Colegio de Postgraduados

The birdlife in the Botanical Garden of Benemérita Universidad Autónoma de Puebla, a sustainable alternative

Silveira-Caminero, Miguel A.; Sánchez-Morales, Primo; López-Olguín, Jesús F.; Ocaña Parada Carlos de Jesús; Casanovas-Cosío, Enrique; Villarreal-Espino Barros, Oscar A.*

Benemérita Universidad Autónoma de Puebla. Cd. Universitaria. 72410. Puebla, Mexico.
* Correspondence: oscar.villarreal@correo.buap.mx

ABSTRACT

Objective: to contribute to the knowledge of the birdlife of the Botanical Garden of the Benemerita Universidad Autonoma de Puebla (JB-BUAP) through a sustainable birdwatching project.

Design/Methodology/Approach: a survey was administered to 94 randomly selected visitors to the JB-BUAP to assess their interest and perceptions. Weekly monitoring was conducted over a one-year period, with 47 field trips to identify and count the number of bird species visiting the study site.

Results: with the trips conducted, 101 bird species were identified, distributed taxonomically among 12 orders and 36 families. Of these species, 10 are endemic, 6 are semi-endemic, and 2 are quasi-endemic. Regarding their conservation status, one species was identified as threatened, the Mexican duck (*Anas diazi*). Three species are subject to special protection, the Least grebe (*Tachybaptus dominicus*), the Peregrine falcon (*Falco peregrinus*), and the MacGillivray's warbler (*Geothlypis tolmiei*).

Limitations/implications of the study: the visitors interviewed were mostly young people with a high school diploma; others were workers, that highly valued the biodiversity present in the JB-BUAP. Therefore, this study could be extended to a more general and varied population that has not yet visited the JB-BUAP.

Findings/Conclusions: there is a general interest in wildlife within urban environments, and in this particular case towards birds in a space intended for the public. It is advisable to promote the promotion of habitats to maintain the populations of these birds; that in this and other places, such as agroecosystems, could function as a natural pest control.

Keywords: endemic, semi-endemic, quasi-endemic, birds, conservation biology, integrated management.

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INTRODUCTION

There are about 10 500 species of birds in the world. Colombia ranks first among the ten countries with the highest diversity of birds with 1815 species. Then come Peru with 1781; Brazil, 1712; Indonesia, 1604; Ecuador, 1559; Bolivia, 1406; and Mexico ranks eleventh with 1136 species, of which 194 are characterized by some level of endemism. Of these, 106 are endemic, 43 are quasi-endemic and 45 are semi-endemic (Plenge, 2017; CONABIO, 2020).

In order to practice birdwatching, binoculars, monocular, telescopes and cameras are usually used, depending on the intended level of detail. Many birders write down the species they can identify in a field notebook (Mackinnon, 2005). Then, to achieve bird identification, they rely on illustrated bird guides or mobile applications such as Merlin Bird, eBird, iNaturalist, Audubon Bird Guide, BirdNET. In Mexico, one of the most widely used illustrated bird guides is that of National Geographic (Dunn & Alfer, 2017).

Birdwatching is free and inclusive, it is a field practice linked to outdoor spaces and at the local level, it develops a sense of belonging to a specific community (Gelder, 2007). In Mexico there are several species of birds of great interest for their conservation, management and, therefore, for their observation. One of the places where you can find a wide variety of birds is the Botanical Garden under the Meritorious Autonomous University of Puebla [Benemerita Universidad Autonoma de Puebla], from this point on (JB-BUAP).

The BUAP botanical garden acts as a refuge for various species of birds that include migratory, endemic, resident and cosmopolitan birds. This birdwatching study was approached from an agroecological point of view as the scientific approach, also has a public character, due to its location in an urban area accessible to anyone interested. Both boarding students and students from other institutions, workers and the public can participate in enjoying birdwatching and learning about the local birdlife. This study, then, aimed to contribute to the knowledge of the birdlife of the Botanical Garden of the Benemerita Universidad Autonoma de Puebla (JB-BUAP) through a sustainable birdwatching project.

MATERIALS AND METHODS

Study area

The research was conducted in the botanical garden of the BUAP (JB-BUAP), a space that has been part of the Mexican Association of Botanical Gardens since 1998. This garden has several accreditations, among which the certification as an Environmental Education Center is notable, with the Level III Quality Certificate granted by the Mexico's Secretariat of Environment and Natural Resources (Secretaría de Medio Ambiente y Recursos Naturales-SEMARNAT), valid until 2015 and in the process of revalidating that accreditation. It is the first botanical garden in Mexico accredited by the Botanic Gardens Conservation International (BGCI) since 2000, and by the Arboreta Network-ArbNet at Level IV since 2019 (Jardín Botánico BUAP, 2025).

The site is inscribed in a temperate subhumid climate with summer rainfall, has a rainfall of 800-1000 mm per year and an average annual temperature of 14-16 °C (INEGI, 2020). Since 1977, the JB-BUAP is identified as an agroecosystem, due to its management and conservation and its human activities. This management has favored a remarkable diversity of plants in that site (Hernández, 1977). It is located at coordinates 19° 00' 00.24" N and 98° 11' 49.61" W, at an altitude of 2128 m; and is part of the University City (CU) of the BUAP, at Av. San Claudio s/n, Col. San Manuel, C.P. 72570, Puebla, Puebla (Mexico). The botanical garden covers a total area of 10.8 ha (about 26.8 acres), with a central lagoon of 3.3 ha (about 8.15 acres) that includes an islet of 0.472 ha (1.16 acres) in its center (Figure 1).

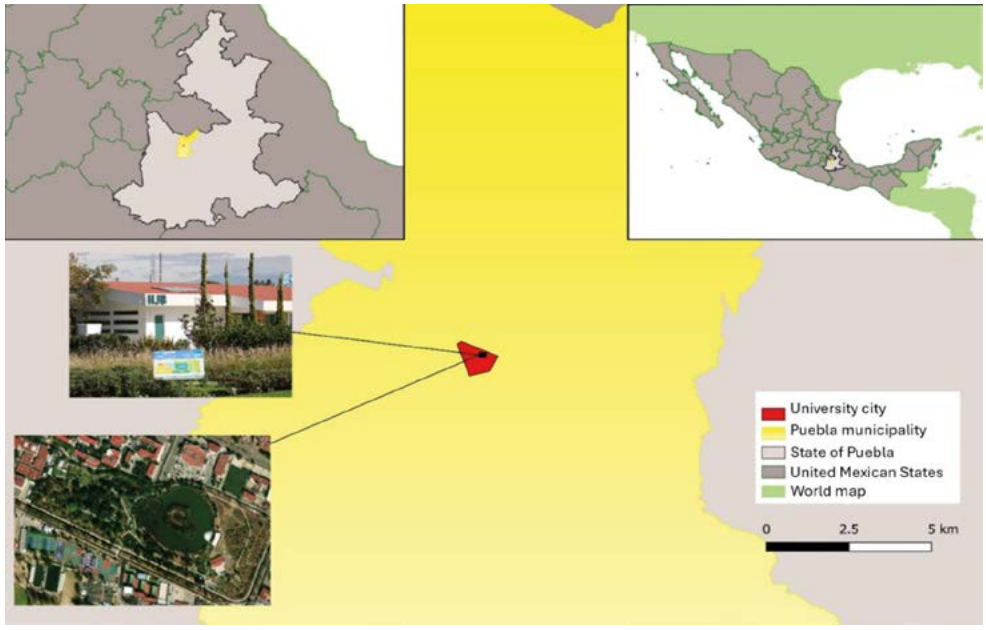

Figure 1. Map of the Botanical Garden of the Benemerita Universidad Autonoma de Puebla (JB-BUAP).

Survey application

The average number of visitors to the JB-BUAP in a year was considered as population size, that is, 3200 people. The sample size calculation was made for a finite population according to the formula of Almaguer *et al.* (2022);

$$n = (p)(q)(N)(Z^2) / \left[E^2 (N-1) + Z^2 (p)(q) \right]$$

where: n=was the necessary sample size (94); N=size of the study population (3200); Z=Z-score value (1.96) corresponding to the 95% confidence level; p=expected proportion of the total population with the visitor characteristic, usually (0.5) to obtain the maximum sample size; E=desirable margin of error (0.1).

The interview was applied completely randomized to measure the level of knowledge that the community has about birdlife and to evaluate the acceptance of birdwatching. In the design of the project activities, the degree of knowledge of the participants was adjusted on a scale (Very low, Low, Medium, High, Very high). The language used to communicate information was adapted to this level of knowledge. The questionnaires designed were applied to visitors when they left the JB-BUAP, to take advantage of their recent experiences in the place. Likewise, the application was distributed throughout the day, to avoid interviewing both the first few and the last few people to leave, to ensure the randomness of the opinions (Hernández *et al.*, 2010). This procedure was followed for 33 consecutive weeks, from June 2024 to February 2025; three questionnaires were applied per week during the interview period.

Birdwatching

The study is defined as observational, prospective, longitudinal and descriptive (Méndez, 1996). The monitoring, to follow visits and birdwatching, was implemented for one year at the JB-BUAP. Because in addition to identifying the different species of birds present and quantifying them, we sought to determine which are the most abundant in each season of the year evaluated. Birdwatching was done by the itinerary method (González, 2019) with tours along the roads that are already formed within the JB-BUAP (1162 m). The tours started from different points on each date. During the monitoring, several species of birds were identified by direct and indirect methods. The direct method includes observation with binoculars, taking photographs and visual identification of the birds. Meanwhile, the indirect methods were the collection of feathers and footprints, the identification of songs, and the observation of nests to determine to which species the evidence found belonged.

The tours were made from 7:30 am to 10:30 am, with two field observers (October 7, 2023 to October 26, 2024). A field notebook, a Canon® ECOS Rebel T7 camera with a Canon® EF 70-300 mm f/4-5.6 telephoto lens and a Sony® Alpha 7rv camera, a Sony® G 200-600 telephoto lens, were used. Tasco® binoculars, model Futura SE, 10×50 mm and other Osprey® Waterproof binoculars, 10×40 mm, were also used. For communication between the observers, portable radio communication equipment (Motorola® Waterproof Talkabout) was used. The data were concentrated weekly in an Excel® records spreadsheet organized by species as they were found. In addition to their taxonomical classification, order, species, common name, scientific name, seasonality of sightings, status of endemism and, where appropriate, protection status.

Statistical methods

The data obtained were processed with descriptive statistics in the IBM statistical program. SPSS v. 27.0.0, to represent them in tables and graphs with numerical and percentage values, according to the objective.

RESULTS AND DISCUSSION

General data and perceptions of the interviewees

Of the 94 people interviewed, 51.06% (n=48) belong to the male sex, 45.74% (n=43) to the female sex, and 3.19% (n=3) do not perceive themselves as having these gender identities. Age ranged from 19 to 63 years old, with an average of 26 years, and mode of 23. The figure is slightly lower than the average municipal age (27) according to data from the population and housing census in the municipality of Puebla (INEGI, 2021).

Regarding the level of schooling, 75.53% (n=71) of the total number of people interviewed have completed high school (Figure 2A), which contrasts with the state data (14.6%) of the Secretariat of Public Education of Puebla in the year (SEP, 2022). Regarding employment status, 84.04% (n=82) are students (Figure 2B).

With a qualitative consideration to measure criteria or perceptions in the surveys, it was found that 70.21% (n=66) of the people interviewed do like to practice birdwatching (Figure 2C). And that 6.38% (n=6) of the people interviewed do not want to have a guide on their visit to explain the birdlife of the JB-BUAP, while 93.62% (n=88) do want a guide

to obtain information. Opinion questions were also included to evaluate what value they give to the biodiversity present in the JB-BUAP, through a scale (Very low, Low, Medium, High, Very high). According to the answers obtained, 61.70% (n=58) of the interviewees rated the value of bird biodiversity present in the JB-BUAP as very high (Figure 2D).

These results point to the importance declared by visitors about bird biodiversity in the JB-BUAP, 97.87% of the people interviewed (92/94) rated bird biodiversity with a High and Very high value, and no opinions were found with Low or Very low values.

Another important piece of information that the survey yielded was the season (spring, summer, autumn, winter) when visitors have seen the greatest variety of bird species. A 45.74% (n=43) of the people have seen more birds in spring. However, in the monitoring tours that were made, the season in which the most bird species were identified was autumn (n=79), in that season 84.04% of the total species identified in the year was represented (Figure 3).

Data obtained in birdwatching sightings

A total of 101 species of birds were identified in the 10.8 ha of the botanical garden with the 47 tours. These species are taxonomically distributed in 12 orders and 36 families. Our data are higher than the 50 species reported by Universidad Autonoma Chapingo (UACh), in Texcoco de Mora, State of Mexico (Valencia-Trejo *et al.*, 2014). They also exceed the 67 species reported in Jardin Valladolid in Yucatán, Mexico (Guzmán-Canul & Sánchez-Soto, 2024). However, this species richness was lower than that reported for the entire area of Ciudad Universitaria of the BUAP, that is, 112 species (González, 2019). As well

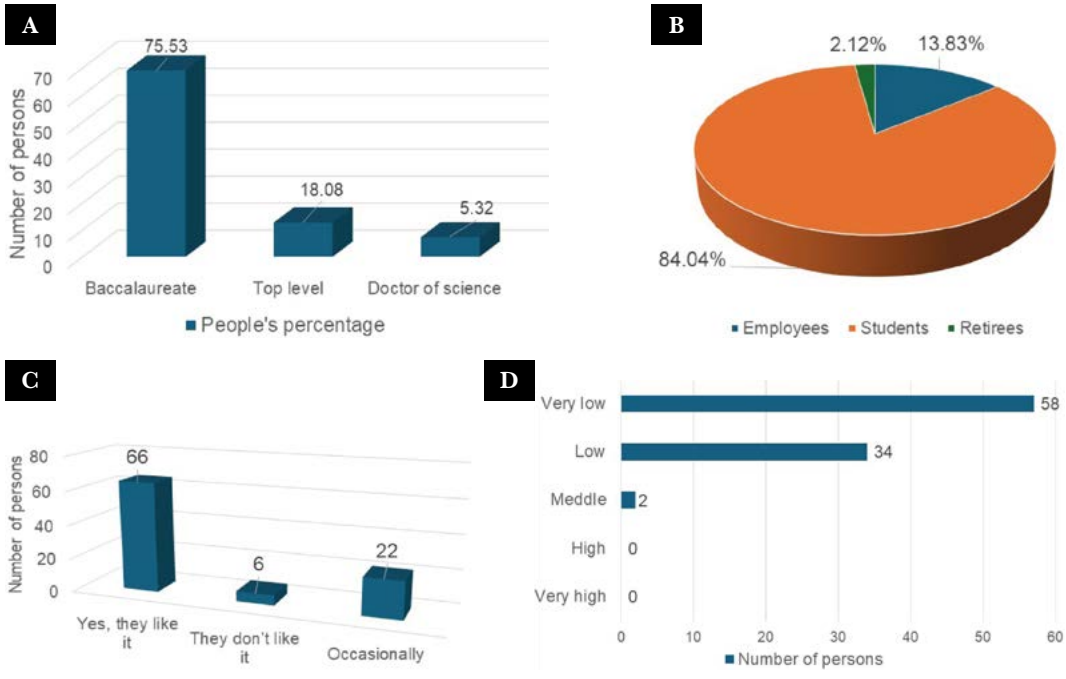

Figure 2. General characteristics of the interviewees A: level of schooling (%); B: employment status (%); C: like or dislike for birdwatching; and D: value given to bird biodiversity, in the botanical garden of the Benemerita Universidad Autonoma de Puebla (JB-BUAP).

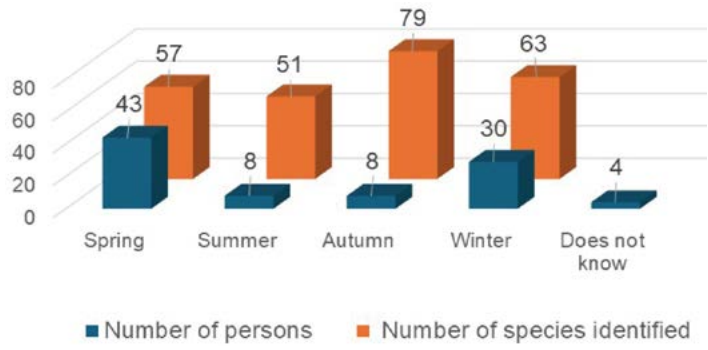

Figure 3. Number of people who observed more bird species in the different seasons of the year *vs.* species data records obtained by monitoring in the Botanical Garden of the Benemerita Universidad Autonoma de Puebla (JB-BUAP).

as, fewer than the 210 species reported for the entire municipality of Puebla (Camacho *et al.*, 2012) or than the total number of bird species reported (595) for the state of Puebla, according to a historical record of sightings (Mendoza *et al.*, 2012).

On the other hand, that value (101) is lower than that in the State Reserve of Palmar, Yucatán, which reported 104 species of birds in 47 931 ha (Chablé-Santos *et al.*, 2008). Another case is the Biosphere Reserve Tehuacan & Cuicatlan, between the states of Puebla and Oaxaca, with 113 species reported in 490 186 ha (Vázquez *et al.*, 2009). It is also lower compared to what was recorded in the Sierra de Cuatro Venados, Oaxaca, where 160 species were observed in 221 000 ha (Lavariega *et al.*, 2016).

On average, 23 species were recorded per tour and of the total species sighted, 18 are in categories of endemism (Table 1). In terms of seasonality, 58 species are resident, 37 are migratory and 6 are transitory. In addition, in regard to their status of endemism, 10 endemic species (E) were present, among which the Mexican duck (*Anas diazi*) (Figure 4A); the rufous-backed thrush (*Turdus rufopalliatus*) (Figure 4B); the dusky hummingbird (*Cynanthus sordidus*) (Figure 4C); the Boucard's wren (*Campylorhynchus jocosus*) (Figure 4D); and the Mexican chickadee (*Poecile sclateri*). As well as, 6 species of semi-endemic (SE) birds, among which are the Broad-billed hummingbird (*Cynanthus latirostris*) and the Cassin's kingbird (*Tyrannus vociferans*). It was also possible to identify 2 species of quasi-endemic birds (QE), these two species were the Russet-crowned motmot (*Momotus mexicanus*) (Figure 4E) and the Grey silky-flycatcher (*Ptiliogonys cinereus*) (Figure 4F).

These results differ from the data reported in the High Mountains region of Veracruz, Mexico by Alcántara-Salinas *et al.* (2020), as they reported 22 endemic species, 12 quasi-endemic, and 17 semi-endemic bird species. On the other hand, in terms of its protection status, it was observed that there is one threatened species that is the Mexican duck (*Anas diazi*) (Figure 4A) and three species that are subject to special protection, the Least grebe (*Tachybaptus dominicus*), the Peregrine falcon (*Falco peregrinus*) and the MacGillivray's warbler (*Geothlypis tolmiei*) (Mendoza *et al.*, 2012). This comparison is also inferior to what was reported for the High Mountains of Veracruz by those authors, who identified 57 species subject to special protection and 29 are threatened (Alcántara-Salinas *et al.*, 2020).

Table 1. Endemic (E), semi-endemic (SE), and quasi-endemic (QE) bird species of Mexico.

Taxonomic Order	Taxonomic Family	Common name	Scientific name	Endemism (status)*
Anseriformes	Anatidae	Mexican duck	*Anas diazi*	E
Apodiformes	Trochilidae	Dusky hummingbird	*Cynanthus sordidus*	SE
		Broad-billed hummingbird	*Cynanthus latirostris*	SE
		Violet-crowned hummingbird	*Amazilia violiceps*	SE
Coraciiformes	Mmomotidae	Russet-crowned motmot	*Momotus mexicanus*	QE
Passeriformes	Tyrannidae	Brown-crested flycatcher	*Myiarchus tyrannulus*	E
		Cassin's kingbird	*Tyrannus vociferans*	SE
	Turdidae	Blue-hooded euphonia	*Chlorophonia elegantissima*	E
		Rufous-backed thrush	*Turdus rufopalliatus*	E
	Parulidae	Black-throated gray warbler	*Setophaga nigrescens*	SE
		Golden-crowned warbler	*Basileuterus culicivorus*	E
	Paridae	Mexican chickadee	*Poecile sclateri*	E
	Troglodytidae	Stotz warbler	*Troglodytes solstitialis*	E
		Rufous-naped wren	*Campylorhynchus rufinucha*	E
		Boucard's wren	*Campylorhynchus jocosus*	E
	Ptiliogonatidae	Grey silky-flycatcher	*Ptiliogonys cinereus*	QE
	Passerellidae	Clay-colored sparrow	*Spizella pallida*	SE
	Icteridae	Scott's oriole	*Icterus parisorum*	se

*Endemism status of the species of Mexico: E: endemic; SE: semi-endemic; QE: quasi-endemic.

Figure 4. A) Mexican duck (*Anas diazi*). Photographer: Miguel Antonio Silveira Caminero. B) Rufous-backed thrush (*Turdus rufopalliatus*). Photographer: Oscar Agustín Villarreal Espino Barros. C) Dusky hummingbird (*Cynanthus sordidus*). Photographer: Miguel Antonio Silveira Caminero. D) Boucard's wren (*Campylorhynchus jocosus*). Photographer: Miguel Antonio Silveira Caminero. E) Russet-crowned motmot (*Momotus mexicanus*). Photographer: Miguel Antonio Silveira Caminero. F) Grey silky-flycatcher (*Ptiliogonys cinereus*). Photographer: Miguel Antonio Silveira Caminero.

As for the different seasons of the year, in spring-summer 74.19% (n=69) of the bird species visualized during a year were identified, which taxonomically belong to 12 orders and 31 families. On the other hand, in autumn-winter, 95.70% (n=89) of the total bird species identified in the year of travels were sighted, belonging to 12 orders and 33 families. This difference in the number of bird species is possibly due to migration in this seasons (autumn-winter).

Between 194 and 212 endemic bird species have been recorded in Mexico, representing 18-20% of the total species of our national territory (Navarro-Sigüenza *et al.*, 2014). This study at JB-BUAP reports 101 species of birds, which include 10 of the 17 endemic species identified in the municipality of Puebla (Mendoza *et al.*, 2012). The 101 species represent 58.8% of the endemic species observed in the region. This finding highlights the importance of the area for the conservation of the endemic birdlife of Mexico. The presence of these species is evidence of the great biological diversity of the region, and its relevance for the protection of these ecosystems. These results underscore the need to continue conservation efforts to protect both the endemic species and their natural habitat within the JB-BUAP.

Species and relative abundance

The bird species that are most abundant in the JB-BUAP are in the first place the Barn swallow (*Hirundo rustica*), the most observed in one day (94 individuals on September 14, 2024). Next one is the House finch or Mexican sparrow (*Haemorhous mexicanus*), with 72 individuals observed in one day (November 25, 2023). The Clay-colored sparrow (*Spizella pallida*) was represented by 58 individuals (20 April 2024); in fourth place is the Cinnamon-rumped seedeater (*Sporophila torqueola*) with 46 individuals on the same date (April 20, 2024). They are followed by the Mexican duck (*Anas diazi*), with a national label of 'threatened species', 40 individuals in one day (November 11, 2023) and the last most identified species was the Scarlet flycatcher or Austral vermillion flycatcher (*Pyrocephalus rubinus*) with 22 individuals sighted in one day (June 22, 2024). These data are essential for the temporality of the presence of birds in the JB-BUAP, which can contribute to conservation strategies and proper management of this important habitat for local birdlife.

Among the diversity of birds that have been meticulously identified, 6 outstanding species are characterized by their ability to adapt and colonize a wide range of habitats in different parts of the world. These cosmopolitan birds belong to 4 different orders and 6 families, embodying the ability of birds to conquer diverse and often very distant territories (Table 2).

These 6 cosmopolitan species exemplify the ability of birds to thrive in a variety of environments, from cities to rural areas and from temperate to tropical regions. This illustrates the amazing adaptability and biological diversity that characterizes birds around the world.

In terms of areas with specific status as Protected Natural Areas (in Mexico, ANP's), in the State Reserve of Palmar, Yucatán (47,931 ha); the Biosphere Reserve Tehuacan & Cuicatlan, Puebla-Oaxaca (490,186 ha), and in the Sierra de Cuatro Venados, Oaxaca (221,000 ha), there are of course more bird species due to their geographical surfaces. Although the JB-BUAP only has 10.8 ha (about 26.8 acres), 101 identified species were

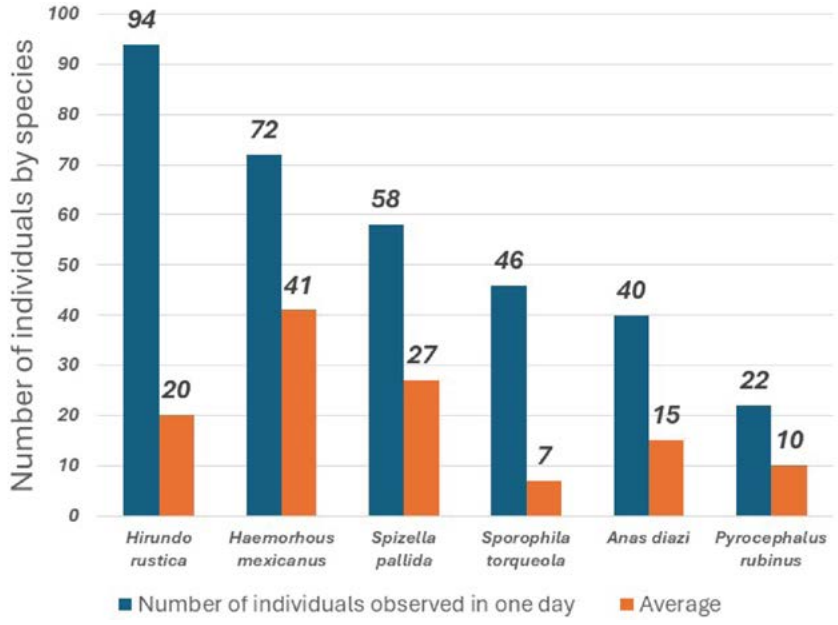

Figure 5. Bird species with the most individuals observed in a day *vs.* the average number of individuals observed by each species during a year, in the botanical garden of the Benemerita Universidad Autonoma de Puebla (JB-BUAP).

Table 2. Cosmopolitan bird species identified in the Botanical Garden of the Benemerita Universidad Autonoma de Puebla (JB-BUAP).

Taxonomic Order	Taxonomic Family	Common name	Scientific name
Columbiformes	Columbidae	Rock dove	*Columba livia*
Pelecaniformes	Ardeidae	Cattle egret	*Bubulcus ibis*
Accipitriformes	Pandionidae	Osprey or Fish hawk	*Pandion haliaetus*
Passeriformes	Sturnidae	Common starling	*Sturnus vulgaris*
	Passeridae	House sparrow	*Passer domesticus*
	Hirundinidae	Barn swallow	*Hirundo rustica*

found, of which 10 are endemic, 6 semi-endemic and 2 quasi-endemic. In addition to the successful sighting of a species classified as threatened according to NOM-059-SEMARNAT-2010 (SEMARNAT, 2010), the Mexican duck (*Anas diazi*). The urban character of this facility (JB-BUAP) highlights the importance of an area immersed in a metropolis, which preserves great diversity and endemism in visiting birds. This may be due to the botanical management of the site, as it created mini-habitats, which are preferred by visiting birds.

From an ecological perspective, the study promotes the conservation of species and the botanical garden functions as an environmental education space that, being located in an urban area, helps to conserve species from different regions of the state of Puebla and encourages knowledge and recreation related to birds in the metropolitan area of Puebla.

The study also seeks to consolidate the management of JB-BUAP as an agroecosystem in an urban environment that provides natural habitat for birds and strengthens their

conservation. As well as to declare this site as a formal tool for environmental education. An additional benefit in terms of administration management is the possibility of increasing the public interest in visiting the botanical garden. This would benefit the facilities and the employees, 20 people, including the director, a curator of scientific collections, as well as researchers, technicians specialized in areas such as conservation and *in vitro* plant production, and gardeners.

CONCLUSIONS

The visitors interviewed were mostly young people, with a high school diploma, as well as workers who highly value the biodiversity present in the JB-BUAP. Among the 101 species identified, 10 are endemic, 6 semi-endemic and 2 quasi-endemic; in addition to the successful sighting of a species classified as threatened, the Mexican duck (*Anas diazi*). This highlights the need for conservation efforts to protect endemic species and their habitat of choice in the botanical garden of the BUAP.

In autumn and winter, more species of birds were identified; this is a migratory seasonality and greater variety was found in sightings during this period. This is indicative of significant biological diversity and the relevance of the site studied. More than 90% of the people interviewed want a guide to explain about the birdlife of the JB-BUAP. This shows the relevance of trained guides, and informs about the interest of most visitors in obtaining professional information during their visit. The Botanical Garden of the Benemerita Universidad Autonoma de Puebla can be a formal site for conservation, and sustainable management and use for birdwatching and amateur photography.

REFERENCES

Alcántara-Salinas, G., Román-Hernández, D., Rivera-Hernández, J., Balderas-San Miguel, M. O., Vargas-Rueda, A., Neri-Fajardo, M. H., Real-Luna, N., Pérez-Sato, J.A., & Escalante-Pliego, P. (2020). La avifauna de la región de las Altas Montañas de Veracruz, México. *Agro productividad, 13*(6), 3-26.

Almaguer, G., Ayala, A. V., Sánchez, M., & Martínez, G. (2022). La Producción de maíz en Huamantla, Tlaxcala. https://doi.org/10.5154/r.textual.2021.80.06

Camacho Morales, M., Mena Reynoso, E., & Gómez Cortés, E. (2012). Avifauna del municipio de Puebla. Asociación Ornitológica Ambiental Huitzilcoatl A. C.

Chablé-Santos, J. B., González, R. J., Peña-Peniche, L. A., & Pasos-Enríquez, R. M. (2008). Bird diversity in the Petens of Yucatán state, México. *Ornitología Neotropical*. 19:55-70.

CONABIO-Comisión Nacional para el Conocimiento y Uso de la Biodiversidad. (2020). AVESMX: Red de Conocimiento sobre las Aves de México. CONABIO. http://avesmx.conabio.gob.mx.

Dunn, J. L., & Alfer, J. (2017). National Geographic; Field Guide to the Birds of North America. National Geographic, Washington, D. C. Seven edition: 591 p.

Gelder, K. (2007). Subcultures: cultural histories and social practice. Routledge. New York; pp: 1-17.

González Oreja, J. A. (2019). Las aves de la BUAP: Una invitación a su conocimiento; pp: 11-25.

Guzmán-Canul, A. R., & Sánchez-Soto, S. (2024). Avifauna associated to a home garden in Valladolid, Yucatán, México. *Agro Productividad*. https://doi.org/10.32854/ agrop.v17i9.2795

Hernández Sampieri, R., Fernández, C., & Baptista, M. (2010). Metodología de la investigación (5ª edición); pp 170-194.

Hernández Xolocotzi, E. (1977). Agroecosistemas de México: contribuciones a la enseñanza, la investigación y la divulgación agrícola. Colegio de Posgraduados, México.

INEGI-Instituto Nacional de Estadística y Geografía. (2020). Continuo Nacional del Conjunto de Datos Geográficos de la Carta de Climas Escala 1:1 000 000, serie I.

INEGI-Instituto Nacional de Estadística y Geografía. (2021). Censo de población y vivienda. INEGI. https://www.inegi.org.mx/

Jardín Botánico BUAP (2025). El jardín botánico de la Benemérita Universidad Autónoma de Puebla. https://jardinbotanico.buap.mx/

Lavariega, M. C., Martín-Regalado, N., Gómez-Ugalde, R. M., & Aragón, J. (2016). Avifauna de la Sierra de Cuatro Venados, Oaxaca, México. Huitzil, *Revista Mexicana de Ornitología 17*(2):198-214.

MacKinnon, B. (2005). Birds in the Mayan culture/ Las aves en la cultura maya (pp: 43-44). In: B. Mackinnon (comp.). Birds & reserves of the Yucatán Península. Amigos de Sian Ka'an A.C. Mérida, Yucatán.

Méndez Ramírez, I. (1996). El protocolo de investigación: lineamientos para su elaboración y análisis.

Mendoza Cuamatzi, R., Rose-Burney, J., Jiménez, F. J., Escobar, V., & Pineda, M. A. (2012). Las aves del municipio de Puebla, pp 13-20.

Navarro-Sigüenza, A., Rebón-Gallardo, M., Gordillo-Martínez, A., Peterson, A., Berlanga-García, H., & Sánchez-González, L. (2014). Biodiversidad de aves en México. *Revista Mexicana de Biodiversidad*, Supl. 85: S476-S495.

Plenge, M. (2017). Lista de las aves de Perú. Boletín de la Unión de Ornitólogos del Perú. https://sites.google.com/site/boletinunop/checklist

SEP-Secretaría de Educación Pública. (2022). Dirección General de Planeación, Programación y Estadística Educativa. https://www.planeacion.sep.gob.mx/

SEMARNAT-Secretaría de Medio Ambiente y Recursos Naturales. (2010). Norma Oficial Mexicana NOM-059-ECOL-2010. Protección ambiental-Especies nativas de México de flora y fauna silvestres-Categorías de riesgo y especificaciones para su inclusión, exclusión o cambio-Lista de especies en riesgo. Diario Oficial de la Federación, 30 de diciembre de 2010, México, Ciudad México, pp: 1-78.

Valencia-Trejo, G.M., Ugalde-Lezama, S., Pineda-Pérez, F.E., Tarango-Arámbula, Lozano-Osornio, A., & Cruz-Miranda, Y. (2014). Diversidad de aves en el campus central de la Universidad Autónoma Chapingo, México. *Agro Productividad 7*(5):37-44.

Vázquez, L., Moya, H., & Arizmendi, M. (2009). Avifauna de la selva baja caducifolia en la cañada del río Sabino, Oaxaca. *Revista Mexicana de Biodiversidad*. 80:535-549.