ETHNOBIOLOGY AND CONSERVATION

RESEARCH ARTICLE

Ethnobiology and Conservation 2020, 9:14(11 May 2020)
doi:10.15451/ec2020-05-9.14-1-19
ISSN 2238-4782 ethnobioconservation.com

Is the knowledge about the wild birds influenced by the socioeconomic conditions of the human populations?

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ABSTRACT

The human populations of the Brazilian semiarid region interact strongly with the avifauna throughout the entire occupation of its territory. These interactions were established in a context of adverse edaphoclimatic conditions that limited crop production and socioeconomic welfare, making the uses of birds as food and income frequent excuses to label them as important subsistence resources. It is relevant to know whether such interactions today are still influenced by socioeconomic factors and in what way. Semi-structured questionnaires were applied to 105 residents, 45 men and 60 women, in rural communities of Casa Nova, Bahia state. Correlation analysis and regression models were performed to verify how the socioeconomic variables 'gender', 'age', 'education', 'monthly income' and 'residence time' of respondents explain the variation in the number of known species and the acknowledgement of the ecological importance of the birds. There were 840 bird citations, corresponding to 60 species. A correlation between age, income, residence time in the region and the number of species mentioned arouse, but there was no correlation with the acknowledgement of the ecological importance of the species. Men cited significantly more bird species than women. The results also indicate a low level of knowledge about bird species among younger populations. Socioeconomic factors strongly influence people's knowledge of bird species in their region. Exposure to wild birds and experience with it, gender, education and income together influence the knowledge about the diversity of this group.

Keywords: Ethnozoology; Ethno-ornithology; Semiarid; Conservation.

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SIGNIFICANCE STATEMENT

This manuscript is the first scientific contribution relating knowledge about wild birds and its uses by human populations in the region of Casa Nova, Bahia state, Brazil. Furthermore, it brings new insights into how socioeconomic factors impact people's knowledge about birds, predicting important causal relationships for conservation education projects and actions for sustainable development.

INTRODUCTION

The way each society interacts with wildlife makes it possible to gather information about species over the years (Alves and Souto 2015). Traditional societies store a vast dynamic and holistic collective ecological knowledge, resulting from historically constructed, socially shared experiences and individual learning (Toledo 2005; Toledo and Barrera-Bassols 2008). Such knowledge is derived from the management needs and impregnated with perceptions, values and beliefs that are transmitted throughout generations and influence the way humans interact with other animals (Drew 2005; Mourão and Nordi 2006). To understand human populations perceptions about natural resources and how management decisions and ecological relations are established is the key to design efficient conservation projects that also reduce poverty and increase people's livelihoods (Tucker 2007).

Among the vertebrates, birds are much appreciated (Soares et al. 2018a) and have been incorporated into human culture throughout history (Bezerra et al. 2012), mainly because they present a set of distinct characteristics of other animals such as colored plumage, capacity to fly and to sing, and for being active and easily seen during the day (Stotz et al. 1996; Alves et al. 2010).

Northeastern Brazil harbors a relative biodiversity of wild birds, with 548 species already recorded (Araujo and Silva 2017). It is also one of the most populated semiarid territories in the planet, home to about 28 million people, mostly rural inhabitants (Silva et al. 2017), with low human development indexes (HDI). In this environment, where the long periods of drought compromise subsistence activities, such as agriculture and livestock, the interactions between people and birds become particularly important. Capture and use of wildlife are ancient practices and play an important role in acquiring the necessary resources for the subsistence of these populations, either directly or as food source, or indirectly, by obtaining income from the sale of captured animals (Alves et al. 2009). To ensure effectiveness in the acquisition of such resources, human groups developed a set of specific techniques, based on the ecological knowledge of wildlife, developing hunting and gathering strategies that have been traditionally maintained (Alves et al. 2009) and disseminated orally through generations (Bezerra et al. 2013), becoming part of the cultural traditions of the inhabitants of the Caatinga (Alves et al. 2009).

Wild birds are very important in northeastern semiarid livelihood being used as subsistence items (Bezerra et al. 2011; Dantas-Aguiar et al. 2011; Alves et al. 2012; Fernandes-Ferreira et al. 2012; Galvane-Loss et al. 2014; Teixeira et al. 2014; Soares et al. 2018a,b), pets (Alves et al. 2010; Alves et al. 2013; Licarião et al. 2013; Alves Macário et al. 2016), traditional medicines (Bezerra et al. 2013; Soares et al. 2018b), raw material for handicrafts (Alves and Souto 2010; Alves et al. 2013; Fernandes-Ferreira et al. 2012), and associated with symbolic, mystical and religious relations (Alves et al. 2009; 2012; Santos and Costa-Neto 2007; Bezerra et al. 2013; Da Silva et al. 2017).

From an economic and social point of view, the exploitation of wild birds in the northeastern semiarid region is protected by the Brazilian Environmental Crimes Law (9605/98), which decriminalizes the hunting and capture of wild animals in case of food demand. This legal permission, somehow, favors the use and the continuing cultural importance of human interaction with wild

birds (Alves and Souto 2010; 2015). However, are socioeconomic factors still the main determinants of the relationships between people and wild birds? Factors such as income, education and age are the main determinants of human-bird relationships?

Although these human-bird relationships threaten the conservation of wild bird species in Caatinga, there is still a notable uneven distribution of these studies in the region. Most part of the researches are in areas close to universities or research institutes in Paraíba, Rio Grande do Norte and Ceará, with a low number of studies being developed in Bahia, despite of its representativeness in size in northeastern of Brazil. Gaps in investigating the influence of socioeconomic factors on such interactions include modelling the relations between socioeconomic aspects and understanding how local populations perceive the ecological importance of such species in the ecosystem.

Regarding local ecological knowledge on bird biodiversity, some aspects have been investigated: popular names, knowledge of species' habits and behavior (Farias and Alves 2007, Pires-Santos et al. 2015, Andrade 2016) and symbolic relationships culturally constructed (Araujo and Silva 2017, Bezerra et al. 2013). Understanding these relationships is of utmost importance to guide sustainable management strategies based on the level of knowledge and real needs of the local human populations (Alves et al. 2009), and to support educational actions, in order to provide relations of coexistence between people and avifauna (Da Silva et al. 2017).

Therefore, the present study aimed to answer the following question: how does vary the knowledge of the diversity of bird species and the acknowledgement of their ecological importance in the ecosystem in relation to socioeconomic aspects? There is a preconception that socioeconomic factors such as lower family income, longtime settled in the region, elder and male, are causally related to local ecological knowledge about birds' biodiversity, due to a utilitarian dependence and a consequent long lifetime experience. However, it is assumed that knowledge about birds' ecological importance is positively related with the level of formal knowledge. Thus, hypothesis formulated suggest that poverty causes more dependence of natural resources, facilitating knowledge of biodiversity (more dependent, implies more knowledge); time of experience with species and exposure to species influences knowledge of biological diversity; gender influences knowledge of birds biodiversity; and, formal education eases knowledge of biological diversity importance.

MATERIAL AND METHODS

Study area

This study was carried out in four communities in the municipality of Casa Nova (09º09'43"S, 40º58'15"W), north of Bahia, in the region of Lower São Francisco River Basin, with an area of 9,647.07 km² and a population of 64,940 inhabitants (IBGE 2011) (Figure 1): 1 - Recreio (09º 21'13"S; 41º04'78"W), 2 - Chapada do Avelar (09º19'49"S; 40º87'77"W), 3 - Lagoa do Barro (09º17'49"S; 41º26'26"W), and, 4 - Serra Branca (09º22'03"S; 40º86'99"W). These communities were selected because they are easily accessible from the county seat, and they constitute a good model for the analysis of the relations with the birds, according to frequent observations made preliminary to this research, when the region

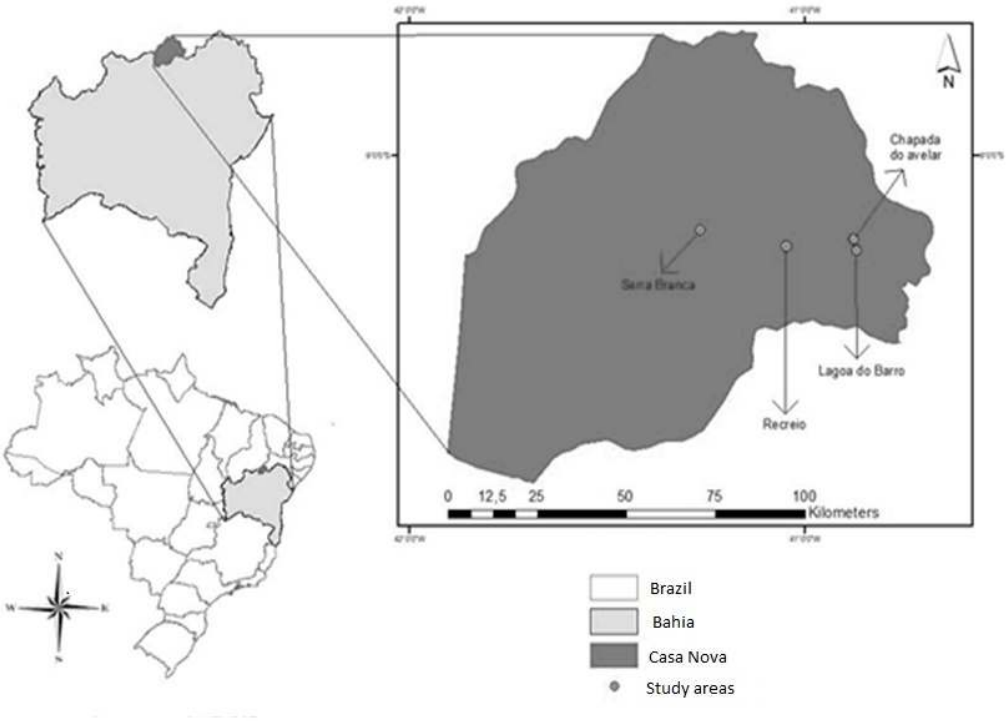

Figure 1. Location map of the study area: Recreio, Chapada do Avelar, Lagoa do Barro and Serra Branca, in the municipality of Casa Nova, Bahia.

was visited to select the collection points.

The municipality' economy includes agricultural and livestock activities, especially goat and sheep ranching. Casa Nova has the largest herd of goats in Bahia (468,258 animals representing 4.8% of Brazilian goat herd) (IBGE 2017a). According to the criteria adopted by the Atlas of Human Development, the HDI of the municipality is considered low (0.570) (PNUD et al. 2013), the average monthly income of the population is 1.5 minimum wages, and in 49.4% of households the monthly income is up to half a minimum wage per person. Also, the proportion of people working registered in Employment Booklet related to the total population is 9.6% (IBGE 2017b). The socioeconomic data collected are shown in Table 1-2.

Data collection

Between December 20, 2018 and March 31, 2019, all the residences of the four communities selected for the study were visited and the residents who volunteered to participate in the survey were interviewed, after signature of authorization for the collection, use and publication of data, required by Brazilian legislation (Resolution n. 466, of 12/12/2012, of the National Health Council of Brazil). It was assured by the researchers the confidentiality about the identity of the participants.

A total of 105 participants included 58 (32.2% of the total respondents) from Recreio community, 22 (73.3%) from Chapada do Avelar, 19 (63.3%) from Lagoa do Barro and 6 (40%) from Sítio Lagoinha (Serra Branca). Data was obtained through a semi-structured questionnaire, conducted in an informal way so that the participant was more comfortable answering the questions

Table 1. Socioeconomic profile (gender, age, education, monthly income, residence time in the region) of the respondents in Recreio, Chapada do Avelar, Lagoa do Barro, Serra Branca, municipality of Casa Nova, Bahia, sampled in the period between December 2018 and March 2019. Data outside parentheses correspond to the number of respondents and in parentheses the equivalent percentage.

Socioeconomic parameters	Number and percentage of respondents
Gender	
Male	45 (42.86%)
Female	60 (57.14%)
Age	
<20	6 (5.7%)
21-40	62 (59%)
41-60	25 (23.8%)
61-80	11 (11.5%)
Education	
No school attendance	15 (14.3)
Incomplete Elementary School	48 (45.7%)
Elementary School	19 (18.1%)
High school	23 (21.9%)
Monthly income	
No fixed income	37 (35.2%)
Up to a minimum wage	61 (58.1%)
Between one and two minimum wages	5 (4.8%)
Above three minimum wages	2 (1.9%)
Residence time in the community	
<20 years	52 (49.5%)
21-40	41 (39.1%)
41-60	8 (7%)
61-80	4 (3.8%)

(according to a method suggested by Huntington (2000)).

The questionnaire protocol was divided into two parts. The first part has questions related to the socioeconomic profile (predictive variables): gender, age, educational level, monthly family income, residence time in the community; and the second part, questions related to the knowledge of the person of wild birds (dependent variables): free listing of known species (Albuquerque and Lucena 2004) and knowledge about the ecological importance of species in the environment. The socioeconomic variables were categorized and organized by groups, as shown in Table 2-3. The birds mentioned by the participants through popular names were identified by confirming morphological characteristics and/or behavioral and/or vocalization. The classification and nomenclature of the species followed the guidelines of the Brazilian Ornithological Records Committee (Piacentini et al. 2015). In the analysis of knowledge about the ecological importance of species in the environment, participants were expected to cite bird supporting ecosystem services as pollinators, seed dispersers, scavengers, and important as biological pest control (Whelan et al. 2008). The answers related to the above quoted ecosystem services were cumulatively quantified according to the number of ecosystem services informed by

Table 2. Categorized predictors variables related to socioeconomic data of the respondents in Recreio, Chapada do Avelar, Lagoa do Barro and Serra Branca, municipality of Casa Nova, Bahia, sampled between December 2018 and March 2019. ES: Elementary School, HS: High School, HE: Higher Education.

Education	Value	Age (years)	Value	Income (minimum wage*)	Value	Residence time (years)	Value
No attendance	0	Up to 20	1	Less than a minimum wage	1	Up to 20	1
Incomplete ES	1	20 to 40	2	one to less than a two minimum wages	2	20 to 40	2
Completed ES	2	40 to 60	3	Two to less than a three minimum wages	3	40 to 60	3
Completed HS	3	60 to 80	4	three to less than a four minimum wages	4	60 to 80	4
Completed HE	0		5				

* Minimum wage in force at the time: R$:954,00

the respondents (0 to 4). For example, if the respondent mentioned: "visits the flowers" and "does not let the insects increase", two functions were assigned correctly, assigning number 2.

The present study follows the instructions suggested by the Declaration of Helsinki and Tokyo for Human Subjects. The ethical approval for the study was issued by the National Commission of Ethics in Research (CONEP) under the number CAAE: 87028717.7.0000.5207, through clearance number 3.051.373.

Data analysis

The theoretical variable in this research is 'knowledge about the wild birds'. In order to measure it, we defined as operational variables 'richness of known species' (or biological diversity) and 'acknowledgement of the ecological importance of birds in the environment'.

In order to verify if the data followed a normal distribution, we applied the Shapiro-Wilk test, indicated for small samples (smaller than 500) (Leotti et al. 2012). The level of significance ($p < 0.05$) did not allow us to reject the null hypothesis once the data does not have a normal distribution. Thus, all applied tests are considered non-parametric. The Variance Inflation Factor (VIF) was used to measure the degree of multicollinearity between the predictive variables, which presented an index of less than 4, avoiding the possibility of inflated multicollinearity (O'brien 2007). The general rule is that the VIF should not exceed 10 (Belsley et al. 1980).

The Mann-Whitney test was performed to verify if there were significant differences between men and women in the average citation of species and in the acknowledgement of the ecological importance of the species.

Spearman's correlation analysis was performed to verify the association between predictive variables (socioeconomic data) and dependent variables (richness of known species and acknowledgement of their ecological importance). Then, due to the non-linear distribution of the variables,

Poisson generalized linear models (GLM) were used to describe the effect of the predictors on the response variable. Poisson GLM is used for data counted as proportions or counting ratios, that is, non-negative integer values (Alvarenga 2015). However, there is a tendency to overdispersion in the Poisson GLM models (Turkman and Silva 2000), which occurs when the variance is greater than the mean (Schmidt 2003). Thus, the dispersion parameter of the model was analyzed through the residual deviance, which resulted in a value greater than 2. The dispersion parameter allowed for the Poisson family are values ≤1 (Provete et al. 2011). Due to the overdispersion, we made use of the Binomial Regression Model as recommended by several authors (Alvarenga 2015; Tadano et al. 2009).

The stepwise backward selection was used, i.e., from the generated global model, the least significant predictive variables were eliminated one by one (Alvarenga 2015). The AIC (Akaike Information Criteria) values were compared to evaluate the model that best explains the variation of the data, including the generated null model. The lower the AIC value, the less information will be lost and, therefore, the better the model will be adjusted (Alvarenga 2015). The Delta AIC (Δi) was calculated to rank the models in increasing order of relevance (low to high), which used as a measure of each model in relation to the best model, considering that: Δi <2 suggests substantial evidence for the model; Δi between 3 and 7 indicates that the model has considerably less support; and, Δi> 10 indicates that the model is highly unlikely (Mazerolle 2004).

It was established a significance level less than or equal to 0.05 ($p \leq 0.05$) for all tests. Statistical analysis was performed using software "R" (R CORE TEAM 2018), with packages support: 'car' (Fox and Weisberg 2011), 'MASS' (Venables and Riplay 2002), 'lattice' (Sarkar 2008), 'MuMIn' (Barton 2019), 'bbmle' (Bolker 2017), and 'ggplot2' (Wickham 2016).

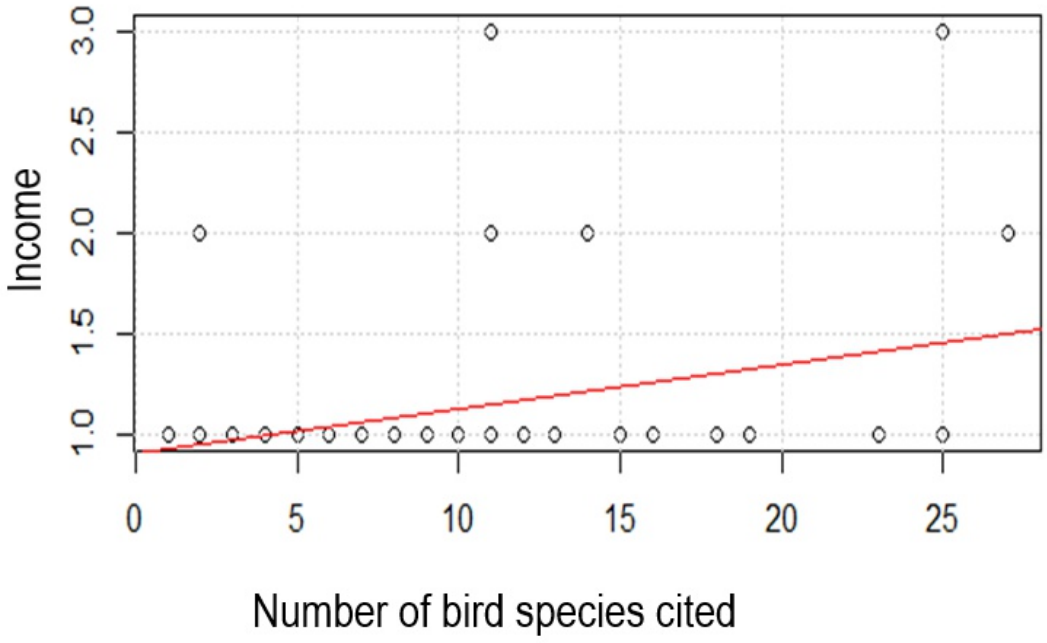

Figure 2. Correlation between the number of bird species cited and income of the respondents of Casa Nova, Bahia.

RESULTS AND DISCUSSION

Does dependence on natural resources promote knowledge on biological diversity?

The respondents made 840 bird citations, totaling 60 species, belonging to 19 orders and 30 families (Table 3-4).

There was a positive correlation between the number of bird species known to the respondents and their income (p = 0.01, rho 0.24) (Figure 2). Thus, the higher the income, the greater the number of species cited. Regarding knowledge about the ecological importance of bird diversity in the environment, there was no correlation with the respondents' income.

This positive correlation between income and the number of bird species cited does not corroborate the initial hypothesis that a lower income causes the dependence of natural resources that favors the knowledge of biological diversity. Hunting in this region may be directed to the acquisition of extra income, in order to raise the consumption pattern of the individuals involved, likewise Swamy and Pinedo-Vasquez (2014) argument that the hunting of wild animals in tropical forests contributes more to generate extra income, to increase the purchasing power of consumer durable goods and hardly for the acquisition of subsistence items. Results in this study is consistent with Duffy et al. (2016) questionings on the links between poverty and illegal wildlife hunting, still prevailing in powerful policy arenas.

Does the exposition and experience with the species influences the knowledge on the biological diversity?

There was positive correlation between the number of bird species named by the respondents and respondents age (p=0.01, rho=0.24) and their residence time in the region (p=0.01, rho=0.27) (Figure 3). However, there was no significant correlation between age and residence time in the region with the acknowledgement of birds' ecological importance. It was observed a relation between age and gender concerning female respondents, with the higher number of species cited (n=27) by an elder female respondent (age group=60-80 years old).

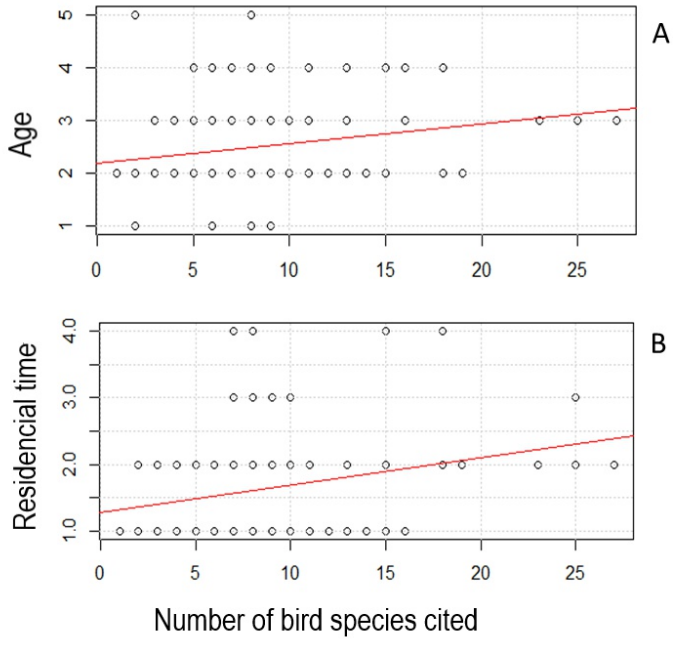

Figure 3. Correlation between the number of bird species cited and age (A) and residence time (B) of respondents in Casa Nova, Bahia.

Table 3. Species of birds cited by the respondents, with their respective citation frequencies (%) (number of citations / number of respondents) x100), in the municipality of Casa Nova, Bahia, from December 2018 to March 2019, with taxonomic characterization: order, family, scientific name, popular names in Portuguese and English, according Piacentini et al. (2015).

	Order	Family	Scientific Name	Popular name (Portuguese)	Popular name (English)
01	RHEIFORMES	Rheidae	*Rhea americana*	Ema	Greater Rhea
02	TINAMIFORMES	Tinamidae	*Crypturellus parvirostris*	Inhambu	Small-billed Tinamou
03			*Rhynchotus rufescens*	Perdiz	Red-winged Tinamou
04			*Nothura boraquira*	Codorna	White-bellied Nothura
05	ANSERIFORMES	Anatidae	*Dendrocygna autumnalis*	Marreca cabloca	Whistling-Duck
06			*Netta erythrophthalma*	Paturi preto	Southern Pochard
07	GALLIFORMES	Cracidae	*Penelopepe jacucaca*	Jacucaca	White-browed Guan
08	PELECANIFORMES	Ardeidae	*Bubulcus ibis*	Garça vaqueira	Cattle Egret
09	CATHARTIFORMES	Cathartidae	*Coragyps atratus*	Urubu	Black Vulture
10	ACCIPITRIFORMES	Accipitridae	*Rupornis magnirostris*	Gavião carijó	Roadside Hawk
11	GRUIFORMES	Rallidae	*Gallinula galeata*	galinha-d'agua	Common Gallinule
12	CHARADRIIFORMES	Charadriidae	*Vanellus chilensis*	Quero quero	Southern Lapwing
13	COLUMBIFORMES	Columbidae	*Columbina talpacoti*	Rolinha Roxa	Ruddy Ground-Dove
14			*Columbina squammata*	Rolinha Cascavel	Scaled Dove
15			*Columbina picui*	Pombinha branca	Picui Ground-Dove
16			*Patagioenas picazuro*	Asa branca	Picazuro Pigeon
17			*Zenaida auriculata*	Avoante	Eared Dove
18			*Leptotila verreauxi*	Juriti pupu	White-tipped Dove
19	CUCULIFORMES	Cuculidae	*Piaya cayana*	Alma de gato	Squirrel Cuckoo
20			*Crotophaga ani*	Anu preto	Smooth-billed Ani
21			*Guira guira*	Anu branco	Guira Cuckoo
22	STRIGIFORMES	Strigidae	*Glaucidium brasilianum*	Caburé	Ferruginous Pygmy-Owl
23			*Athene cunicularia*	Coruja buraqueira	Burrowing Owl
24	APODIFORMES	Trochilidae	*Eupetomena macroura*	beija-flor-tesoura	Swallow-tailed Hummingbird
25	GALBULIFORMES	Bucconidae	*Nystalus maculatus*	Cava chão	Spot-backed Puffbird
26	PICIFORMES	Picidae	*Colaptes melanochloros*	pica-pau-verde-barrado	Green-barred Woodpecker
27	CARIAMIFORMES	Cariamidae	*Cariama cristata*	Seriema	Red-legged Seriema
28	FALCONIFORMES	Falconidae	*Caracara plancus*	Carcará	Southern Caracara
29			*Herpetotheres cachinnans*	Acauã	Laughing Falcon
30	PSITTACIFORMES	Psittacidae	*Primolius maracana*	Maracanã	Blue-winged Macaw
31			*Eupsittula cactorum*	Periquitinha	Cactus Parakeet
32			*Forpus xanthopterygius*	Periquitinha s.josé	Blue-winged Parrotlet
33			*Amazona aestiva*	Papagaio	Turquoise-fronted Parrot
34	PASSERIFORMES	Furnariidae	*Pseudoseisura cristata*	Casaca de couro	Caatinga Cacholote
35		Tyrannidae	*Stigmatura napensis*	Papa moscas	Lesser Wagtail-Tyrant
36			*Myiarchus tyrannulus*	maria-cavaleira-de-rabo-enferrujado	Brown-crested Flycatcher
37			*Pitangus sulphuratus*	Bem-te-vi	Great Kiskadee
38			*Fluvicola nengeta*	Lavadeira-mascarada	Masked Water-Tyrant
39		Corvidae	*Cyanocorax cyanopogon*	Cancão	White-naped Jay
40		Hirundinidae	*Progne tapera*	andorinha-do-campo;	Brown-chested Martin
41		Troglodytidae	*Troglodytes musculus*	Corruíra	Southern House Wren
42		Turdidae	*Turdus rufiventris*	Sabiá laranjeira	Rufous-bellied Thrush
43		Mimidae	*Mimus saturninus*	Sabiá do campo	Chalk-browed Mockingbird
44		Icteridae	*Icterus pyrrhopterus*	Pêga	Variable Oriole
45			*Icterus jamacaii*	Sofrê, corrupião	Campo Troupial
46			*Gnorimopsar chopi*	Pássaro preto	Chopi Blackbird
47			*Molothrus bonariensis*	Chupinho	Shiny Cowbird
48		Thraupidae	*Paroaria dominicana*	Cardeal-do-nordeste	Red-cowled Cardinal
49			*Sicalis flaveola*	Canário da Terra	Saffron Finch
50			*Coryphospingus pileatus*	Maria fita	Pileated Finch
51			*Coereba flaveola*	Cambacica	Bananaquit
52			*Sporophila lineola*	Bigodinho	Lined Seedeater
53			*Sporophila nigricollis*	Baiano	Yellow-bellied Seedeater
54			*Sporophila caerulescens*	Coleirinho	Double-collared Seedeater
55			*Sporophila albogularis*	Golinho	White-throated Seedeater
56			*Sporophila bouvreuil*	Caboclinho	Copper Seedeater
57			*Saltator coerulescens*	sabia-gongá	Grayish Saltator
58		Cardinalidae	*Cyanoloxia brissonii*	Azulão	Ultramarine Grosbeak
59		Fringillidae	*Euphonia chlorotica*	Fim fim	Purple-throated Euphonia
60		Passeridae	*Passer domesticus*	Pardal	House Sparrow

Our results show that knowledge related to local wild birds is influenced by exposition to, and experience with, the species. Positive correlation between age and number of known species might be related to individuals' life experience and, probably, to improvements in livelihood, considering that youngest generations have an easier access to more and more diverse resources to survive than those adults had with their age. This supports initial hypothesis that experience with species impacts knowledge on biological diversity. Quilan and Quilan (2007) highlight a trend in knowledge about natural resources according to elderly, once a long lifetime provides more experience opportunities, beyond the fact that this group is less vulnerable to external factors that might interfere in the spread of knowledge about one subject. Musila et al. (2018) observed that elder people belief less in wrong myths about bats in Kenya: authors suggest that longer life that accumulate experiences, along with more time to interact with nature, could transform myths learned as youths in more realistic perceptions of nature.

Other aspect to be considered to reduce knowledge of new generations is the local decline or extinction of species, which decreases the sighting of many species. Farias and Alves (2007) indicate the biological diversity loss as a constraint for young generations to build social representations of locally non-sighted species, leading to impoverishment on transfer of traditional knowledge on wild birds. Kai et al. (2014) describe the extinction of bird species in Southeast China as a key factor for local knowledge erosion, especially among youngest generations unable to birdwatching and listen to birds' songs in the wild.

Recent changes in rural infrastructures on the sampled communities, such as electricity and consequent improvements on communication (television, mobile phones, radio and others), seem to decrease the youngest populations interest on outdoor activities, thus, they build a weak empirical knowledge on local biodiversity. Pergams and Zaradic (2006), Hofferth (2009) and Ballouard et al. (2011) highlight that direct contact with nature is being replaced by virtual experiences. Henderson et al. (2011) and Green et al. (2012) bring light to the lost of interaction with nature, especially in western countries, which causes decrease in knowledge about environment and ability to identify species, even the common ones. Cassey and Hogg (2015) state that to have the minimum capacity to identify species is a first requirement to understand and appreciate biodiversity, once species are its key element. Soga and Gatson (2016) state that decrease of interactions with environment, especially of young ones, causes loss of experience and devaluing of natural heritage, which becomes a bottleneck for conservation once human connection with nature changes people's feelings of love and motivation for protection.

Are there differences between genders on biodiversity knowledge?

Data show statistically significant differences between the number of cited species related to respondent gender (U=1.71; p=0.02). Men (n=40) named, in average, more species than women (n=65) (Average: men=9.3; women=7.6). Nevertheless, there was no significant difference between this variable and knowledge on ecological importance of birds (U=1.33; p=0.89). The effect of gender and age on the knowledge of wild birds corroborate Alves et al. (2010) research, in

which elder men and women are better able to identify species at group level. It corroborates previous findings of Pam et al. (2018), who stated that hunting birds is a boy's activity, which allows them to know and find more birds than girls, who do not engage with hunting.

Alves et al. (2012) and Da Silva et al. (2017), in studies in Brazilian northeastern semiarid, also identified difference between the number of species among genders, with male respondents naming higher number of wild bird species. The better knowledge detained by men is probably related to the ancient cultural method of tasks division, with outdoor activities under the responsibility of men (Da Silva et al. 2017). Traditionally, poaching is seen as a practice that adds social prestige and bravery to the man (Vargas-Tovar 2000). From early age, mainly boys accompany their fathers in capturing wildlife, activity from which they acquire sound knowledge about bird species, their habits and behavior.

Does formal education enhance knowledge on biological diversity importance?

There was no significant correlation between the educational level of the respondents and the number of species named (p=0.11, rho=-0.15) and the acknowledgment of wild birds' ecological importance. Results show that formal education does not significantly interfere on knowledge about diversity of birds or on the acknowledgment of their ecological importance in ecosystems. However, Figure 4 shows a trend relating higher education with lower number of species named.

Oliveira (2011) observed that people with higher education have less knowledge about wildlife and people with lower education know more about wildlife because it becomes resources from which they depend for their survival. Thus, the absence of a positive correlation between educational level and individual ecological knowledge may reflect a fundamental educational system that does not connect science and traditional knowledge, through practical experiences and awareness of local reality. Furthermore, Musila et al. (2018) found positive correlation between the higher level of schooling and lower beliefs in myths and positive attitudes towards science and ecology of bats in Kenya. This stresses the important role of formal education for biodiversity conservation, although the importance of educational interventions of governmental and non-governmental institutions.

How do socioeconomic factors jointly interfere in the knowledge about wild bird species?

A global model of negative binomial regression was performed, the parameters of which are presented in Table 4-5. Other nested models were built deriving from global model through stepwise backward selection (Table 5-6). Comparing Delta AIC (Δi) values (Table 6-7) it is possible to verify that global model, model 1 and model 2 show values below 2 and, in that case, are considered the better adjusted to the collected data. Model 1 presents the lowest Δi and shows that the socioeconomic variables: income, age and residence time together better explain the pattern observed for the number of wild bird species mentioned. The ratio between the weight of the best model (model 1) and the weight of the second best model (global model), following Mazerolle (2004) method, shows that the first one has a chance of 1.43 of

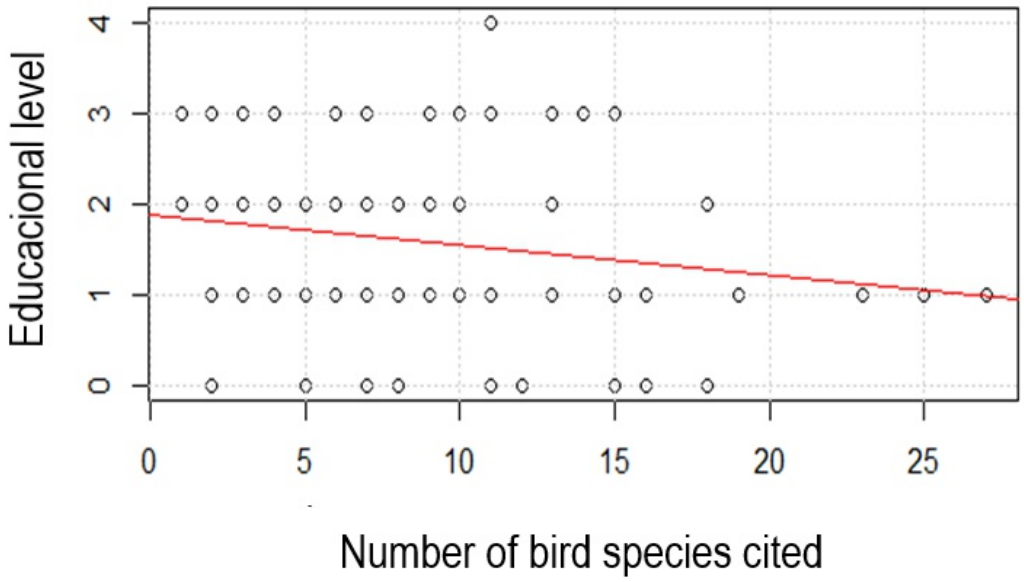

Figure 4. Correlation between number of species named and educational level of respondents in Casa Nova, Bahia.

Table 4. Estimated parameters of the negative binomial global model with explanatory variables: age, educational level, income and residence time, and, dependent variable: number of cited bird species in Casa Nova, Bahia.

	Estimate	Std. error	Z value	Pr (>|z|)
Intercept	1.27626	0.26609	4.796	1.62e-06 ***
Age	0.09622	0.06713	1.433	0.15175
Education	-0.07313	0.05903	-1.239	0.21535
Income	0.43302	0.14308	3.026	0.00247 **
Residence time	0.13324	0.07452	1.788	0.07378

* Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

being better than the global model, and 1.66 related to model 2, which lead us to conclude that although model 1 is considered the best, it is not possible to ignore education as a socioeconomic factor with impact on the knowledge of wild bird diversity in the region.

It is noteworthy that individually the variables income, residence time and age were elected as the best predictive variables for the knowledge on bird species. This result is consistent with other studies in northeastern region (Alves et al 2012; Da Silva et al 2017), that associate socioeconomic factors such as gender, educational level, income, professional occupation and age to knowledge and use of wildlife in northeastern semiarid. Quite few studies analyze and compare models with different associations among socioeconomic factors. Castilla et al. (2020) used a GLM analyses and found a positive perception about bats in Escaba region (Tucumán province, Argentina) related to age and in people who concluded fundamental schooling. However, authors did not compare different models, thus any understanding of how socioeconomic factors impact knowledge and perception towards fauna is very restricted.

Table 5. Estimated parameters of the negative binomial nested models with explanatory variables: age, educational level, income and residence time, and, dependent variable: number of cited bird species in Casa Nova, Bahia. Nested models: model 1: number of cited species ~ income + age+ residence time); model 2: number of cited species ~ income + residence time and model 3: number of cited species ~ income.

Estimate	Model 1	Model 2	Model 3	Null model
Intercept	1.10413	1.3453	1.6187	2.11683
Income	0.40083	0.3967	0.4457	
Age	0.11922			
Residence time	0.15470	0.1950		

Table 7. Global model, nested models and null model with values of Akaike information criteria (AIC), delta AIC (Δi), degrees of freedom (df) and weight.

Model	AIC	Δi	df	Weight
Global: (nº of known species ~ income + age+ residence time + educational level)	603.77	0.7	6	0.298
Model 1: (nº of known species ~ income + age+ residence time)	603.3	0.0	5	0.426
Model 2: (nº of known species ~ income + residence time)	604.53	1.0	4	0.256
Model 3: (nº of known species ~ income)	609.95	6.3	3	0.018
Null model	617.28	13.5	2	<0.001

The lack of correlation between socioeconomic variables and acknowledgment of ecological importance of wild birds is probably related to the low number of respondents who named at least one ecological function of birds in the ecosystem. Only 6% (n=6) know at least two functions and 18% (n=19) know the function related to seed dispersal. It is noteworthy that most of the respondents (76%) did not mention any environmental services provided by wild birds, still mention to value biodiversity, stating the importance of their protection based on utilitarian, affective and cultural criteria, as some quotes herewith:

"For them to sing early in the morning, it is so beautiful!"

"For them to reproduce and have freedom, no one wants to live caged"

"For our grandchildren to see, it is so good, we can watch them, they have the same right".

"They are the joy of sertão".

These results corroborate Alves-Barbosa and Barbosa (2011) findings, in the semiarid region of Paraíba state, in which 78 (100%) of respondents defined "animal" according to utilitarian, affective and conceptual criteria, ranking them from especially important to less important. Pam et al. (2018) describe similar situation in a study with 50 Nigerian children, questioning them about birds' importance: 73% mentioned "food", 9% aesthetical aspects, 7%, commercial value, 7%, plague (compete for planted crops), 2%, pet, and 5%, no value at all, just because they are not humans. These authors findings oppose to Kellert (1985) who stated that children tend to attribute less a utilitarian value to wildlife than adults. Different contexts may be the cause and further

studies are required.

It is important to highlight that interactions between wild birds and ecosystem are highly important for biodiversity conservation and the maintenance of the Caatinga ecosystem services (Araujo and Silva 2017), with several mutualistic interactions (Leal et al. 2011) among endemic species or restricted-distribution species (Quesada et al. 2011; Sobrinho et al. 2016). In Caatinga studies prove the existence of several ornithocoric plant species, i.e., when seed dispersal depends totally on wild birds (Griz and Machado 2001), like pollination by hummingbirds on 15% of native vegetation (Machado and Lopes 2004). Furthermore, roles of wild birds include organic matter cycling and biological pest control, thus, individuals removed from wild for consumption or pet fail to perform key functions to the environment.

The lack of knowledge about the ecological importance of the birds might lead to overvalue of human interests' criteria and non-ecological criteria, with negative consequences for species due to specimens removal from wild, fostering their decline and extinction (Alves et al. 2012; Dirzo et al. 2014; Nascimento et al. 2015; Rocha et al. 2017), compromising important ecological services provided to ecosystem. Changes or deprivation of such services may cause a cascade effect at several ecological levels, including resilience (Leal et al. 2018). Efforts on formal education that aims to change perspectives about ecosystem services provided by avifauna may be an essential investment to promote behavior and attitude changes towards birds and environment.

CONCLUSIONS

Socioeconomic factors strongly influence the knowledge people have about bird species in their region. Exposure to wild birds and experience with it, gender, education and income together influence the knowledge about the diversity of this group, even considering that the best predictive model was the one including the variables age, time of residence and income. Elder men, residing in the region for long time know more species of wild birds. It was observed that even those socioeconomic factors with single low impact, when combined had an influence on that variable. Thus, further studies are recommended using models to explain the synergic influence of such factors.

Income showed a positive relation with the knowledge of the local wild bird species. This causality is not clear because it was expected that people with lower income would know more bird species, for the utilitarian importance of the group to their livelihood. However, results did not corroborate this hypothesis and the relationship might be explained by the acquisition of extra income with the use and consequent knowledge of the wild birds. Therefore, further studies detailing these relationships are necessary.

Our results also indicate a reduction in the level of knowledge about bird species among younger populations. From the conservationist point of view this is important because it indicates a reduction of hunting activities (positive impact) and a trend of knowledge erosion and consequent loss of environmental awareness due to lack of connection with nature, devaluing biological heritage (negative impact). For further insights on this subject, we recommend work with focal groups, of children and youths.

The weak correlation between formal education and knowledge of local biodiversity as well as the acknowledgement of the ecological importance of species, seems to indicate a probable lack of articulation between scientific and traditional knowledge in schools, which should be considered in environmental education programs.

We highlight the relevance of permanent educational measures including different age groups, in order to reconnect a wide range of people with nature, fostering a behavior change in favor of wild birds based on the ecological importance of this group in the ecosystem.

ACKOWLEDGEMENTS

We are very grateful to the residents of Casa Nova communities who were available and willing to participate in the research. Also to CONEP for the permission and clarification provided so that the research attended the Brazilian ethical standards. We are also thankful to Dr. Rebeca M. Barreto and Dr. Washington F. Soares for their suggestions and valuable contributions to our work.

Data availability

The quantitative data (except the data that may lead to the respondent) used to support the findings of this study are available from the corresponding author upon reasonable request.

Conflicts of interest

There was not and there is not conflict of interest among the authors.

Contribution statement

Conceived of the presented idea: SSNS, FCM.

Carried out the experiment: SSNS.

Carried out the data analysis: SSNS, FCM.

Wrote the first draft of the manuscript: SSNS, FCM.

Review and final write of the manuscript: SSNS, FCM, CSGM.

Supervision: SSNS, FCM, CSGM.

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Received: 15 July 2019
Accepted: 02 April 2020
Published: 11 May 2020