

# The use of Passeriformes in the eastern Amazonia of Brazil: culture encourages hunting and profit encourages trade

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**Abstract** This study characterized the ethnoornithological knowledge of passerine bird keepers, known locally as *criadores* or *passarinheiros*, who capture, train, breed and sell wild species in the eastern Amazonia of Brazil. The data were collected from 62 bird keepers through informal, semi-structured interviews and participant observation. The family Thraupidae was the most captured group, with 23 species used, predominantly of the genus *Sporophila*. *Sporophila angolensis* had the highest use value and price. Our findings suggest that conservation strategies should be a priority for *Sporophila maximiliani*, *S. angolensis* and *Saltator maximus*. The Passeriformes are obtained by capturing them from the wild, by captive breeding or in trade. They are trapped and sold locally, in nearby municipalities, and also in more distant locations as far as the border with Suriname, French Guiana and Guyana. On the international market, sale prices can reach USD 5,400 per individual bird. Species with both significant economic value and regional cultural significance are of the greatest importance to the bird keepers. To mitigate the negative effects of this activity, we recommend implementation of environmental education programmes for bird keepers, to improve their capacity to raise awareness about wildlife, and to inform them of the legal processes for bird keeping and for breeding birds in captivity for legal trade. Long-term strategies for bird conservation should also be considered, such as the implementation of ecotourism in protected areas to encourage the practice of birdwatching.

**Keywords** Amazonia, bird trade, Brazil, ethnoornithology, management, Passeriformes, pet, *Sporophila*

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## Introduction

Birds are one of the most hunted vertebrate groups (Alves et al., 2016) and are threatened as a result of habitat loss and/or exploitation for various forms of use (Alves et al., 2013a,b). Passeriformes are in particular demand, especially as pets, because of their colourful plumage and attractive song (Alves & Rocha, 2018), which have stimulated commercial exploitation (Alves et al., 2016; Roldán-Clarà et al., 2017). The annual global commercial exploitation of wild birds for pets has been estimated to be worth EUR 2 million (van Uhm, 2016). In Brazil, the breeding and trade of birds for pets is unregulated in many areas (Alves et al., 2013a,b; Nascimento et al., 2015) and there is little information on the bird trade or its value. The last national report about trafficking of wild fauna estimated that 2–5 million live birds are trafficked annually (Renctas, 2001), threatening some species (Alves et al., 2010). Passeriformes are hunted in Brazil by traffickers and *passarinheiros* (who train and raise songbirds; Fernandes-Ferreira et al., 2012; Oliveira et al., 2018). There is a large commercial bird trafficking network in the north-east that is having a marked impact on the conservation of songbirds (Oliveira et al., 2020).

In Brazilian Amazonia poaching is also common, although prohibited. Impacts on the ecosystem include the progressive replacement of species, extinction, and the increase of zoonotic diseases (Bragagnolo et al., 2019). In the Amazon, local culture has a strong influence on the use of wild animals as food and medicine (Morsello et al., 2015; El Bizri et al., 2020). For example, in the municipality of Abaetetuba, Pará state, deforestation rates are high (INPE, 2015), as is hunting pressure, and the municipality is a trafficking route for wild animals and their parts (Renctas, 2001; Baía Júnior et al., 2010). There is, however, a lack of information about human–bird interactions and the status of any commercial network for trade in Passeriformes.

Ethnoornithological studies help characterize bird use, breeding and ecology (Roldán-Clarà et al., 2017), and contribute to the development of conservation strategies in the pursuit of social and environmental well-being (Roldán-Clarà et al., 2014). Here we provide information



FIG. 1 Location of the municipality of Abaetetuba in Pará state, Brazil, where we characterized the ethnoornithological knowledge of passerine bird keepers who capture, train, breed and sell wild species, and the areas where Passeriformes are hunted and commercialized beyond Abaetetuba.

to support the management of wild avifauna in the eastern Amazonia of Brazil, focusing on the use, management and sale of Passeriformes in Abaetetuba. Specifically, we (1) identify the species used and the main factors that influence their economic value, (2) describe captive management, (3) assess local ecological knowledge about the species, (4) evaluate the relative influence of socio-economic and cultural factors on the customs and traditions of bird keepers, and (5) identify commercial networks and distribution routes.

## Study area

The study was conducted during December 2017–September 2018 in the municipality of Abaetetuba in Pará state, Brazil (IBGE, 2017). The 1,611 km<sup>2</sup> municipality has a population of 156,292 (IBGE, 2018; Fig. 1).

## Methods

### Data collection

Initially, we held informal talks and interviews with local residents to identify people involved in bird keeping, and subsequently identified bird keepers using snowball sampling (Bailey, 1994; Albuquerque et al., 2014). We held informal conversations in the streets, street markets or bird keepers' homes with 96 bird keepers, explaining the objectives of the study in accessible language (i.e. without the use of technical terms), and we invited the bird keepers to participate in the study. Semi-structured interviews and direct observation of bird management were conducted with the 60 men and two women who consented to participate. Socio-economic, cultural and ethnoornithological data (knowledge about the

biology of Passeriformes, reasons for breeding, opinions on the characteristics of species, including beauty, song and territoriality, details of trapping locations and techniques, captive management, economic value and commercialization) were collected during the interviews (Supplementary Material 1). We also asked participants whether they were registered with the environmental agency, which is a legal requirement for owning wild animals.

Species were identified at the Museu Paraense Emilio Goeldi (Belém, Brazil) from photographs taken when the interviews were conducted. The field guide by Sigrist (2009b) was used to assist in species identification. Nomenclature follows the Comitê Brasileiro de Registros Ornitológicos (CBRO, 2015).

### Data analysis

The data were analysed both qualitatively and quantitatively (Vergara, 2012). From compilation of the interview data, photographs and our observations, we identified bird species involved in the trade network, and the various forms of use (hunting, breeding for pets, commercialization), captive management techniques used, the main actors involved and their empirical knowledge, and how the trade network functions. To determine the level of use of each species among the people interviewed, we calculated the use value of each species as  $U/n$ , adapted from Phillips et al. (1994), where  $U$  is the number of interviewees who cited the species and  $n$  is the total number of interviewees (62).

The sale price of birds involved in the commercial network were converted from BRL to USD using the exchange rate on 29 September 2018 (USD 1.00 = BRL 4.05). For tests involving the sale price of each species, the median of the highest values cited by interviewees was used. Use of the

median avoids any bias caused by potential heteroscedasticity (Gotelli & Ellison, 2010). We used the median of the values (USD) indicated by the interviewees as the price of an individual of each species, and then defined five price range categories in USD (very low:  $\leq 24.69$ ; low: 24.70–123.44; high: 123.45–246.90; very high:  $\geq 247.00$ ). We then examined whether the binary variables song, beauty and territoriality of bird species, jointly, were predictors of the sale price of wild origin or captive-bred birds, using permutational multivariate analysis of variance (PERMANOVA) based on similarity matrices with Euclidean distance and 9,999 randomizations (Anderson, 2001), and ordination with a principal coordinates analysis to visualize the results (Gotelli & Ellison, 2010). To examine whether the price range (very low, low, high, very high) was influenced separately by each of song, beauty or territoriality, we used the Kruskal–Wallis test, a non-parametric analysis, if the assumption of homogeneity of variance was rejected at  $P = 0.05$ , and otherwise ANOVA, which is a parametric test (Gotelli & Ellison, 2010).

A second PERMANOVA (Anderson, 2001) using Gower's distance, a method that allows the simultaneous analysis of quantitative and qualitative data, with 9,999 randomizations (Gower, 1971), was used to examine whether the socio-economic and cultural characteristics of interviewees influenced whether they were principally a hunter, local seller, trainer, breeder or external seller (i.e. someone who sells birds outside the municipality). These categories were defined based on the roles that the study participants appeared to play in bird keeping and trade. To visualize differences in the bird keeper categories in this PERMANOVA, we constructed an ordination using principal coordinates analysis (Gotelli & Ellison, 2010). R 3.0.2 (R Core Team, 2019) was used for all statistical analyses.

## Results

We found that a total of 23 species of Passeriformes, in five families, were bred and sold (Table 1). The species with the highest use and economic values was the chestnut-bellied seed-finch, *Sporophila angolensis* (0.77, USD 5,400). The bird keepers suggested that in the previous 10 years, populations of *S. angolensis*, the great-billed seed-finch *Sporophila maximiliani* and the buff-throated saltator *Saltator maximus* had decreased (Plate 1) and that *S. angolensis* and *S. maximus* were no longer readily encountered in the region. These birds were hunted in north-east and south-east Pará. The causes cited by bird keepers for the decrease in these species were (1) increase in demand, (2) capturing of the young, (3) urban expansion into rural areas, (4) monocultures of oil palm *Elaeis guineensis*, and (5) use of herbicides and pesticides in agricultural areas.

Information from the semi-structured interviews and our observations of bird management indicated that the

commercial price of a bird depended on (1) whether the species was commercialized, (2) whether it was male (the song of males is more greatly appreciated than that of females, and they can be used for hunting), (3) its skill in singing or having strong territoriality), (4) the availability of the species in the wild, (5) its ability to adapt to captivity, (6) its health, (7) whether it already molted, and (8) its genealogy, for birds in captivity. The most important biological characteristics cited by the bird keepers for identifying a bird species are: (1) song, (2) plumage color, (3) size, and (4) shape and size of the beak. Differentiating the sex of the animals only occurs during the reproductive phase, after moulting, as males and females normally differ in colour.

We documented four traditional techniques used to catch birds (Plate 2): (1) The *arapuca* is a trap comprising a small cage with a trigger attached to the bottom of the lid, which is attached to another, larger cage. A bird is placed in the larger cage to attract another bird of the same species, with its song. When a bird lands, the trigger is fired and the lid closes. This technique was used by 29% ( $n = 18$ ) of the interviewees. (2) The *arapuca de rede* also comprises a cage containing a bird, to attract another bird, but with a net on the side of the cage that is triggered when a wild bird touches the net. This technique was used by 19% ( $n = 12$ ) of the interviewees. (3) *Visgo* is a sticky substance prepared from the resin of trees, such as *Hevea brasiliensis*. The resin is chewed or heated until it has a sticky consistency, and is then applied to the surface of branches or sticks, trapping birds that land. This technique was used by 11% ( $n = 7$ ) of the interviewees. (4) *Preseiro* is a term used for caged birds trained to catch wild birds, and takes advantage of the territorial characteristics of some species. The *preseiro* attracts a wild bird, usually of the same species, and they start a dispute. The bird keeper waits until the *preseiro* is holding the wild bird with its feet or beak and then approaches and catches it with his hands. This technique was used by 32% ( $n = 20$ ) of the interviewees.

Training a *preseiro* starts with a bird (*S. maximus*, *Sporophila collaris*, *S. americana* or *S. angolensis*) caught as a fledgling. Captive-bred birds are generally not used for this purpose. The training of a *preseiro* takes place in the forest, where the bird keeper stimulates the contact of the bird with other wild birds. The breeders use a model bird, with the physical characteristics of the species, to assist in the training. The skill of the *preseiro* is assessed based on how fast it can secure and then release a bird, when prompted by the bird keeper, without hurting it.

The PERMANOVA analysis using Euclidean distance revealed that the price of birds depends jointly on their song, beauty and territoriality (pseudo  $F = 4.896$ ,  $P < 0.003$ ). The first and second axis of the principal coordinates analysis explained 86.8% and 8.6% of the variance in the data, respectively (a total of 95.4% of the variance). Birds with *preseiro* characteristics tended to be more expensive, with median values starting at USD 247, followed by birds that were

TABLE 1 Species of Passeriformes observed in the wild bird or captive bred trade network in the eastern Amazonia of Brazil, with their Red List status (IUCN, 2020), the hunting techniques used to catch them, the environments in which they were hunted, their use value (see text for details), and minimum and maximum economic value in trade (per individual).

Species (by family)	Red List status <sup>1</sup>	Hunting techniques <sup>2</sup>	Hunting environment <sup>3</sup>	Use value	Economic value (USD)	
					Minimum	Maximum
<b>Cardinalidae</b>						
<i>Cyanoloxia rothschildii</i>	LC	Nt, Tl, Vg	Ag, Fr	0.32	12.35	74.00
<b>Fringillidae</b>						
<i>Euphonia cayennensis</i>	LC	Nt, Tl, Vg	Fp	0.19	3.70	17.30
<i>Euphonia chlorotica</i>	LC	Nt, Tl, Vg	Fp	0.35	3.70	17.30
<i>Euphonia violacea</i>	LC	Nt, Tl, Vg	Fp	0.39	3.70	17.30
<b>Icteridae</b>						
<i>Cacicus cela</i>	LC	Nt, Tl	Fp	0.24	12.35	74.10
<i>Icterus cayanensis</i>	LC	Nt, Tl	Fr	0.40	12.35	74.10
<i>Icterus jamacaii</i>	LC			0.05	24.70	148.15
<b>Thraupidae</b>						
<i>Saltator maximus</i>	LC	Nt, Ps, Tl	Fr	0.37	98.80	1,975.30
<i>Sicalis luteola</i>	LC			0.15	49.40	148.15
<i>Sporophila americana</i>	LC	Nt, Ps, Tl	Ag, Fr	0.47	7.40	493.85
<i>Sporophila angolensis</i>	LC	Nt, Ps, Tl	Ag, Fp, Fr	0.77	123.45	5,400.00
<i>Sporophila collaris</i>	LC	Nt, Ps, Tl	Ag, Fp, Fr	0.47	7.40	493.85
<i>Sporophila crassirostris</i>	LC	Nt, Tl	Ag, Fp, Fr	0.27	24.70	247.00
<i>Sporophila lineola</i>	LC	Nt, Tl, Vg	Ag, Fr	0.37	12.35	98.80
<i>Sporophila maximiliani</i>	EN	Nt, Tl	Ag, Fr	0.44	197.55	3,400.00
<i>Sporophila minuta</i>	LC	Nt, Tl, Vg	Ag, Fr	0.35	14.85	123.45
<i>Sporophila plumbea</i>	LC	Nt, Tl, Vg	Ag, Fr	0.19	37.00	123.45
<i>Sporophila schistacea</i>	LC	Nt, Tl, Vg	Ag, Fp	0.23	24.70	148.15
<i>Tachyphonus rufus</i>	LC	Nt, Tl, Vg	Ag, Fp, Fr	0.03	3.70	24.70
<i>Tangara episcopus</i>	LC	Nt, Tl, Vg	Ag, Fp, Fr	0.26	3.70	17.30
<i>Volatinia jacarina</i>	LC	Nt, Tl, Vg	Ag, Fp, Fr	0.22	7.40	17.30
<b>Turdidae</b>						
<i>Turdus fumigatus</i>	LC	Nt, Tl, Vg	Ag, Fp, Fr	0.58	24.70	1,481.50
<i>Turdus leucomelas</i>	LC	Nt, Tl, Vg	Ag, Fp, Fr	0.30	12.35	74.10

<sup>1</sup>LC, Least Concern; EN, Endangered.

<sup>2</sup>Nt, net trap; Ps, *preseiro*; Tl, trap with lid; Vg, *visgo*.

<sup>3</sup>Ag, agriculture area; Fp, floodplain; Fr, primary and secondary forest.

good singers or beautiful (Fig. 2). Analysing the influence of song, beauty and territoriality separately on price indicated that beauty alone did not have a significant effect ( $H(3, N = 23) = 6.122, P = 0.106$ ), although territoriality ( $H(3, N = 23) = 13.654, P = 0.003$ ) and song ( $H(3, N = 23) = 9.982, P = 0.019$ ) both had significant effects on price.

*Sporophila angolensis* and *S. maximiliani* were bred by three (4.8%) of the bird keepers. Reproduction begins in the second year of life. For males, this occurs after the second molting of feathers, when they change colour. The process from copulation to separation is c. 35 days. Starting during the second month of life, the birds are exposed daily to the sounds of their own species, so they learn to repeat the song. A bird is considered a good singer when it can sing for > 2 minutes.

The commercial network involved five main groups (Fig. 3): hunters, local sellers, trainers, breeders and external sellers. Eighteen of the people we interviewed were hunters. They were men, mostly 21–30 years old, with high school

education and a monthly income of USD 235.50–493.85. Nine had hunted for > 10 years and train *preseiros*, and all 18 had learnt the practice from their parents. The birds they captured were destined for local sellers or trainers. Most of the hunters caught birds in Abaetetuba (94.4%) and other municipalities of north-east (44.4%) and south-east (22.2%) Pará State (Fig. 1).

Thirteen of the people we interviewed were local sellers, acting as middlemen in the commercial bird network. They received birds from hunters and resold them to local bird keepers and external sellers. Selling occurred at open markets or in the house of the bird keeper. They were men, not registered with environmental agencies, had conducted the activity for > 10 years, most were 21–30 years of age, with high school education and a monthly income of USD 235.50–493.85. Only three of the local sellers reported they sometimes hunted and trained birds.

Twenty-six of the people we interviewed were trainers. They obtained birds from local sellers or directly from



PLATE 1 Passeriformes with reduced populations, according to reports by interviewees: (a) *Sporophila angolensis*, (b) *Sporophila maximiliani* and (c) *Saltator maximus*. Photos: Samantha Silva.



PLATE 2 Hunting techniques used to catch wild birds in Abaetetuba: (a) trap with lid, (b) net trap, (c) *visgo*, (d) *preseiro*. Photos: (a–c) Samantha Silva, (d) provided by a bird keeper and reproduced with permission.

hunters for the primary purpose of rearing a pet rather than using it for breeding. Generally, they were men, most (96.2%) were not registered with environmental agencies, with a high school education and a monthly income of USD 235.50–493.85. Twelve of the trainers had conducted this activity for > 10 years. Among the trainers, nine said they trained *preseiros* for leisure, and later released the birds, and six participated in bird song competitions.

Three of the people we interviewed were breeders, breeding birds in captivity for sale to local trainers and external sellers. This group comprised men > 30 years old who were not registered with environmental agencies. All participated in bird singing competitions and two trained *preseiros*.

Two men identified as external sellers, buying the birds from local sellers and breeders and reselling them in other

national locations (in the states of Pará and Amapá) and international locations on the border of Suriname, French Guiana and Guyana (Fig. 1). The birds were also bought and resold in Abaetetuba. The men were 36 and 40 years of age, with high school education. They usually bought chicks at a low price, trained them to hone their singing and territorial skills, and resold them for a higher price.

The PERMANOVA analysis using Gower's distance revealed differences in the socio-economic and cultural characteristics of the five categories of interviewees (hunter, trainer, local seller, breeder and external seller; pseudo  $F = 3.005$ ,  $P < 0.0119$ ). The first and second principal coordinate axes explain 40.8 and 33.5%, respectively, of the variance in the data (74.3% of total variance). The variable that best described the structure among the bird keeper categories was family influence (Fig. 4).

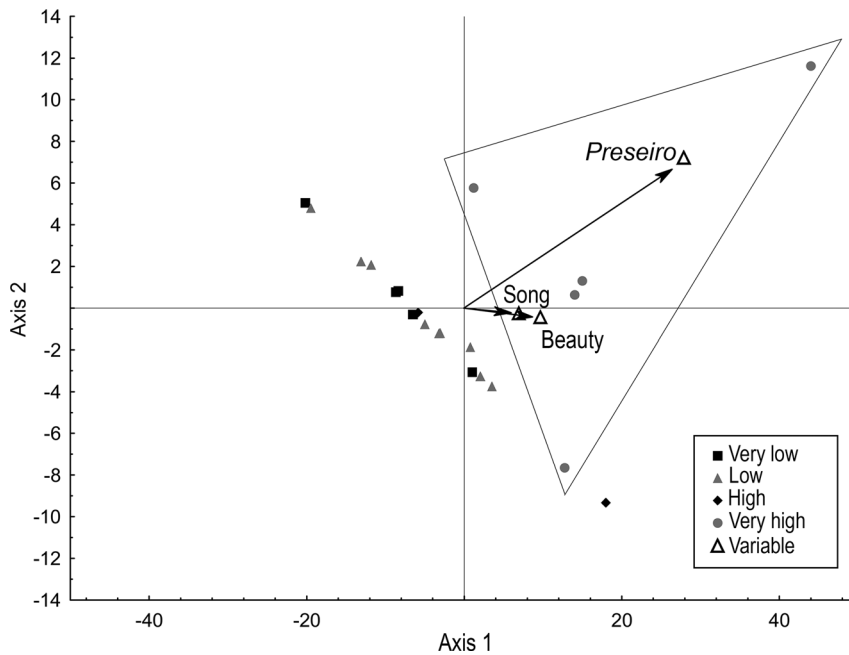


FIG. 2 Principal coordinates analysis of the influence of the song characteristics, beauty and whether a bird was a good *preseiro* (see text for details) on the commercial price of 23 species of Passeriformes (each symbol represents one species). Prices were categorized as very low (USD  $\leq$  24.69), low (24.70–123.44), high (123.45–246.90) or very high ( $\geq$  247.00). The arrows indicate the direction of influence of the three variables (song, beauty, *preseiro*), and the triangle delimits species in the very high price category.

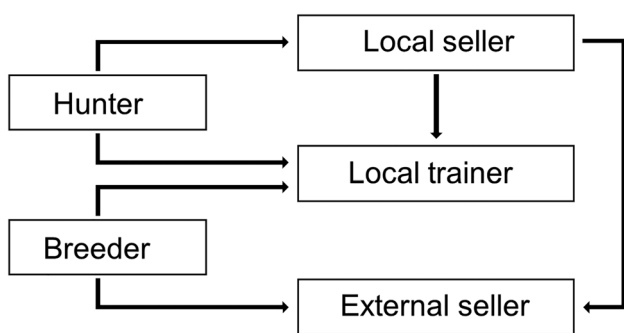


FIG. 3 The commercial network involving Passeriformes in Abaetetuba, Pará state, Brazil (Fig. 1), as determined through interviews with 62 bird keepers.

## Discussion

Our findings demonstrate the existence of a national and international commercial network for the sale of 23 species of birds in the eastern Amazonia of Brazil, based in Abaetetuba, Pará state. The network involves hunters, trainers, breeders and sellers motivated by both cultural and economic influences. These birds are in high demand and provide an attractive income. Similarly to Daut et al. (2015), we found that birds in the family Thraupidae are the most commonly sold. In Brazil, birds of this family are the most frequently bred and traded (Fernandes-Ferreira et al., 2012; Oliveira et al., 2018). It contains species that have some of the most highly appreciated songs amongst songbirds in the Americas (Sigrist, 2009a). Species of *Sporophila* (Thraupidae) were the most common in local trade (39% of the species cited). This has also been observed

in other regions (Nascimento et al., 2015; Oliveira et al., 2018) and is probably a national pattern.

*Sporophila angolensis* is widely distributed in Brazil (del Hoyo et al., 2011), and we found it to be one of the most frequently used species. However, this species is less popular in the north-east of Brazil despite a strong culture of bird keeping in this region (Souto et al., 2017). Its prominence in Amazonia may be because bird keepers, in addition to appreciating its song, use this species as a *preseiro* to hunt. Although *S. angolensis* is categorized as Least Concern on the IUCN Red List (BirdLife International, 2018), the interviewees reported that the species can be difficult to find in the wild. *Turdus fumigatus*, which also has high use and economic importance, is also less used in other regions of Brazil, probably because it mostly occurs in Amazonia (del Hoyo et al., 2011). However, studies in other areas have shown that species of *Turdus* are commonly raised and traded, primarily *Turdus rufiventris* (Souto et al., 2017; Oliveira et al., 2018), which does not occur in Amazonia (del Hoyo et al., 2011). For *S. maximus*, its high economic value could be related to its hunting skills as a *preseiro*, and to its declining population population in Abaetetuba, even though it is widely distributed in Amazonia.

Our research did not suggest any direct relationship between whether a species is endemic and its importance in local trade. Of the species endemic to Amazonia, only *S. americana* was among the four species with the highest use value (del Hoyo et al., 2011). This differs from north-east Brazil, where the species most held in captivity were also more typical of the regional avifauna (Fernandes-Ferreira et al., 2012). This could be related to the

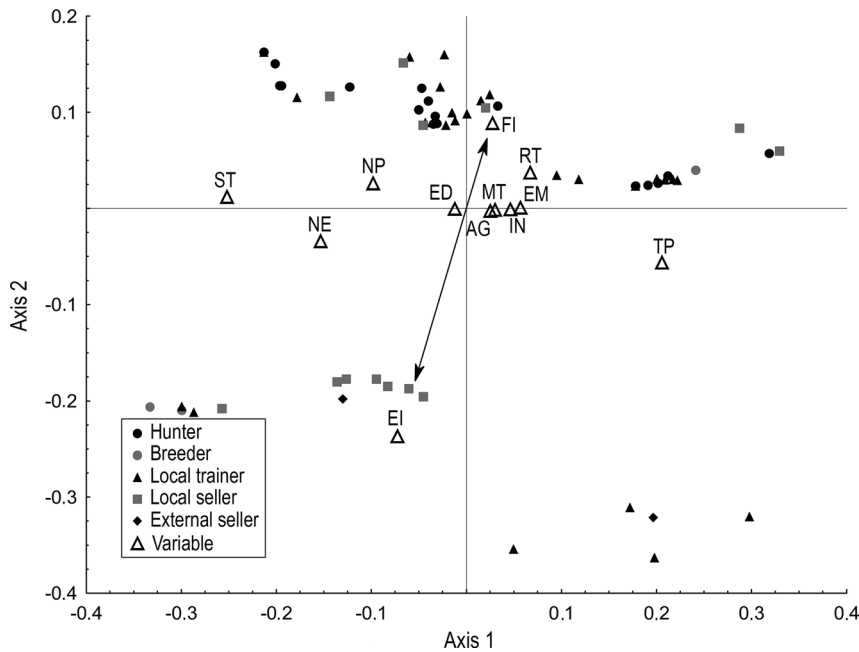


FIG. 4 Ordination of socio-economic and cultural variables (NT, does not train *preseiros*; TP, trains *preseiros*; ST, student; EM, employed; NE, unemployed; RT, retired; ED, education level; MT, management time; AG, age; IN, income; FI, family influence; EI, economic influence) to examine their influence on whether the 62 people interviewed are hunters, breeders, local trainers, local sellers or external sellers (i.e. to areas beyond Abaetetuba). The double-ended arrow indicates that the influence of economy is high amongst local sellers, and that of family amongst hunters.

environmental characteristics of each region. Species of Oscines, a suborder of Passeriformes that includes songbirds, are mostly associated with areas of open vegetation, as found in north-east Brazil, whereas species of the suborder Suboscines are more associated with forest vegetation (Sick, 2001).

Besides availability, the characteristics that most influenced bird prices were singing ability and skill as a *preseiro*. Species with the latter characteristic (*S. maximus*, *S. collaris*, *S. americana* and *S. angolensis*) were among the most expensive in the commercial network. Although we found that *S. maximiliani* is one of the most expensive species, it is not used as a *preseiro* to hunt. However, in addition to its highly appreciated song, it is the only threatened species of the 23 species bred and sold in Abaetetuba, categorized as Endangered on the IUCN Red List (BirdLife International, 2019); it is difficult to find and, consequently, has a high economic value. This species has been the target of hunters and traffickers and, consequently, it is difficult to observe it in the wild (Ubaid et al., 2018).

Male birds were preferred by bird keepers because of their stronger territoriality and more melodious song compared to females, and birds that were descendants of song competition champions were also in high demand. Females were selected for breeding based on the number of eggs they laid, hatching success of their eggs, and the number of surviving offspring, phenotypic characteristics, and whether they were bird singing tournament champions. The cultural importance of breeding birds for song competitions has been reported elsewhere (e.g. Indonesia: Jepson et al., 2011; Taiwan: Su et al., 2014). Conversely, in Australia, where this practice is uncommon, song characteristics do not affect the price of birds (Vall-llosera & Cassey, 2017).

All but one of the hunting techniques we observed are passive as they involve trapping effort and capture time independent of the active action of the hunter (Lee, 2000). These techniques involve methods similar to those used by hunters in Mexico (Roldán-Clarà et al., 2017) and elsewhere in Brazil (Souto et al., 2017; Oliveira et al., 2018). The only exception is the *preseiro* technique. Araujo (2000) reported the use of *preseiro* birds (*S. angolensis*) in Amazonia, a unique practice that has not been recorded in other locations. It was the technique most used among the bird hunters we spoke with.

Socio-economic variables appeared to be only weak motivators for bird keepers to become breeders and did not differentiate the actors involved in the commercial bird network. This corroborates findings from Indonesia, where bird breeding was not found to be strongly correlated with social profile (Jepson & Ladle, 2009). However, family, cultural heritage and economic motivations appear to be influential. Bird trapping, in particular, is a cultural practice (Alves et al., 2018). In addition to being an important motivator for wild meat consumption in Amazonia (Morsello et al., 2015), cultural characteristics are also a motivator for hunting animals for use as pets. Although people use wild birds for many reasons (e.g. for food, and for medicinal and mystic/religious purposes; Roldán-Clarà et al., 2014; Santos-Fita et al., 2015), we found that songbirds were only being used as pets, or for trading as pets.

It is possible that the commercial routes used by bird traders in Pará lie mainly along rivers or the coast. Renctas (2001) identified rivers as the main way of moving hunted wild animals in northern Brazil, and the border with the Guianas is an important destination for trafficked wild

animals from Brazil because of the absence of enforcement there (Destro et al., 2012). The lucrative trade in Passeriformes has stimulated hunting (Regueira & Bernard, 2012) and, combined with other factors such as habitat loss and deforestation, has resulted in a decrease in the diversity of the local avifauna (Alves et al., 2013a,b). This, in turn, can affect key ecological functions (e.g. seed dispersal by frugivorous birds) and disrupt food webs (Kohorn, 2011).

Mitigating the negative impacts of this commercial network will be challenging and will require a range of strategies, including (1) increasing monitoring and enforcement of wildlife regulations, (2) development of education programmes to demonstrate the importance of preserving the local avifauna, and (3) improved regulation of bird keeping. The large number of interviewees that were not registered with environmental agencies indicates a widespread lack of knowledge about the legal requirements for bird keeping and/or the difficulties associated with negotiating the bureaucratic barriers associated with legally obtaining birds for trade.

Breeding wild species in captivity is a conservation strategy, as this activity can decrease illegal trade and provide individuals for restocking wild populations (Burivalova et al., 2017). In Indonesia, bird conservation projects have used flexible political instruments to incentivize the commercialization of birds bred in captivity (Kristiano & Jepson, 2011; Jepson, 2016). Thus, conservation measures could be more effective with the introduction of a market-based system (Jepson et al., 2011). The suggestion is not to prohibit breeding but to find strategies for sustainable use, to encourage legal breeding in captivity. Thus, education regarding breeding of Passeriformes in captivity could be useful for species that are widely exploited commercially (e.g. *S. maximiliani*, *S. angolenses* and *S. maximus*).

Birdwatching ecotourism is another underdeveloped activity in Brazil, although it has been shown to produce significant value if done well (Dias, 2011), with economic benefits for local communities (Steven et al., 2014). A study in Białowieża Forest, Poland, estimated that bird watching contributed nearly USD 2.2 million annually to the local economy (Czeszczewik et al., 2019). In the USA, 47 million people spend USD 9.3 billion per year on bird-related activities (Rosenberg et al., 2019). Incentives such as the improvement of existing protected areas to attract birdwatchers, from Brazil and other countries, and education of bird keepers as guides could form part of a long-term conservation strategy for avifauna. However, our findings show that culture encourages the hunting of songbirds, and that the high commercial value of some species, and thus the potential profit, encourages trade. The challenge is to maintain the cultural aspects of the hunting and keeping of songbirds, but to minimize any concomitant negative effects on their conservation.

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**Conflicts of interest** None.

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