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Biocultural salient birds: which biological and cultural factors define them?

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People's interests and needs, as well as biological characteristics of species, determine human perception and interaction with biodiversity. Thus, both cultural and biological factors should be considered to understand biocultural salient species. We studied the cultural and biological traits that influence bird salience for an indigenous community in Mexico. Firstly, we used bird lists mentioned by local people to compute salient indexes for species. Then, we constructed seven cultural association categories to represent the local significance of birds (recreation, beliefs, environment, food, crop damage, economy, pets) and compiled biological information about species (color, size, vocal activity, detectability, abundance, daily activity pattern, habitat, residence status, taxonomic family). Finally, we determined the relations of cultural associations and biological traits with bird salience using hierarchical clusters. We observed a strong link between salient birds and human feeding, as these animals were locally recognized as food and threat to crops. Salient and non-salient birds were differentiated by their residence status and vocal activity, as local awareness was greater towards year-round resident and vocal species. Salience related the most with abundance, followed by color and detectability. Our study provides a route to identify cultural and biological factors influencing biocultural salience, which might prove useful for establishing conservation initiatives, public policies, and environmental education actions.

KEYWORDS

abundance, crop damage, ethnobiology, hierarchical cluster, residence status, salience, Sutrop index, vocal activity

1 Introduction

Culture and nature are deeply interconnected (Maffi and Woodley, 2010). Biodiversity surrounding human communities determines their survival, welfare, and world view, whereas people's actions and decisions have an impact on ecosystems, from genes to the global cycles of nature (Maffi, 2001). This close bond is usually more evident when referring to the interactions of indigenous communities and their territories, as it has ancient roots

developed for millennia and people of these communities directly sustain their lives on goods and benefits provided by ecosystems (Nakashima and Roué, 2002; Oviedo and Noejovich, 2007). Studying human knowledge, use, and management of biocultural resources is relevant to understand the bidirectional relationship between culture and nature (Gadgil et al., 1993; Berkes et al., 2000). Moreover, assessing the connections that people establish with biodiversity has strong implications for attending the global need of both biological and cultural conservation (Nóbrega Alves, 2012; Gavin et al., 2015; Loch et al., 2023).

From the vast diversity of living things, only a fraction is directly and explicitly relevant to human communities (Sousa et al., 2019; Alcántara-Salinas et al., 2022). Such relevance might be explored through the study of salience, which refers to the properties of things that capture human attention (Berlin et al., 1973; Gosler, 2017). Salience values vary among the resources that are appreciated by people (Wyndham and Park, 2018). Thus, research on salience must go beyond identifying important species and determine their magnitude of prominence too (Sutrop, 2001; Parra-Rondinel et al., 2021). Biocultural salience particularly focuses on identifying the biological and cultural traits associated with species that are relevant for human communities (Berlin et al., 1981; Gosler, 2017). Salience values of biocultural resources might be associated with anthropogenic needs (e.g., feeding, dressing, housing, healing) (de Paula et al., 2017; Loch et al., 2023), human-wildlife conflicts (Ojeda-Linares et al., 2021; Piña-Covarrubias et al., 2022), and aesthetic, ethical, and symbolic relational aspects between human and non-humans (Holbrook and Woodside, 2008; Loch et al., 2023). From a biological perspective, biocultural salient resources might be appreciated for their abundance, biochemical constitution, or seasonality (Shaheen et al., 2020). However, it is still necessary to understand what makes a salient species for different groups of people and among distinct biological assemblages (Jain, 2000; Ladle et al., 2019).

Birds are among the most popular animals used and appreciated by human communities around the world (Turner and Bhattacharyya, 2016). They might be deeply linked with the beliefs, ecological knowledge, nourishment, economy, and recreation of people (Miller and Doolittle, 2017; Cantú et al., 2020). However, the motivations and factors that determine biocultural salient birds are expected to vary according to local practices and pools of species (Wyndham and Park, 2018). Traditionally, the biocultural study of birds has relied on identifying the identity of species that are appreciated by communities, but until recently it has been focused on defining and comparing the factors that motivate such relevance (de Oliveira et al., 2018; Ladle et al., 2019; Andrade et al., 2022). The characteristics of different bird species (e.g., song, color, size) represent biological factors that might affect how people perceive them (Miller and Doolittle, 2017; Andrade et al., 2022), whereas uses, interests and needs of people might influence the human interaction with such animals (Tidemann and Gosler, 2010). Thus, analyzing the relations that exist between cultural and biological factors might enhance an integral identification of the key elements that make a biocultural salient bird.

Here, we aimed to identify the cultural and biological traits that influence salience of birds for an indigenous community in western Mexico. Through semi-structured interviews we learned from local people about birds, enabling us to compute a salience index for species and classifying them into categories of cultural associations. Then, we gathered information about the biological traits that we suspected to impact on local awareness on birds. Finally, we analyzed the relations of local cultural associations and biological traits with bird salience through hierarchical clustering analyses. We hypothesized that the cultural associations (e.g., food) and the biological traits (e.g., abundance) that are linked with a regular coexistence between birds and people have a strong relation with salience values of local species.

2 Methods

2.1 Study site

Our research was performed in the Nahua community of Zacualpan, which is located in the state of Colima, western Mexico (19°21.789'N, 103°49.437'O, 640 m asl) (Figure 1). The human population is comprised by ~2,000 inhabitants who are mainly farmers and traders. Most of the people live in a village of ~30 ha extent. Agricultural fields (e.g., maize - *Zea mays*, squash - *Cucurbita* spp.), orchards, riparian habitats, and remnants of tropical dry forest surround the settlement. Traditional clothing and language have almost disappeared from Zacualpan, but ancestral farming techniques and culinary practices persist in the community (Grupo Xolocuahuitl Zacualpan, 2020; Mejía, 2021).

The area is quite relevant for the cultural history and the rich biodiversity that it encompasses. However, avian studies are incipient in the site (Ortega-Álvarez and Casas, 2022; Ortega-Álvarez et al., 2022), whereas other animal groups have not been studied across the zone. Ancient cultural practices are still present in the region, but its conservation is under stake (Corona Magaña, 2021). Therefore, further ethnographic studies are needed in the area to design strategies for conservation of the local biocultural diversity. In such a context, our research motivations (Hill et al., 2023) include fostering local ethnobiological knowledge, promoting the documentation of traditional knowledge and practices on use and relational values of biodiversity. We consider that understanding the human perception towards biodiversity, and addressing the cultural use and values of biodiversity, is crucial for maintaining both human cultural and biological aspects of the local context. Through these approaches, we seek to contribute to the community by fulfilling local interests on increasing the awareness about the biological resources that are present in their territory and identifying actions that might foster the preservation of communities' knowledge and traditions.

2.2 Surveys on salient birds: Sutrop index and cultural associations

During October 2022, we performed semi-structured interviews to learn about the importance of birds to the people of Zacualpan.

Semi-structured interviews were constructed following Batthyány and Cabrera (2011), for which we employed a main working topic (i.e., names and relevance of local birds) that was presented and discussed with people according to the flow of the conversation. Prior to the implementation of the survey, we tested the interview with elders from the community who had vast knowledge on local birds. This stage enabled us to determine if the wording, format, and content of the interview were clear enough for local people, and if such tool would produce the data aimed for our project. After validating the interview, we proceeded to perform surveys on salient birds by walking the streets of the urban settlement and randomly selecting interviewees (n = 40; 22 men and 18 women), which represented ~2% of the local population. All of them were Nahuas, but did not speak an indigenous language, only Spanish. Farming was their main occupation (63% of interviewees), but they usually performed other activities related with the commerce, construction, and housekeeping sectors. The mean, mode, and median values associated with the age of the group were 52, 70, and 58 years old, respectively. During surveys, we asked community members to list the bird species that lived across their territory. Before they responded, we commented on the main characteristics of birds (i.e., feathers) in order to be sure that people exclusively referenced to these animals. We were interested in the named birds because there is an association between the elements that are mentioned by people and the use that the human group gives to them (Smith et al., 1995; Quinlan, 2005). Moreover, we registered the listing order of the birds that were referenced by community members, as the frequency and position of the elements in the list are used for

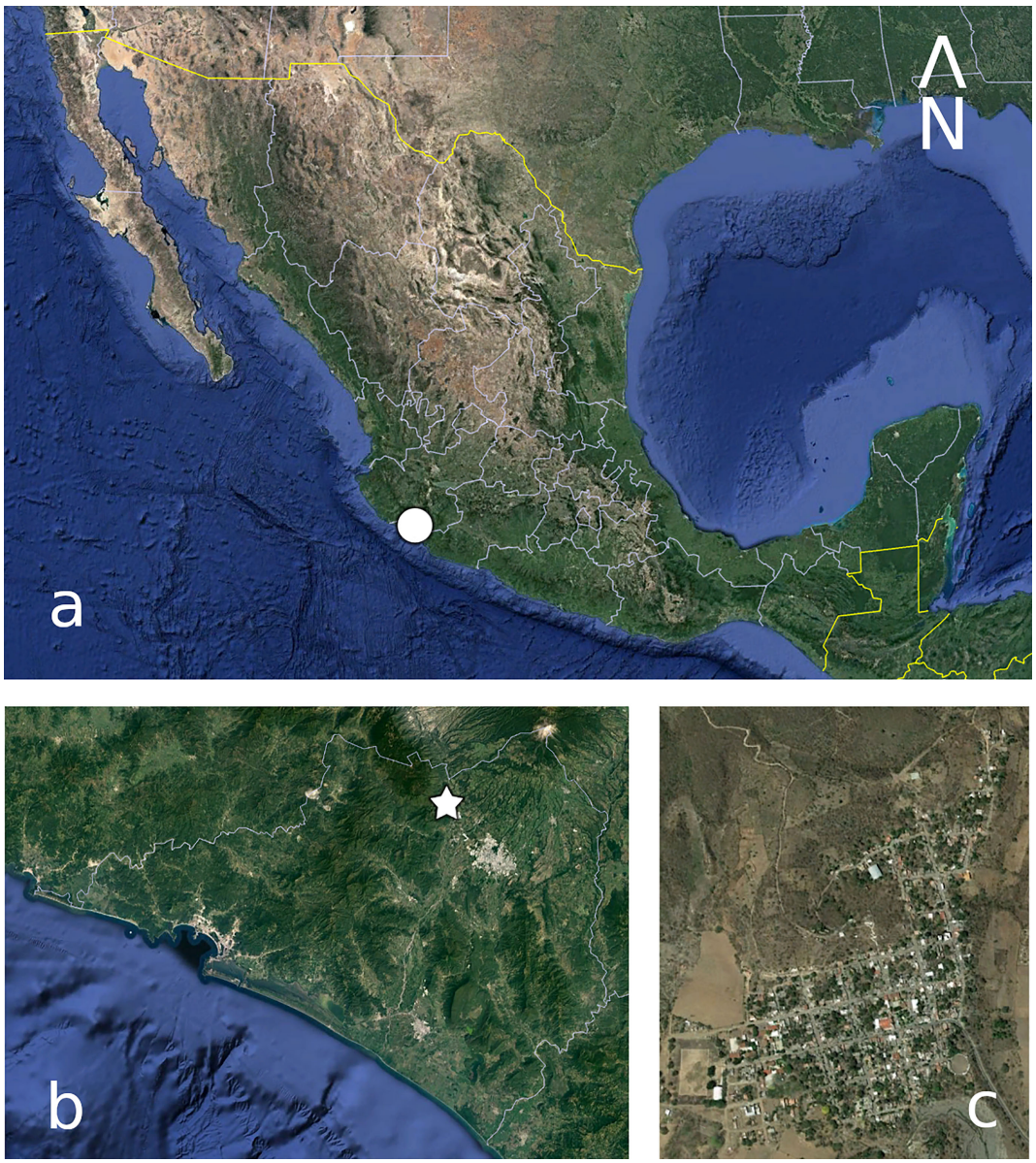

FIGURE 1
Map of the study site. **(A)** The white circle shows the location of Colima at western Mexico. **(B)** The white star depicts the location of Zacualpan at northern Colima. **(C)** Urban settlement of Zacualpan.

calculating a salient index for each species (Sutrop, 2001). In particular, we used the information provided by people to calculate a Sutrop Index because lists lengths were variable among respondents (Sutrop, 2001). We employed the open-source software for free-list analyses FLARES (Wencelius et al., 2017) to compute the index by combining term frequency and its mean position in the lists (Sutrop, 2001).

Once people finished listing birds, we asked them to mention the relevance of such animals for the community and its surrounding environment. During this stage, interviewees were encouraged to name species that exemplified such importance (e.g., myths, pollination, seed dispersal, consumption of crops, among others). We used this information for constructing our own set of categories of cultural associations in order to represent the local biocultural meaning of birds. Complementary data from participatory observations, field diary notes, and informal talks with people was used to improve both our categories and classification, as suggested by Batthyány and Cabrera (2011). As a result, seven categories were assembled, including: recreation (e.g., bird feeding, bird watching), beliefs (i.e., birds used to explain how the world works around the community through myths, stories, or religion; Usó-Doménech and Nescolarde-Selva, 2016), environment (e.g., pollination, seed dispersal, carcass removal), food (i.e., birds as a source of food), crop damage (e.g., birds as a threat to harvest of fruit and seeds), economy (i.e., traded birds), and pets (i.e., cage birds).

Birds mentioned by community members were identified to the species level. During this process, we consulted elders from the community who had vast knowledge on local birds to corroborate our tentative identification and remove doubts. This task was facilitated by using the photographs and sounds of the Merlin App (Cornell University, 2023). Previous ethnoecological work in the site also enhanced the association of local and scientific bird names (Ortega-Álvarez and Casas, 2022; Ortega-Álvarez et al., 2022). When different related species received a unique local name (e.g., hummingbirds), we used the family or the genus names for data analyses. If we were unable to identify the bird species mentioned by the people (i.e., 11 cases), we excluded them from the analyses.

2.3 Bird classification according to species biological traits

We built a local pool of species that included the birds mentioned by the interviewees (salient birds) and other species that were overlooked by community members (non-salient birds) but that are present in the territory of the community according to previous studies (Ortega-Álvarez and Casas, 2022; Ortega-Álvarez et al., 2022) and observations performed by the authors in the site. For each species, we included biological information that we suspected to influence people's awareness on birds, such as color, size, vocal activity, detectability, abundance, daily activity pattern, habitat, and residence status. Moreover, we annotated the bird taxonomic family following Chesser et al. (2022). A detailed description of the species biological traits that were used for the study are shown in Table 1.

2.4 Relations between species traits and salient birds

We used a clustering analysis to detect strong relations between species traits and salience of birds with the R package ClustOfVar (Chavent et al., 2012). Specifically, we employed a hierarchical clustering algorithm that enables lumping both numerical and categorical variables. This approach is based on a principal component method for qualitative and quantitative variables (Kiers, 1991). Cluster variables are defined as homogeneous when they are strongly linked, which is measured by the squared Pearson correlation (quantitative variables) and by the correlation ratio (qualitative variables) (Chavent et al., 2012). In this way, we were able to arrange a mixture of qualitative and quantitative variables for our assessment, as an alternative to a Principal Component Analysis (only suitable for numerical data) or to a Multiple Correspondence Analysis (restricted to categorical data). A detailed description of the method can be consulted in Chavent et al. (2012).

Clustering was performed for three different analyses. First, we constructed a dendrogram for the entire pool of species registered in the area by lumping their biological traits and their salience status. Salience status included two mutually-exclusive categories: salient and non-salient species. Salient birds were those species mentioned by the community members during the interviews, whereas non-salient birds were represented by overlooked species by the interviewees, but that were present in the territory of the community (Ortega-Álvarez and Casas, 2022; Ortega-Álvarez et al., 2022). This first analysis enabled us to determine which biological traits might be used to discriminate between salient and non-salient birds.

In our second analysis, we investigated which biological traits had strong relationships exclusively among salient birds. Thus, we removed non-salient species and clustered the Sutrop Index values of salient birds with their biological traits. Finally, through our third analysis we explored which cultural associations were heavily related with salient species by clustering cultural associations of local birds with the Sutrop Index value of each species. Biological traits and cultural associations were assessed in separated analyses (second and third analyses, respectively) to facilitate the interpretation of the results.

3 Results

On average, 8.7 birds (standard deviation: 7.3) were listed per interviewed person. The mode of our data set was 3. The highest number of names (32) was provided by two people, whereas the majority of members of the sample (n = 30; 75%) listed up to 10 species. Our local pool of birds included 130 species (Appendix 1), of which 58 (44.6%) were listed by the interviewees (salient birds; Appendix 2) and 72 (55.4%) were not mentioned by people at all (non-salient birds). The highest Sutrop Index values corresponded to the West Mexican Chachalaca (*Ortalis poliocephala*), Inca Dove (*Columbina inca*), Orange-fronted Parakeet (*Eupsittula*

TABLE 1 Description of the biological traits that we used for assessing salient birds of Zacualpan, Mexico.

Biological trait	Type	Subcategories and specifications
Color	Categorical	*Very noticeable*: mostly green, red, orange, and light blue colored birds. *Noticeable*: birds with bright colors (e.g., yellow, white) or a combination of light and dark coloring. *Poorly noticeable*: dull colored birds (e.g., grey, brown, black), with monochromatic or camouflaged plumage.
Size	Numerical	Bill length measured from tip of bill to tip of tail.
Vocal activity	Categorical	*Very vocal*: birds that vocalize for large periods, produce high volume vocalizations, or are very familiar for local people. *Vocal*: birds that usually vocalize. *Poorly vocal*: birds that do not frequently vocalize, have a low volume of vocalization, or are barely appreciated by local people.
Detectability	Categorical	*Conspicuous*: species are easily noted because of their bold habits, are frequently seen or heard in open habitats. *Inconspicuous*: shy species, which might also inhabit densely vegetated areas, and are usually unperceived by people.
Abundance	Categorical	*Common*: the species might be recorded daily in large numbers, in proper habitat and season. *Fairly common*: the species might be recorded in small numbers on most days, in proper habitat and season. *Uncommon*: the species might not be seen daily, but could be recorded at least once a week in small numbers, in proper habitat and season. *Rare*: the species is unlikely to be seen even in proper habitat and season, and only in small numbers.
Daily activity pattern	Categorical	*Diurnal*: the species is mostly active during daytime. *Nocturnal*: the species is mostly active during nighttime.
Habitat	Categorical	*Terrestrial*: the species does not live at or is not associated with bodies of water. *Aquatic*: the species lives at or is very associated with bodies of water.
Residence status	Categorical	*Year-round resident*: the species lives in the area throughout the year.
		Migratory: the species is present in the area only for winter or summer periods.
Family	Categorical	Taxonomic family of the species.

Size followed that provided by Howell and Webb (1995); when two measurements were given (e.g., male and female), we employed a mean size value. We utilized the abundance categories suggested by Howell and Webb (1995), but we classified species according to our observations from the site. Family was determined following Chesser et al. (2022).

canicularis), and White-winged Dove (*Zenaida asiatica*) (Appendix 2). The cultural association that contained more local birds was beliefs (19 species), followed by food (12 species), crop damage (8 species), and pets (5 species) (Appendix 2). Poorly noticeable (26 species), medium sized (21-30 cm; 18 species), very vocal (21 species), and conspicuous birds (36 species) were usually mentioned by members of the sample. Common (21 species), diurnal (56 species), terrestrial (53 species), and year-round resident birds (52 species) were also the most frequently listed birds. Species from the families Columbidae (8 species), Cuculidae (4 species), Icteridae (4 species), and Picidae (4 species) were commonly included among the salient birds (Appendix 2).

3.1 Cultural associations, biological traits, and salience of birds

We determined that food and crop damage were the cultural associations with the strongest relations with Sutrop Index Values of salient birds (Figure 2). Our clustering analysis about the relation between biological traits and salience status of the local pool of birds (salient *vs.* non-salient species) suggested that salience was tightly related with residence status and vocal activity of species (Figure 3). When solely focusing over salient birds, we had to exclude daily activity pattern and habitat traits from the analysis because both enclosed only a few species (2 and 5, respectively). Then, we observed that Sutrop Index values were strongly related with abundance (Figure 4). Moreover, the cluster that was conformed by these two variables was closely related with the one comprised by color and detectability.

4 Discussion

Although most interviewees were farmers who usually experience an intimate contact with wildlife, only a minority of them (15%) were able to name a considerable number of local birds (16-32 spp.), whereas most people (85%) listed less than 15 species. This is relevant for our study as it determined the variability of lists' length that we used for the analyses, suggesting that local bird knowledge might be unequally distributed within Zacualpan. Such pattern is consistent with previous studies from the site, which found that traditional knowledge on birds is declining (Ortega-Álvarez and Casas, 2022). According to our observations in the field, we suggest that the personal interest on traditions and biodiversity might be a key factor determining salience, as it influences the desire to create, apply, and maintain the traditional use and knowledge of biocultural resources (Wyndham, 2010). Future studies might explore such individual variation on local bird knowledge.

We observed that there was a strong link between salient birds and human feeding. For instance, birds were locally appreciated as a source of food. However, hunting is locally forbidden, which might increase the populations of common game species (e.g., West Mexican Chachalaca, White-winged Dove), but might jeopardize the maintenance of traditional practices and knowledge associated with the local avifauna. As suggested by elders from the community, the latter might be true because hunting provided the opportunity to community members (i.e., young people) to learn about and appreciate birds. This situation is paradoxical because a biodiversity conservation measure (i.e., hunting ban) might has a proximate

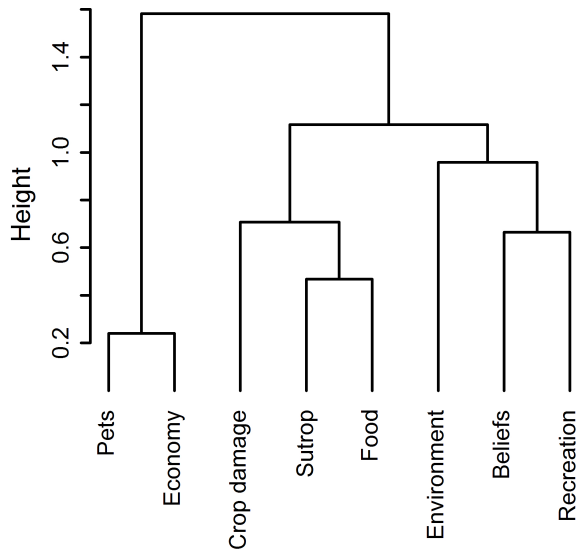

FIGURE 2
Relations between cultural associations and Sutrop Index values of salient birds of Zacualpan, Mexico. Sutrop = Sutrop Index values of salient birds.

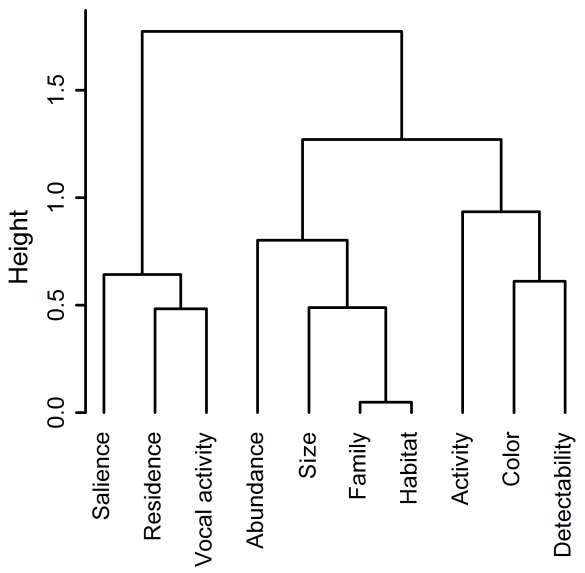

FIGURE 3
Relations between biological traits and the salience status of the pool of birds of Zacualpan, Mexico. Salience = salience status (salient *vs.* non-salient species); Residence = residence status; Activity = daily activity pattern.

benefit to bird demography, but might be ultimately compromising traditional knowledge and wildlife appreciation. Thus, if hunting has to be banned, we suggest that such policy should be accompanied by the promotion of complementary activities for reducing its negative impact on local cultural practices. For example, birdwatching could be promoted to mimic hunting related activities, including the opportunity to learn about avian identification, tracking, and behavior (Sheard, 1999). Moreover, the establishment of wildlife management units within the community might provide a local alternative to hunting for accessing to wild meat (Espino-Barros et al., 2008; Contreras-Hernández, 2021).

Birds were also relevant for other aspect of human feeding: food production. In particular, our study showed that local birds have a cultural relevance as a threat to crops (Anderson et al., 2013; Linz et al., 2015). Nevertheless, we perceived through people's comments that these animals might not impose huge problems to local farming practices as others do, including mammals (e.g., Collared Peccary - *Dicotyles tajacu*, White-nosed Coati - *Nasua narica*) and insects (e.g., ants of the genus *Atta*) (Lofgren, 1986; Piña-Covarrubias et al., 2022). Additionally, some farmers mentioned that birds were important agricultural pests long time ago, but their numbers and negative associated impacts on crops were reduced after the introduction of agrochemicals. Further research on this topic deserves special attention to understand the effects of industrial pesticides and fertilizers on the local avifauna.

We showed that salient and non-salient birds might be differentiated by their residence status and vocal activity. Local awareness on year-round resident birds might be linked with the possibility to observe their full annual cycle across the territory of the community, including courtship, mating, nesting, hatching, and fledgling stages. Such events are almost impossible to be locally noticed for migratory birds because they mostly happen at distant breeding grounds (DeGraaf and Rappole, 1995). Vocal activity might be specially relevant for the appreciation of year-round resident birds, as they usually initiate singing behavior during the onset of the reproductive period (Rubolini et al., 2010; Furnas and McGrann, 2018). Bird songs are usually attractive for people, influencing the conformation of common names, myths, and species' selection for cage birds (Tidemann and Gosler, 2010; de Oliveira et al., 2018). Moreover, songs play an important role in the local identification of species, to the extent that community members were more familiarized with the sounds of certain birds than with their visual aspect (e.g., wrens - Troglodytidae, Blue Mockingbird - *Melanotis caerulescens*, Lesser Ground-Cuckoo - *Morococcyx erythropygus*).

Abundance was the biological trait that related the most with salience. A species that could be recorded daily in large numbers might facilitate people´s chances to use and learn from it, or simply encounter it in everyday situations (Celis-Diez et al., 2017; Ladle et al., 2019). Other biological traits that were of secondary importance for salient birds were color and detectability. Noticeable colors are usually appreciated by people (Andrade et al., 2022; Senior et al., 2022), for example the bright green of parrots (Psittacidae) or the deep orange of orioles (Icteridae). Finally, bold habits of conspicuous birds might facilitate direct observations by community members, increasing cultural knowledge and awareness (Celis-Diez et al., 2017).

5 Conclusion

We acknowledge that we might have missed to detect other salient birds for particular members of the community of

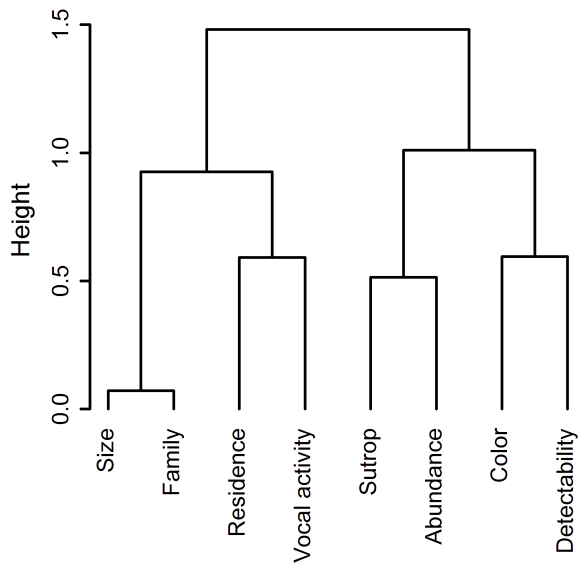

FIGURE 4
Relations between biological traits and Sutrop Index values of salient birds of Zacualpan, Mexico. Sutrop = Sutrop Index values of salient birds.

Zacualpan, as our sample represented about 2% of the population living in the area. This apparently reduced sample size is associated with the time- and effort-consuming methodologies that we used for performing our research. Still, the qualitative methods that we employed provide meaningful, representative, locally contextualized, and high-quality results (Drury et al., 2011), which enabled us to have a better understanding on the biological and cultural traits that are associated with salient birds. Our findings could be locally employed to guide environmental education actions, conservation initiatives, and public policies (Wyndham and Park, 2018). For example, given that local interest on birds is decreasing (Ortega-Álvarez and Casas, 2022), workshops focused on resident, abundant, and vocal species might aid to attract and increase the attention of people towards these animals. Moreover, we suggest that hunting regulations in the community deserve to be reassessed, as this activity simultaneously provide food and educational opportunities for the welfare of the local population. Because governmental and social perception external to the community might reduce its acceptance, alternative activities to hunting (e.g., birdwatching, wildlife management units) might be considered to fulfill sustenance and learning needs of the community.

Our study provides a valuable route to identify cultural and biological factors that influence animal relevance to human communities. This type of assessments is expected to vary among sites and cultures, as other human groups may utilize, appreciate, and understand in different ways the biological diversity that surrounds them (Jain, 2000; Ladle et al., 2019). Also, variations among avian species might have a differential impact on human appreciation (Alcántara-Salinas et al., 2022). Other factors that should deserve future investigation include intergenerational changes of attitudes towards nature, human migration, globalization, personal abilities on bird identification, and the modification of species distribution as a consequence of climate fluctuation. Because human perception is dynamic, temporal variation on the traits that determine biocultural salient birds should deserve special attention by forthcoming research. Although this study focused on birds, assorted biological groups might be assessed through a similar approach. Moreover, this research might serve to future studies as a baseline to design survey tools (e.g., questionnaires, interviews) for understanding differences on the perception of biodiversity among distinct sectors of the community.

We recognize that methods, analyses, and interpretations of results depend on the positionalities of researchers (Hill et al., 2023). However, our approach might serve as a starting point to further investigations, even if they have positionalities of their own. The proposals and interpretations derived from this study should be discussed with the community, as our visions and suggestions might be influenced by our position as conservationists of biocultural diversity. Still, we believe that the results associated with our research could also serve as a guideline to set the dialogue with community members and construct a biocultural conservation agenda that follows the interests, needs, perceptions, and limitations of the local population.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary Material. Further inquiries can be directed to the corresponding author.

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements. Local authorities and interviewees granted permission to perform surveys. Ethical review and approval was not required for the animal study because research on vertebrates was bibliographical and based on information provided by people.

Author contributions

RO-A and AC conceived the study. RO-A collected and analyzed the data. RO-A and AC interpreted the data and wrote the manuscript. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fcosc.2023.1215967/full#supplementary-material

References

Alcántara-Salinas, G., Hunn, E. S., Ibáñez-Bravo, M. E., Aldasoro-Maya, E. M., Flores-Hernández, N., Pérez-Sato, J. A., et al. (2022). Bird conservation status and cultural values in indigenous Mexican communities: towards a bioculturally informed conservation policy. *J. Ethnobiol. Ethnomed.* 18, 1–17. doi: 10.1186/s13002-022-00567-z

Anderson, A., Lindell, C. A., Moxcey, K. M., Siemer, W. F., Linz, G. M., Curtis, P. D., et al. (2013). Bird damage to select fruit crops: the cost of damage and the benefits of control in five states. *Crop Prot.* 52, 103–109. doi: 10.1016/j.cropro.2013.05.019

Andrade, R., Larson, K. L., Franklin, J., Lerman, S. B., Bateman, H. L., and Warren, P. S. (2022). Species traits explain public perceptions of human–bird interactions. *Ecol. Appl.*, e2676. doi: 10.1002/eap.2676

Batthyány, K., and Cabrera, M. (2011). *Metodología de la investigación en ciencias sociales. apuntes para un curso inicial* (Uruguay: Departamento de Publicaciones, Unidad de Comunicación de la Universidad de la República (UCUR).

Berkes, F., Colding, J., and Folke, C. (2000). Rediscovery of traditional ecological knowledge as adaptive management. *Ecol. Appl.* 10, 1251–1262. doi: 10.1890/1051-0761(2000)010[1251:ROTEKA]2.0.CO;2

Berlin, B., Boster, J. S., and O'Neill, J. (1981). The perceptual bases of ethnobiological classification: evidence from aguaruna jívaro ornithology. *J. Etnobiol.* 1 (1), 95–108.

Berlin, B., Breedlove, D. E., and Raven, P. H. (1973). General principles of classification and nomenclature in folk biology. *Am. Anthropol.* 75, 214–242. doi: 10.1525/aa.1973.75.1.02a00140

Cantú, J. C., García de la Puente Orozco, E., González, G. M., and Sánchez, M. E. (2020). *Riqueza alada. El crecimiento del aviturismo en méxico* (México: Defenders of Wildlife, UABCS, ENESUM). doi: 10.25145/j.fortunat.2018.28.004

Celis-Diez, J. L., Muñoz, C. E., Abades, S., Marquet, P. A., and Armesto, J. J. (2017). Biocultural homogenization in urban settings: public knowledge of birds in city parks of Santiago, Chile. *Sustainability* 9, 485. doi: 10.3390/su9040485

Chavent, M., Kuentz-Simonet, V., Liquet, B., and Saracco, J. (2012). ClustOfVar: an r package for the clustering of variables. *J. Stat. Software* 50, 1–16. doi: 10.18637/jss.v050.i13

Chesser, R. T., Billerman, S. M., Burns, K. J., Cicero, C., Dunn, J. L., Hernández-Baños, B. E., et al. (2022). *Check-list of north American birds* Vol. 28 (American Ornithological Society), 2023).

Contreras-Hernández, A. (2021). *Importancia socioambiental del manejo de la vida silvestre. unidades de manejo para la conservación de la vida silvestre en veracruz, Tabasco y chiapas* (México: Secretaría de Medio Ambiente y Recursos Naturales, Instituto de Ecología A. C).

Cornell University (2023). *Merlin bird ID* (Ithaca, New York: The Cornell Lab of Ornithology, Cornell University).

Corona Magaña, A. L. (2021). *Ya no somos los indígenas de antes" testimonios de mujeres nahuas en su lucha por mantener a zacualpan libre de minería* (Tlaquepaque, Jalisco: Universidad Jesuita de Guadalajara).

DeGraaf, R. M., and Rappole, J. H. (1995). *Neotropical Migratory birds: natural history, distribution, and population change* (Ithaca, New York: Cornell University Press).

de Oliveira, W. S. L., Lopes, S. D. F., and Nóbrega Alves, R. R. (2018). Understanding the motivations for keeping wild birds in the semi-arid region of Brazil. *J. Ethnobiol. Ethnomed.* 14, 1–14. doi: 10.1186/s13002-018-0243-6

de Paula, M., Xerente, V., and Pezzuti, J. (2017). Hunting and monitoring: community-based research in xerente indigenous land, Brazilian cerrado. *Hum. Ecol. Rev.* 23, 23–44. doi: 10.22459/HER.23.01.2017.02

Drury, R., Homewood, K., and Randall, S. (2011). Less is more: the potential of qualitative approaches in conservation research. *Anim. Conserv.* 14, 18–24. doi: 10.1111/j.1469-1795.2010.00375.x

Espino-Barros, O. A. V., Guevara Viera, R., Franco Guerra, F. J., Hernández Hernández, J. E., Romero Castañón, S., and Barrera Hernández, T. (2008). Evaluación de las unidades de manejo para la conservación de la vida silvestre del venado cola blanca en la región mixteca, méxico. *Zootec. Trop.* 26, 395–398.

Furnas, B. J., and McGrann, M. C. (2018). Using occupancy modeling to monitor dates of peak vocal activity for passerines in California. *Condor* 120, 188–200. doi: 10.1650/CONDOR-17-165.1

Gadgil, M., Berkes, F., and Folke, C. (1993). Indigenous knowledge for biodiversity conservation. *Ambio* 22, 151–156.

Gavin, M. C., McCarter, J., Mead, A., Berkes, F., Stepp, J. R., Peterson, D., et al. (2015). Defining biocultural approaches to conservation. *Trends Ecol. Evol.* 30, 140–145. doi: 10.1016/j.tree.2014.12.005

Gosler, A. G. (2017). The human factor: ecological salience in ornithology and ethno-ornithology. *J. Ethnobiol.* 37, 637–662. doi: 10.2993/0278-0771-37.4.637

Grupo Xolocuahuitl Zacualpan (2020). *Comida tradicional rural de la comunidad indígena de zacualpan, comala, colima* (Colima: Gobierno del Estado, PACMYC).

Hill, C., Athreya, V., Linnell, J. D. C., McQuinn, B., Redpath, S., Young, J., et al. (2023). "The role of the conservationist," in *IUCN SSC guidelines on human-wildlife conflict and coexistence* (Switzerland: IUCN), 25–27.

Holbrook, M. B., and Woodside, A. G. (2008). Animal companions, consumption experiences, and the marketing of pets: transcending boundaries in the animal-human distinction. *J. Bus. Res.* 61, 377–381. doi: 10.1016/j.jbusres.2007.06.024

Howell, S. N. G., and Webb, S. (1995). *A guide to the birds of Mexico and northern central America* (UK: Oxford University Press).

Jain, S. K. (2000). Human aspects of plant diversity. *Econ. Bot.* 54, 459–470. doi: 10.1007/BF02866545

Kiers, H. A. L. (1991). Simple structure in component analysis techniques for mixtures of qualitative and quantitative variables. *Psychometrika* 56, 197–212. doi: 10.1007/BF02294458

Ladle, R. J., Jepson, P., Correia, R. A., and Malhado, A. C. M. (2019). A culturomics approach to quantifying the salience of species on the global internet. *People Nat.* 1, 524–532. doi: 10.1002/pan3.10053

Linz, G. M., Bucher, E. H., Canavelli, S. B., Rodriguez, E., and Avery, M. L. (2015). Limitations of population suppression for protecting crops from bird depredation: a review. *Crop Prot.* 76, 46–52. doi: 10.1016/j.cropro.2015.06.005

Loch, V., do, C., Celentano, D., Carvalho Saraiva, R. V., Alvarado, S. T., Berto, F. D. F., et al. (2023). Forest species for biocultural restoration in eastern Amazon, Brazil. *Ethnobiol. Conserv.* 12, 1–15. doi: 10.15451/ec2023-02-12.03-1-15

Lofgren, C. S. (1986). *Fire ants and leaf-cutting ants* (Boca Raton, Florida: CRC Press).

Maffi, L. (2001). *On biocultural diversity: linking language, knowledge, and the environment* (Washington, DC: Smithsonian Institution Press).

Maffi, L., and Woodley, E. (2010). "Biocultural diversity conservation," in *A global sourcebook* (London, UK: Earthscan).

Mejía, N. (2021). *Montañas de colima, una cocina de altura. colima. una gran travesía gastronómica* (Tomo III. México: Nicolás Mejía).

Miller, A. M., and Doolittle, E. (2017). Rarámuri bird knowledge and environmental change in the Sierra tarahumara, chihuahua, Mexico. *J. Ethnobiol.* 37, 663–681. doi: 10.2993/0278-0771-37.4.663

Nakashima, D., and Roué, M. (2002). Indigenous knowledge, peoples and sustainable practice. *Encyclopedia Global Environ. Change* (Chichester) 5, 314–324.

Nóbrega Alves, R. R. (2012). Relationships between fauna and people and the role of ethnozoology in animal conservation. *Ethnobiol. Conserv.* 1, 1–69. doi: 10.15451/ec2012-8-1.2-1-69

Ojeda-Linares, C., Álvarez-Ríos, G. D., Figueredo-Urbina, C. J., Islas, L. A., Lappe-Oliveras, P., Nabhan, G. P., et al. (2021). Traditional fermented beverages of Mexico: a biocultural unseen foodscape. *Foods* 10, 2390. doi: 10.3390/foods10102390

Ortega-Álvarez, R., and Casas, A. (2022). "Las aves están en el monte, no en el pueblo": percepción comunitaria sobre la riqueza aviar asociada a los traspatios de Zacualpan, México. *El Hornero* 37, 1–10. doi: 10.56178/eh.v37i2.396

Ortega-Álvarez, R., Pacheco-Flores, A., and Casas, A. (2022). The "Guamúchil" cultivation in a Mexican cultural landscape: a wild food source for people and birds. *Front. For. Glob. Change* 5. doi: 10.3389/ffgc.2022.1020207

Oviedo, G., and Noejovich, F. (2007). Challenges for the maintenance of traditional biodiversity knowledge in Latin America. *Indig. Knowl. Syst. Sustain. Dev. Relev. Africa. Tribes Tribals* 1, 225–239.

Parra-Rondinel, F., Casas, A., Begazo, D., Paco, A., Márquez, E., Cruz, A., et al. (2021). Natural and cultural processes influencing gene flow among wild (atoq papa), weedy (araq papa and k'ipa papa), and crop potatoes in the Andean region of southern Peru. *Front. Ecol. Evol.* 9. doi: 10.3389/fevo.2021.617969

Piña-Covarrubias, E., Chávez, C., and Doncaster, P. (2022). Knowledge of wildlife, hunting, and human-felid interactions in Maya forest communities of the northern yucatán peninsula, Mexico. *Hum. Ecol.* 50, 1035–1045. doi: 10.1007/s10745-022-00363-z

Quinlan, M. (2005). Considerations for collecting freelists in the field: examples from ethobotany. *Field Method.* 17, 219–234. doi: 10.1177/1525822X05277460

Rubolini, D., Saino, N., and Møller, A. P. (2010). Migratory behaviour constrains the phenological response of birds to climate change. *Clim. Res.* 42, 45–55. doi: 10.3354/cr00862

Senior, R. A., Oliveira, B. F., Dale, J., and Scheffers, B. R. (2022). Wildlife trade targets colorful birds and threatens the aesthetic value of nature. *Curr. Biol.* 32, 4299–4305. doi: 10.1016/j.cub.2022.07.066

Shaheen, H., Qureshi, R., Qaseem, M. F., and Bruschi, P. (2020). The fodder grass resources for ruminants: a indigenous treasure of local communities of thal desert punjab, Pakistan. *PloS One* 15, e0224061. doi: 10.1371/journal.pone.0224061

Sheard, K. (1999). A twitch in time saves nine: birdwatching, sport, and civilizing processes. *Sociol. Sport J.* 16, 181–205. doi: 10.1123/ssj.16.3.181

Smith, J., Furbee, L., Maynard, K., Quick, S., and Ross, L. (1995). Salience counts: a domain analysis of English color terms. *J. Linguist. Antropol.* 5, 203–216. doi: 10.1525/jlin.1995.5.2.203

Sousa, R., da, S., Muniz de Medeiros, P., and Albuquerque, U. P. (2019). Can socioeconomic factors explain the local importance of culturally salient plants in a social-ecological system? *Acta Bot. Brasilica* 33, 283–291. doi: 10.1590/0102-33062018abb0320

Sutrop, U. (2001). List task and a cognitive salience index. *Field Methods* 13, 263–276. doi: 10.1177/1525822X0101300303

Tidemann, S., and Gosler, A. G. (2010). *Ethno-ornithology: birds, indigenous peoples, culture and society* (UK: Earthscan). doi: 10.4324/9781849774758

Turner, N. J., and Bhattacharyya, J. (2016). Salmonberry bird and goose woman: birds, plants, and people in indigenous peoples lifeways in northwestern north America. *J. Ethnobiol.* 36, 717–745. doi: 10.2993/0278-0771-36.4.717

Usó-Doménech, J., and Nescolarde-Selva, J. (2016). What are belief systems? *Found. Sci.* 21, 147–152. doi: 10.1007/s10699-015-9409-z

Wencelius, J., Garine, E., and Raimond, C. (2017) *FLARES. free list analysis under r environment using shiny*. Available at: http://www.anthrocogs.com/shiny/flares/ (Accessed 15, 2023).

Wyndham, F. S. (2010). Environments of learning: rarámuri children's plant knowledge and experience of schooling, family, and landscapes in the Sierra tarahumara, Mexico. *Hum. Ecol.* 38, 87–99. doi: 10.1007/s10745-009-9287-5

Wyndham, F. S., and Park, K. (2018). "Listen carefully to the voices of the birds": a comparative review of birds as signs. *J. Ethnobiol.* 38, 533–549. doi: 10.2993/0278-0771-38.4.533