (Wagler, 1827)	Small-billed tinamou [Lambu-do-pé-vermelho]	F, M	0.4	0.85	0	0.58	0.22	154	100
Crypturellus tataupa (Temminck, 1815)	Tataupa tinamou [Lambu-do-pé-roxo]	F, M	0.35	1.00	0	0.61	22.76	170	70
Nothura boraquira (Spix, 1825)	White-bellied nothura [Codorniz]	F, S, M	0.25	0.92	0.07	0.58	0	175	100
Nothura maculosa (Temminck, 1815)	Spotted nothura [Espanta-boiada]	F	0	0.15	0	0.06	0	165	85
ANATIDAE									
Dendrocygna viduata (Linnaeus, 1766)	White-faced whistling duck [Marreca-viuvinha]	F	0.25	0.23	0	0.24	0	800	100
Amazonetta brasiliensis (Gmelin, 1789)	Brazilian teal [Paturi]	F	0.10	0.08	0	0.09	0	700	85
CRACIDAE									
Penelope jacucaca (Spix, 1825)	White-browed guan [Jacu]	F	0.35	1.00	0	0.61	0.22	1500	100
Penelope superciliaris (Temminck, 1815)	Rusty-margined guan [Jacupemba]	F	0.30	0.62	0	0.42	0.88	1000	100
ARDEIDAE									
Tigrisoma lineatum (Boddaert, 1783)	Rufescent tiger-heron [Socó-boi]	F	0.10	0	0	0.06	0.22	2000	85
CATHARTIDAE									
Coragyps atratus (Bechstein, 1793)	Black vulture [Urubu]	M	0	0.08	0	0.03	2.19		70
Cathartes aura (Linnaeus, 1758)	Turkey vulture [Urubu-da-cabeça-vermelha]	S, M	0	0.08	0.03	0.06	2.63		70
ACCIPITRIDAE									
Spizateus melanoleucus (Vieillot, 1816)	Black-and-white hawk-eagle [Tourona]	S	0	0	0.03	0.03	0.66		60
Buteogallus meridionalis (Latham, 1790)	Savanna hawk [Gavião-vermelho]	S	0	0	0.03	0.03	0.22		60
Rupornis magnirostris (Gmelin, 1788)	Roadside hawk [Gavião-pedrez]	S	0	0	0.03	0.03	18.60		30
ARAMIDAE									
Aramus guarauna (Linnaeus, 1766)	Limpkin [Carão]	F, S	0.15	0.08	0.27	0.36	0	1000	100
RALLIDAE									
Aramides cajaneus (Statius Muller, 1776)	Grey-necked wood-rail [Três-pote]	F, S	0.20	0.31	0.20	0.42	0.22	500	100
Gallinula galeata (Lichtenstein, 1818)	Common gallinule [Galinha-da-água-preta]	F	0.25	0.54	0	0.36	0.22	300	100

Table 2 (continued)

Taxon	Common name [Portuguese]	Use	UVa	UVp	UVs	UVg	FO (%)	BM (g)	CPI
Porphyrio martinicus (Linnaeus, 1766)	Purple gallinule [Galinha-da-água-azul]	F	0.20	0.31	0	0.24	0	250	100
CHARADRIIDAE									
Vanellus chilensis (Molina, 1782)	Southern lapwing [Tetéu]	S	0	0	0.07	0.06	0.22		60
BUCCONIDAE									
Nystalus maculatus (Gmelin, 1788)	Spot-backed puffbird [Fura-barreira]	S	0	0	0.03	0.03	1.97		60
CARIAMIDAE									
Cariama cristata (Linnaeus, 1766)	Red-legged seriema [Sariema]	F, S	0.15	0.15	0.13	0.27	1.75	1400	100
FALCONIDAE									
Herpetotheres cachinnans (Linnaeus, 1758)	Laughing falcon [Acauã]	F	0	0	0.43	0.39	2.63		75
COLUMBIDAE									
Columbina minuta (Linnaeus, 1766)	Plain-breasted ground dove [Rolinha-cachecha]	F, P, S	0.15	0.08	0.03	0.15	1.31	27	92.5
Columbina talpacoti (Temminck, 1810)	Ruddy ground dove [Rolinha-caldo-de-feijão]	F, P	0.20	0.31	0	0.24	4.38	47	85
Columbina squammata (Lesson, 1831)	Scaled dove [Rolinha-cascavel]	F, P, S	0.20	0.38	0.03	0.30	1.53	47	100
Columbina picui (Temminck, 1813)	Picui ground dove [Rolinha-branca]	F, P, S	0.25	0.08	0.03	0.21	7.00	42	85
Patagioemas picazuro (Temminck, 1813)	Picazuro pigeon [Asa-branca]	F, S	0.05	0.08	0.03	0.09	0.22	250	85
Zenaida auriculata (Des Murs, 1847)	Eared dove [Ribaçã, arribaçã]	F	0.40	0.31	0	0.36	0.44	100	100
Claravis pretiosa (Ferrari-Perez, 1886)	Blue ground dove [pomba-azul]	F	0.05	0.23	0	0.12	26.26	100	47.5
Leptotila verreauxi (Bonaparte, 1855)	White-tipped dove [Juriti]	F, P	0.45	0.92	0	0.64	49.23	153	55
PSITTACIDAE									
Eupsittula cactorum (Kuhl, 1820)	Cactus parakeet [Louro]	P	0.20	0.38	0	0.24	10.94		62.5
CUCULIDAE									
Crotophaga major (Gmelin, 1788)	Greater ani [Anum-preto]	S	0	0	0.17	0.15	0		67.5
Crotophaga ani (Linnaeus, 1758)	Smooth-billed ani [Anum-preto]	S, M	0	0.08	0.03	0.06	4.16		70
Guira guira (Gmelin, 1788)	Guira cuckoo [Anum-branco]	S, M	0	0.08	0.03	0.06	0.44		60
Coccyzus melacoryphus (Vieillot, 1817)	Dark-billed cuckoo [papa-lagarta]	S	0	0	0.17	0.15	0.44		67.5

Table 2 (continued)

Taxon	Common name [Portuguese]	Use	UVa	UVp	UVs	UVg	FO (%)	BM (g)	CPI
TYTONIDAE									
Tyto alba (Scopoli, 1769)	American barn owl [Rasga-mortalha]	S	0	0	0.33	0.30	0		75
STRIGIDAE									
Athene cunicularia (Molina, 1782)	Burrowing owl [Caburé]	S	0	0	0.03	0.03	0		60
CAPRIMULGIDAE									
Antrostomus rufus (Boddaert, 1783)	Rufous nightjar [João-corta-pau]	S	0	0	0.10	0.09	0.22		60
Nyctipolus hirundinaceus (Spix, 1825)	Pygmy nightjar [Coruja-pequena]	S	0	0	0.10	0.09	0.44		60
Caprimulgus parvulus (Gould, 1837)	Little nightjar [Bacurau]	S	0	0	0.03	0.03	0		60
TROCHILIDAE									
Eupetomena macroura (Gmelin, 1788)	Swallow-tailed hummingbird [Beija-flor-rabo-de-tesoura]	S	0	0	0.07	0.06	0.66		60
Chlorostilbon lucidus (d'Orbigny & Lafresnaye, 1838)	Glittering-bellied emerald [Beija-flor-pequeno]	S	0	0	0.03	0.03	11.60		30
FURNARIIDAE									
Furnarius leucopus (Swainson, 1837)	Pale-legged hornero [João-de-barro]	S	0	0	0.23	0.21	5.69		60
CORVIDAE									
Cyanocorax cyanopogon (Wied, 1821)	White-naped jay [Cancão]	F, P, S	0	0.08	0.07	0.09	10.94	90	55
TURDIDAE									
Tudus amaurochalinus (Cabanis, 1850)	Creamy-bellied thrush [Sabiá-branca]	P, S	0	0.15	0.03	0.09	0.66		77.5
Turdus rufiventris (Vieillot, 1818)	Rufous-bellied thrush [Sabiá-laranjeira]	P, S	0.05	0.15	0.10	0.18	4.60		70
THRAUPIDAE									
Paroaria dominicana (Linnaeus, 1758)	Red-cowled cardinal [Galo-de-campina]	P, S	0.45	0.23	0.03	0.39	6.78		77.5
Sicalis flaveola (Linnaeus, 1766)	Saffron finch [Canário-da-terra]	P	0.05	0.23	0	0.12	0.22		85
Sporophila albogularis (Soix, 1825)	White-throated seedeater [Golinha]	P	0.25	0.15	0	0.21	2.63		85
Sporophila bouvreuil (Statius Muller, 1776)	Cooper seedeater [Caboclo]	P	0	0.08	0	0.03	0		77.5
Sporophila lineola (Linnaeus, 1758)	Linned seedeater [Bigode]	P	0.15	0.08	0	0.12	0.88		85

Table 2 (continued)

Taxon	Common name [Portuguese]	Use	UVa	UVp	UVs	UVg	FO (%)	BM (g)	CPI
Sporophila nigricollis (Vieillot, 1823)	Yellow-bellied seedeater [Bico-de-prata]	P	0.10	0	0	0.06	1.31		77.5
Volatinia jacarina (Linnaeus, 1766)	Blue-black grassquit [Peruazinha]	S	0	0	0.03	0.03	7.22		45
Coryphospingus pileatus (Wied, 1821)	Sibite	P	0.05	0	0	0.03	3.94		62.5
PASSERELLIDAE									
Zonotrichia capensis (Müller, 1776)	Pileated finch [Tio-tio]	P	0.05	0	0	0.03	0		77.5
CARDINALIDAE									
Cyanoloxia brissonii (Lichtenstein, 1823)	Ultramarine grosbeak [Azulão]	P	0.15	0.23	0	0.18	0.22		85
ICTERIDAE									
Icterus pyrrhopterus (Vieillot, 1819)	Variable oriole [Viana]	P	0.05	0.31	0	0.15	0.66		85
Icterus jamacaii (Gmelin, 1788)	Campo troupial [Sôfreu]	P	0.05	0.31	0	0.15	0.22		85
Gnorimopsor chopi (Vieillot, 1819)	Chopi blackbird [Craúna]	P	0	0.08	0	0.03	0		77.5
Cacicus solitarius (Vieillot, 1816)	Solitary black cacique [Bico-de-osso]	P, S	0.05	0	0.07	0.09	0.22		77.5
Leistes superciliaris (Bonaparte, 1851)	White-browed blackbird [Pardal]	F	0.05	0	0	0.03	0	47	85
Chrysomus ruficapillus (Vieillot, 1819)	Chestnut-capped blackbird [Xéxeu-de-bananeira]	S	0	0	0.03	0.03	0		60
Molothrus bonariensis (Gmelin, 1789)	Shiny cowbird [Pássaro-de-arroz]	P	0.05	0.08	0	0.06	0.44		77.5
FRINGILLIDAE									
Spinus yarrellii (Audubon, 1839)	Yellow-faced siskin [Pintassilgo]	P	0	0.23	0	0.09	0		77.5
Euphonia chlorotica (Linnaeus, 1766)	Purple-throated euphonia [Vim-vim]	S	0	0	0.40	0.36	23.19		45

F, food; P, pet; M, medicinal; S, symbolic; UVp, potential use value; UVc, current use value; UVs, symbolic use value; UVg, general use value; FO, frequency of occurrence in MacKinnon lists; BM (g), body mass in grams of species cited for food use; CPI, conservation priority index

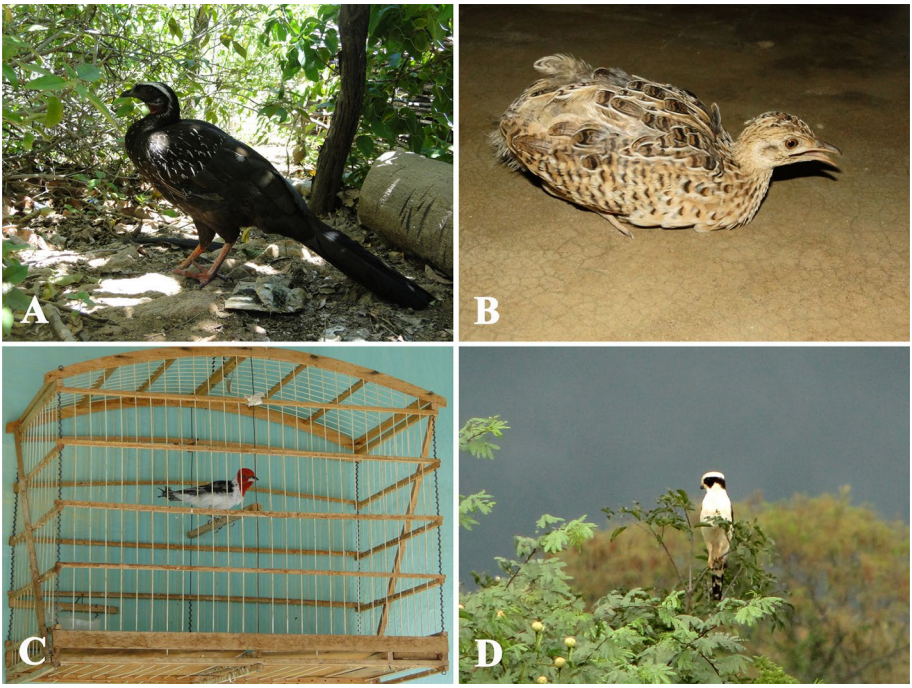

Fig. 2 Examples of bird species used as food resource (**a** *Penelope jacucaca* e **b** *Nothura boraquira*), zootherapeutic resource (**b** *N. boraquira*), pets (**c** *Paroaria dominicana*) and symbolic knowledge (**d** *Herpetotheres cachinnans*), according to the respondents from Santa Catarina Mountain, Paraíba State, Brazil

The statistical analysis showed a positive correlation (rs = 0.7223, $p < 0.0001$) between the current and potential use values of species that are actually used on Santa Catarina Mountain.

The correlation analysis between the current use values of wild birds that are hunted for food and their relative abundance (frequency of occurrence) at Santa Catarina Mountain showed no significant correlation (rs = 0.1955, $p = 0.360$). No correlations between the potential use of wild birds that were hunted as food resources and their relative abundance (rs = 0.2099, $p = 0.325$) and between their body mass and the current (rs = 0.0697, $p = 0.746$) and potential (rs = 0.1019, $p = 0.636$) use values were found.

3.2.1 Conservation priority

Four hundred fifty-seven MacKinnon lists were prepared from the different vegetation formations of Santa Catarina Mountain. The number of records of each species per list was tallied to calculate their frequency of occurrence. The species *Leptotila verreauxi* (49.23) had the highest occurrence frequency value.

These species had conservation priority index (CPI) scores ranging from 30 to 100. Of all the species cited by respondents, 12 had the maximum score (CPI = 100), and all the species were actually captured for use as a food resource (see Table 2).

Birds with CPI values ranging from 62.5 to 92.5 included a total of 34 species. Eighteen of those species are specifically captured for use as pets in cages; nine species are hunted,

primarily for use as a food resource; four species are used as a zootherapeutic resource; and three species were related to symbolic knowledge.

Eighteen of the 19 bird species with CPI scores ranging from 30 to 60 were birds related to symbolic knowledge, and only one species (*Leptotila verreauxi*) is captured for use as a food resource.

4 Discussion

4.1 Use categories

Social-affective and trophic interactions exerted the highest use pressure on avifauna in the study area because they include the actual capture of wild birds, and most of the high number of cited bird species related to those interactions had high use values. This situation has been recorded by other authors (Fernandes-Ferreira et al. 2012; Alves et al. 2013; Oliveira et al. 2018), who also indicate that these uses promote the illegal trade of wild birds. This activity applies high pressure to the birds of the north-east semiarid region. Although the commercial use of wild birds was not recorded among the respondents in the study area, they indicated that this practice occurs in the Santa Catarina Mountain region. Thus, the commercial use of wild birds could most likely be considered one of the uses that most impact these bird populations, because the higher the number of hunted or captured individuals, the higher the profit gained by the hunter and traders would be, respectively.

Bird hunting for food resources provides an alternative protein source for human populations that capture birds directly from the environment (Bezerra et al. 2011a). However, it is noteworthy that killing birds through hunting practices is currently associated with subsistence but may also have recreational purposes (Alves et al. 2009). Game birds are consumed by hunters, donated to friends and relatives and, in some cases, even sold, thereby generating income that may be used to purchase household goods.

Symbolic knowledge included an impressive number of bird species and was the type of interaction cited by the most respondents. Despite precluding the capture of birds, this type of interaction demonstrates the importance that this vertebrate group has in the culture and imagination of local human populations. Bezerra et al. (2013) stated that symbolic knowledge of avifauna, which is usually passed on orally, expresses a system of beliefs that is intrinsically related to the hunting practices and daily experiences of local populations in the Brazilian semiarid region.

The medicinal use of wild birds was the interaction associated with the lowest number of species and the lowest number of citations per respondent, assuming that the value of birds as medicinal resources is not significant in the study area, although the people from the study area still have this knowledge. Similarly, Teixeira et al. (2014) reported small numbers of birds that were cited as therapeutic resources, and respondents cited this type of use in the municipality of Barbalha, Ceará state. Several research studies on animal use in folk medicine in the north-east semiarid region have indicated that birds are one of the vertebrate groups with the lowest number of species cited when compared with the numbers of mammals, reptiles and fish (Ferreira et al. 2009; Souto et al. 2011; Alves et al. 2012, 2016). Ethno-zoological studies conducted in other countries also support this trend (Benítez 2011; Chakravorty et al. 2011).

The statistical analysis showed that the bird species with the highest current and potential use values were very similar when considering the current and past use

(species used before the year 2013) of those species in the study area. Thus, the peculiar characteristics of those bird species are likely culturally important for the human populations that use them, reflecting the ongoing practice of using those birds (either as food sources, pets or zootherapeutic resources) in that region. Similarly, ethno-botany studies have also shown positive correlations between the current and potential use values of plants used by human populations in the north-east semiarid region (Lucena et al. 2012a; Ribeiro et al. 2014a, b). It is noteworthy that the Santa Catarina Mountain region has a Caatinga area that is still well preserved, with populations of birds that have already experienced a strong population decline in other areas. Thus, the environmental availability of historically hunted and preferred species is a factor that enables the perpetuation of their use over time (Araujo and Vieira-Filho 2018).

The species *Leptotila verreuaxi* and *Crypturellus tataupa* showed abundance (frequency of occurrence) in the higher environment than larger species such as cracids. In spite of this, our data do not suggest that these hunted species suffer more pressure of use at present because they have greater availability in the environment. The statistical analysis showed no correlation between the current use value and relative abundance of species hunted as food resources. Similarly, no correlation between the potential use value and relative abundance of birds was shown either. These data suggest that both the current and past use of avifauna species hunted in the study area are not related only to the environmental availability of birds and that other factors contributing to the choice of bird species that are hunted for food should also be present in this region.

The preference for birds of the Tinamidae, Columbidae and Cracidae families as food resources is clear in the study area and in other Brazilian semiarid regions (Albuquerque et al. 2012; Fernandes-Ferreira et al. 2012; Loss et al. 2014; Teixeira et al. 2014). This preference is not related only to the body mass factor, because the birds of the Anatidae, Rallidae, Aramidae and Ardeidae families, which have a relatively high biomass, had a low use value in the present study and in other studies on the use of birds as food resources that were conducted in the states of Rio Grande do Norte (Bezerra et al. 2011a), Ceará (Fernandes-Ferreira et al. 2012) and Bahia (Loss et al. 2014), showing a lower preference for aquatic birds than terrestrial or arboreal birds. Furthermore, species from the Columbidae family, for example, the *Zenaida auriculata* species and the *Columbina* genus, are commonly hunted as food resources, despite their small size. Corroborating these findings, the statistical analysis showed no correlation between the current and potential use values and the body masses of birds used as trophic resources on Santa Catarina Mountain. Therefore, the body size of the birds is not the only factor affecting their choice of food resources in the study area. A set of factors, and not a single characteristic, most likely determines the choice of preferred species for this use category. That is, in addition to the body mass, the meat taste, environmental availability and the gregarious behaviour of small-sized species (for example, *Z. auriculata*) may also be considered key factors in this choice.

In this context, the results have shown that some species with low relative abundance, including cracids, are still commonly hunted in the Santa Catarina Mountain area. This hunting is rather concerning from a conservationist standpoint, because hunting is one of the primary factors that contributes to the population decrease in this family and may lead to local extinctions (Brooks and Fuller 2006). Another key factor in conservation is related to the role that cracids play in ecological interactions. Cracids are considered key seed dispersers and maintain the constant regeneration of forests (Redford 1992; Silva and Tabarelli 2000; Brooks and Fuller 2006).

4.2 Conservation priority

Species that are captured for use as food resources receive the maximum conservation priority index (CPI = 100) value, including the *P. jacucaca* species, which is already found in the "vulnerable" category of the endangered species of Brazil and the world (BirdLife International 2016; MMA 2014). Hunting activities are one of the primary factors in this categorisation (Brooks and Fuller 2006; Silveira and Straube, 2008; Fernandes-Ferreira et al. 2012). The use of birds as food resources, in addition to their great cultural importance in the region, exerts a strong hunting pressure and may be one of the primary causes of the population decline of several wild bird species on Santa Catarina Mountain. These results highlight the need for more urgent conservation measures for these species and indicate that they should be considered in management plans for the wild avifauna of this region.

Forty-six species have a conservation priority index with values of $62.5 \leq \text{CPI} \leq 92.5$, and most are included in the pet use category. These species also deserve attention from a conservationist standpoint, because the ongoing and intense capture of these birds for cage-keeping may cause their population to decline in the region and therefore lead to threats of local extinction. This threat is exemplified by the case of the endangered species *Spinus yarrelli*, which is in the vulnerable category (BirdLife International 2018; MMA 2014) because of habitat destruction combined with intense capture to supply the illegal wild bird market (Lima 2008).

Nineteen bird species had the lowest conservation priority indices ($\text{CPI} \leq 60$) are commonly related to symbolic knowledge. This finding was already expected because they are not captured in the Santa Catarina Mountain region, and therefore, they experience no use pressure. Furthermore, the symbolism associated with some species prevents them from being hunted. The case of the specie *Vanellus chilensis* is an example of a food taboo that was also recorded in the present research study. According to the respondents, the use of this species as a food resource could presumably cause insomnia disorders in its consumers. Marques (2006, 2010) highlighted the role of birds in the popular imagination, including knowledge and beliefs about several species. In addition to birds, several authors have also discussed various other animals related to artistic, religious, symbolic and mythological aspects that are present in the culture of human populations in several parts of the world (Adeola 1992; Colding and Folke 2001; Alves 2012; Herrmann et al. 2013).

The species *Leptotila verreauxi*, *Claravis pretiosa* and *Cyanocorax cyanopogon* had a low conservation priority index, despite the pressure from their use as food resources or as pets. The low conservation priority index found for these species is related to the fact that they have higher frequency of occurrence at Santa Catarina Mountain than other species experiencing similar use pressure.

4.3 Implications for conservation

Our results show that birds are present in the daily life and imagination of hunters in the study area and play a key role from a cultural, symbolic, affective, recreational and/or food standpoint. The high number of avifauna species associated with symbolic aspects demonstrates the cultural importance of birds in the daily and imaginary lives of these human populations, and the knowledge of some species of wild birds affects their conservation because most species cited in this category had a low conservation priority index. The

habit of keeping wild birds is also a cultural practice that is widespread throughout several Brazilian regions and is often practised because of an admiration for birds. This factor may be used to raise awareness among local populations regarding the illegality of that activity in Brazil.

Among the use categories identified here, bird capture for food may be considered the category with the highest hunting pressure because of the high number of species involved, including one endangered species, and because of the high use and conservation priority index values recorded for the species included in this category. The bird species experiencing the highest use pressure are members of the Columbidae, Tinamidae and Cracidae families. Thus, there is an urgent need for conservationist policies to target the birds of these families have suffered intense use pressure in several locations in the Northeast Brazil (Fernandes-Ferreira et al. 2012; Teixeira et al. 2014; Loss et al. 2014). In addition, the species *Penelope jacucaca* is already endangered, primarily because of the high hunting pressure throughout the history of Brazilian bird hunting (Brooks and Fuller 2006; BirdLife International 2016).

No association was identified between the choices of birds used as food resources and their local availability or body masses. That result evidenced that the birds preferred as food resources were chosen because of other factors, including cultural considerations and the personal preferences of the hunters themselves (such as the taste of their meat). Within that context, it will be important for future research in the area to consider other cultural factors influencing the choices of wild bird species in cinegetic activities, such as their taste.

Although hunting is considered an illegal activity under Brazilian law, and active efforts are expended by authorities to suppress hunting as well as the capture and commerce of wild animals, those activities are still widely practiced. As such, reinforcing vigilance and applying fines will not be sufficient in themselves to suppress those practices. One possible way to overcome those problems would be to develop environmental education strategies that focus on cinegetic practices. We believe that conservation strategies to avoid, or at least minimise, bird hunting and trapping in north-eastern Brazil must involve education and socialisation efforts.

Finally, the creation of a conservation area that includes the Serra de Santa Catarina region would be extremely useful in protecting local biodiversity, especially birds considered rare and/or threatened with extinction. The creation of a protected area would also potentialise the participation and involvement of the local population in conservation efforts in the region. As such, an interesting alternative designed to include populations within or adjacent to the Serra de Santa Catarina Mountains could involve incentives for adopting birdwatching as an eco-touristic activity. That activity would generate income while taking advantage of (and valorising) the ethno-ornithological knowledge of local populations and their capacity to serve as guides in the region—as no one knows more about those mountains than the local residents themselves. As such, public policy should be directed to incentivise the aptitude of local residents as eco-tourist guides. Those activities would not only generate income for those people but also help guarantee the maintenance of bird species in their natural environment and the ecosystem services provided by conserved lands.

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Compliance with ethical standards

Ethical approval The present study was submitted to and approved by the Research Ethics Committee of the Federal University of Paraíba (certificate of presentation for ethical consideration—CAAE: 02254412.4.0000.5188).

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