UNIVERSIDAD DE GUADALAJARA

Centro Universitario de Ciencias Biológicas y Agropecuarias

Variación espacio-temporal de la comunidad de aves y sitios de anidación en tres parques urbanos de Guadalajara, Jalisco, México

Tesis
que para obtener el grado de

Maestro en Ciencias en Biosistemática y Manejo de Recursos Naturales y Agrícolas

Presenta
Kirey Aurora Barragán Farías

Zapopan, Jalisco **Enero de 2019**

UNIVERSIDAD DE GUADALAJARA

Centro Universitario de Ciencias Biológicas y Agropecuarias

Variación espacio-temporal de la comunidad de aves y sitios de anidación en tres parques urbanos de Guadalajara, Jalisco, México

Tesis
que para obtener el grado de

Maestro en Ciencias en Biosistemática y Manejo de Recursos Naturales y Agrícolas

Presenta

Kirey Aurora Barragán Farías

Director

Aarón Rodríguez Contreras

Co-director

Francisco Javier Padilla Ramírez

Zapopan, Jalisco

Enero de 2019

UNIVERSIDAD DE GUADALAJARA

Centro Universitario de Ciencias Biológicas y Agropecuarias

Variación espacio-temporal de la comunidad de aves y sitios de anidación en tres parques urbanos de Guadalajara, Jalisco, México

Por

Kirey Aurora Barragán Farías

Maestría en Ciencias en Biosistemática y Manejo de Recursos Naturales y Agrícolas

Aprobado por:

Aarón Rodríguez — Dic 19, 2018

Dr. Aarón Rodríguez Contreras — **Fecha**
Director de Tesis e integrante del jurado

12-DIC-2018

Dr. Francisco Javier Padilla Ramírez — **Fecha**
Asesor del Comité Particular e integrante del jurado

Verónica Rosas — 12-DIC-2018

M.C. Verónica Carolina Rosas Espinoza — **Fecha**
Asesor del Comité Particular e integrante del jurado

Miguel Vásquez Bolaños — 18 diciembre 2018

Dr. Miguel Vásquez Bolaños — **Fecha**
Sinodal e integrante del jurado

19/dic/2018

Dr. José Luís Navarrete Heredia — **Fecha**
Sinodal e integrante del jurado

Agradecimientos

Quiero agradecer a mis padres y a mis hermanas, ya que ellos son el centro de mi universo, y sin ellos no sería quien soy. Gracias por siempre apoyarme y echarme porras. A Alejandra Galindo por apoyarme, ayudarme a aclarar mis ideas, y ser la mejor compañera tanto de casa como para salir a pajarear. A Arturo Galindo, por alentarme durante el proceso.

A Verónica Rosas, que desde hace años ha estado conmigo y me ha enseñado a ser una buena bióloga. Gracias a ella descubrí mi amor por las aves, y me ha acompañado en esta aventura, sin ella no lo habría logrado. A Aarón Contreras por aceptarme como estudiante a pesar de no trabajar con plantas y ayudarme a lograr mi propósito. A Javier Padilla por su ayuda y consejos. A Miguel Vásquez, José Luis Navarrete y Ana Luisa Santiago por sus correcciones y comentarios, así como por apoyarme a lograr mi objetivo.

A Patricia Zarazúa por su buen desempeño como coordinadora del programa de Maestría en Ciencias en Biosistemática y Manejo de Recursos Naturales y Agrícolas (BIMARENA) y a Yuri, por su apoya. A Jorge García, Ismael Sotelo, Jesús Cinco y Cristián de la Torre de Bosque Los Colomos; a Jorge Villaseñor, Manuel Corona, Ana María González, Denys Bautista y a los Guardaparques del Parque Metropolitano; a José Velázquez, a Felipe Lozano y a los trabajadores del Parque de la Solidaridad, por concederme el permiso de realizar mi trabajo de campo en los parques y por el apoyo para concluir mis actividades. Agradezco al Consejo Nacional de Ciencia y Tecnología (CONACYT) por la beca número 779555.

A Athziri Pérez por levantarse temprano e ir conmigo a recorrer los parques y hacerme plática. A Adhaly, Mariano, Andrea, Paulina, Ruth, Rosa y todos los demás alumnos que me acompañaron en los muestreos. A Ray y Rosana por sus correcciones al inglés. A todos mis familiares que siempre me apoyan y me quieren; sus palabras de aliento me ayudaron para poder terminar este documento. Y a la cafeína, por ayudarme a terminar.

¡Muchas gracias!

Índice

Índice de tablas

Índice de figuras

Capítulo I

Introducción

Introducción

Las aves (Neornithes) son los vertebrados terrestres más numerosos del mundo. Más de 10,500 especies habitan la Tierra (Gill y Donsker, 2018). Se distinguen por sus llamativos colores, cantos y su capacidad de vuelo. Esto último las ha llevado a conquistar desde selvas, bosques, desiertos y tundras, hasta costas e islas oceánicas. Si bien hay aves no voladoras como los pingüinos o los avestruces, esto solo reafirma su variedad de formas, tamaños y colores. Cada especie de ave presenta adaptaciones en su pico, patas y cuerpo para sobrevivir en distintos hábitats y conseguir una amplia variedad de alimentos (Enríquez et al., 2010; Perrins, 2005).

Las aves cumplen un papel importante en los ecosistemas. Son controladoras de las poblaciones de insectos, roedores, conejos, lagartijas y serpientes. Fungen como polinizadoras y dispersoras de semillas (Berlanga et al., 2010). Además han servido de alimento, de vestido, como símbolos religiosos o mágicos, de mascotas, medicina o adornos, incluso se encuentran inmersas en nuestra cultura, pudiendo encontrar vestigios de su importancia en las culturas prehispánicas (Navarro y Sánchez González, 2003).

México tiene el onceavo lugar de riqueza de aves entre los países megadiversos del mundo (Navarro y Sánchez González, 2013; BirdLife International, 2018a). De las aproximadamente 10,672 especies de aves (Gill y Donsker, 2018), entre 1,119 y 1,146 (BirdLife International, 2018a; LePage, 2018), cerca del 11% del total mundial, habitan en el país. En Jalisco se han registrado 565 especies, que representan cerca de la mitad, lo que lo posiciona en el 7° lugar a nivel nacional (Navarro y Sánchez-González, 2003; Santana et al., 2017).

Actualmente, las poblaciones de aves experimentan un declive por la pérdida de sus hábitats a lo largo y ancho del país ocasionado por el continuo crecimiento de la población humana y el cambio climático. (BirdLife International, 2018b). Estos disturbios afectan la calidad, la selección de hábitat y disponibilidad de alimento a escala local hasta la regional. Su presencia en los ecosistemas está estrechamente relacionada con la condición de sus hábitats, pues muchas son sensibles a cambios mínimos en ellos (Brawn et al., 2001; Taylor et al., 2013). Los efectos negativos de la pérdida de hábitat en la fauna, se reflejan en la riqueza, abundancia, distribución, diversidad genética, la tasa de crecimiento de la población e interacciones intraespecíficas (Fahrig, 2003). Existen evidencias que la reducción del tamaño de una población ocurre en áreas donde hay pérdida de hábitat (Fahrig, 2003).

La urbanización transforma territorios silvestres en tierras con algún grado de presencia humana, esto se debe al aumento de la población, así como la migración de lo rural a lo urbano, dejando atrás los hábitats silvestres y sus necesidades (Marzluff et al., 2001). El Área Metropolitana de Guadalajara (AMG), incluye los municipios de Guadalajara, Zapopan, San Pedro Tlaquepaque, Tonalá, Tlajomulco de Zúñiga, El Salto, Juanacatlán, Ixtlahuacán de los Membrillos y Zapotlanejo. Entre 1980 y 2015 el AMG duplicó su población al pasar de 2,371,278 a 4,865,122 de habitantes, con un incremento del 105%. Durante ese mismo período el área de la AMG aumentó de 22,329 a 69,250 ha, con lo cual estuvo cerca de triplicar su superficie urbanizada (IMEPLAN, 2016). Esta alta densidad ha impulsado la creación de mayores desarrollos inmobiliarios dejando espacios reducidos y poco ideales para la fauna como bordes de carreteras, cementerios o plazas (Sulaiman, 2013).

La pérdida de hábitat es la amenaza directa más importante para la biodiversidad de aves (Brawn et al., 2001; Sulaiman, 2013). La riqueza de especies y su abundancia depende de la biología de las especies, su sensibilidad al disturbio, el tamaño del área, la estructura de la vegetación, el aislamiento y el disturbio humano, así como los usos históricos del área (Carbó-Ramírez y Zuria, 2011; MacGregor-Fors et al., 2016). La urbanización favorece solamente a unas pocas especies, las cuales logran adaptarse al ambiente urbano y resultan "ganadoras", ejemplo de ellos son la Paloma Doméstica (*Columba livia*), el Zanate Mayor (*Quiscalus mexicanus*) y el Gorrión Doméstico (*Passer domesticus*). Sin embargo, perjudica a la mayor parte de las aves nativas, las que evitan lo urbano y resultan "perdedoras", por ejemplo el Carpintero Bellotero (*Melanerpes formicivorus*) o el Azulejo Garganta Canela (*Sialia sialis*). Con base en su respuesta a la urbanización, se pueden distinguir tres categorías: (1) especies que logran adaptarse a utilizar los recursos presentes en las ciudades, logrando mayores densidades en áreas urbanizadas; (2) especies que son capaces de explotar algunos de estos recursos y (3) especies sensibles a la urbanización, por lo que sería más fácil encontrarlas en sus ambientes naturales (González-Oreja y Buzo, 2007).

La riqueza de especies, es decir ¿cuáles son?, es usualmente más baja en áreas urbanas que en el hábitat natural alrededor de estas. En contraste, la densidad, es decir ¿cuántas hay?, es más alta en la urbe (Reale y Blair, 2005; Chace y Walsh, 2006; González-Oreja y Buzo 2007; MacGregor-Fors 2008). Por ejemplo la Paloma Doméstica (*Columba livia)* y el Gorrión Doméstico (*Passer domesticus*) son especies europeas que han logrado adaptarse y reproducirse ampliamente en las condiciones de la ciudad; de hecho estas aves son especies que no solo explotan lo urbano sino que se han vuelto dependientes de los recursos que los humanos proveen (Chace y Walsh, 2006; Seress y Liker, 2015; Escobar-Ibáñez y MacGregor-Fors, 2016).

La urbanización afecta la anidación de las aves. La poca cobertura disminuye la presencia de sitios ideales e incrementa la competencia por los mismos. La anidación en sitios poco óptimos aumenta la posibilidad de que un depredador encuentre y ataque el nido. También existe la posibilidad de que otras aves lo parasiten o que huevos y nidos sean destruidos por otras especies. Como resultado se reduce el éxito reproductivo (Reale y Blair, 2005; White et al., 2005; López-Flores et al., 2009). Por ejemplo, algunas aves dependen de cavidades en los árboles para su reproducción. Estas aves tienen preferencia por árboles o sustratos con características específicas de altura, tamaño, edad, condición o especie, pero la disponibilidad de sitos para la construcción de cavidades está disminuyendo de manera alarmante debido a la deforestación, la degradación de áreas naturales y la urbanización (Íñigo-Elías y Enkerlin-Hoeflich, 2001; Acosta-Pérez et al., 2013).

Otro factor es la muerte de aves causada directamente por actividades humanas. Las más frecuentes son colisiones con vehículos y edificios, envenenamiento, depredación por gatos, y muerte por electrocución. Se estima que en promedio 600,000 individuos al año mueren en Estados Unidos por colisiones con edificios y hasta 2,400,000 por ataques de gatos (Loss, 2015).

La afectación en las poblaciones de aves altera su función ecológica. Las que se alimentan de néctar (los colibríes) son importantes en procesos de polinización para varias plantas y las que se alimentan de frutas ayudan al ecosistema diseminando semillas, mejorando la germinación y ayudan a restaurar o revegetar áreas perturbadas y a incrementar la vegetación (Sulaiman, 2013).

Dentro del área urbana existen diferentes espacios verdes (Lepczyk et al., 2017). Se ha visto que jardines, canchas deportivas, parques, bosques urbanos, campos de golf, y derechos de vía albergan más biodiversidad que las áreas con más desarrollo comercial o industrial (MacGregor et al., 2016). Los parques urbanos conservan algo de la biodiversidad original, funcionan como corredores, sirven como sitios de paso durante la migración de algunas especies y ofrecen alimento (Sandström et al., 2006; Ramírez-Albores, 2008; Carbó-Ramírez y Zuria, 2011). El parque urbano es un espacio abierto de uso público y mejorar la calidad de sus componentes. Los parques expresan una relación sociedad-naturaleza. Por un lado, se rigen por leyes de carácter biológico, y tienen una función ecológica. Por otra parte, tienen una función social; ayudan a los habitantes a relajarse del estrés del ambiente urbano, y facilitan actividades como caminar y correr (Anaya Corona, 2001). Además de albergar plantas y animales, los parques purifican el aire y el agua, filtran el ruido y el viento, y crean microclimas (Chiesura, 2003). Son espacios ideales para preservar la naturaleza en un contexto muy transformado, como lo son las ciudades. (Anaya Corona, 2001; Sulaiman, 2013).

La vegetación es la características del hábitat que más afecta a las aves (MacGregor-Fors y Schondube, 2011). Mantener y mejorar la vegetación nativa ayuda a conservar y a atraer más aves (Sulaiman, 2013). Otras características que buscan las aves incluyen la disponibilidad de alimento, un menor riesgo de depredación y la disponibilidad de sitios para anidar (Brawn et al., 2001). Por lo tanto, es importante conocer cómo las características de los parques urbanos afectan la comunidad de aves. Por lo anteriormente mencionado, los objetivos del presente trabajo son 1) Determinar el efecto de las características del sitio y del paisaje en la comunidad de aves y 2) Conocer las características de los sitios de anidación de aves en parques urbanos. La información permitirá crear estrategias de manejo y conservación.

Literatura citada

Acosta-Pérez, V., Zuria, I., Castellanos, I. y Moreno, C. 2013. Características de las cavidades y sustratos de anidación utilizados por el carpintero mexicano (*Picoides scalaris*) en dos localidades del centro de México. Ornitología Neotropical 24, 107-111.

Anaya Corona, M. 2001. Los parques urbanos y su panorama en la Zona Metropolitana de Guadalajara. Revista Vinculación y Ciencia 9, 4-16.

Berlanga, H., J. A. Kennedy, T. D. Rich, M. C. Arizmendi, C. J. Beardmore, P. J. Blancher, G. S. Butcher, A. R. Couturier, A. A. Dayer, D. W. Demarest, W. E. Easton, M. Gustafson, E. Íñigo-Elías, E. A. Krebs, A. O. Panjabi, V. Rodríguez-Contreras, K. V. Rosenberg, J. M. Ruth, E. Santana-Castellón, R. M. Vidal y T. Will. 2010. Conservando a nuestras aves compartidas: la visión trinacional de Compañeros en Vuelo para la conservación de las aves terrestres. Ithaca: Cornell Laboratory of Ornithology.

BirdLife International. 2018a. BirdLife International. Obtenido de http://www.birdlife.org/

BirdLife International. 2018b. State of the world's birds: taking the pulse of the planet. Cambridge: BirdLife International.

Brawn, J.D., Robinson, S. K. y Thompson III, Frank R. 2001. The role of disturbance in the ecology and conservation of birds. Annual Review of Ecology and Systematics 32, 251-76.

Carbó-Ramírez, P., y Zuria, I. 2011. The value of small urban greenspaces for birds in a Mexican city. Landscape and Urban Planning 100(3), 213-222.

Chace, J. F., y Walsh, J. J. 2006. Urban effects on native avifauna: A review. Landscape and Urban Planning 74(1), 46-69.

Chiesura, A. 2003. The role of urban parks for the sustainable city. Landscape and Urban Planning 68,129-138.

Enríquez Rocha, P. L., Rangel-Salazar, J L. y Sánti López, E. C. 2010. Vuelo, color y canto. Actividades ambientales para el conocimiento de las aves. Chiapas: El Colegio de la Frontera Sur.

Escobar-Ibáñez, J. F., y MacGregor-Fors, I. 2016. Peeking into the past to plan the future: Assessing bird species richness in a Neotropical city. Urban Ecosystems 19(2), 657-667.

Fahrig, L. 2003. Effects of habitat fragmentation on biodiversity. Annual Review of Ecology, Evolution and Systematics 34, 487-515.

Gill, F y Donsker, D. 2018. IOC World Bird List (v 8.2). Obtenido de http://www.worldbirdnames.org

González-Oreja, J. A. y Buzo, D. 2007. Caracterización ecológica de la avifauna de los parques urbanos de la Ciudad de Puebla (México). Ardeola 54(1), 53-67.

Instituto Metropolitano de Planeación IMEPLAN 2016. Plan de ordenamiento territorial metropolitano del Área Metropolitana de Guadalajara. Jalisco: IMEPLAN.

Íñigo-Elías, E. E. y Enkerlin-Hoeflich, E. C. 2003. Amenazas, estrategias e instrumentos para la conservación de las aves. En H. Gómez de Silva y A. Olivares (Eds.) Conservación de Aves. Experiencias en México (pp 24-85) México: CIPAMEX- National Fish and Wildlife Foundation-CONABIO.

LePage, D. 2018. Avibase. Obtenido de https://avibase.bsc-eoc.org/avibase.jsp

Lepczyk, C. A., Aronson, M. F., Evan, K. L., Goddard, M. A., Lerman, S. B. y MacIvor, J. S. 2017. Biodiversity in the city: fundamental questions for understanding the ecology of urban green spaces for biodiversity conservation. BioScience 67, 799-807.

López-Flores, V., MacGregor-Fors, I. y Schondube, J. E. 2009. Artificial nest predation along a Neotropical urban gradient. Landscape and Urban Planning 92, 90-95.

Loss, S. R., Will, T. y Marra, P. P. 2015. Direct mortality of birds from anthropogenic causes. Annual Review of Ecology, Evolution, and Systematics 46, 99-120.

MacGregor-Fors, I. 2008. Relation between habitat attributes and bird richness in a western Mexico suburb. Landscape and Urban Planning 84(1), 92-98.

MacGregor-Fors, I. y Schondube, J. E. 2011. Gray vs. green urbanization: Relative importance of urban features for urban birds communities. Basic and Applied Ecology 12, 372-381.

MacGregor-Fors, I., Escobar, F., Rueda-Hernández, R., Avendaño-Reyes, S., Baena, M. L., Bandala, V. M. y Utrera-Barrillas, E. 2016. City “green” contributions: The role of urban greenspaces as reservoirs for biodiversity. Forests 7(7), 1-14.

Marzluff, J. M., Bowman. R. y Donnely, R. 2001. Ahistorical perspective on urban bird research: trends, terms and approaches. En J. M. Marzluff, R. Bowman y R.

Donnely (Eds.). Avian Conservation and Ecology in an Urbanizing World. (pp. 1-17) Boston: Kluwer Academic.

Navarro, A. G. y Sánchez-González, L. A. 2003. La diversidad de las aves. En H. Gómez de Silva y A. Olivares (Eds.) Conservación de Aves. Experiencias en México (pp. 24-85) México: CIPAMEX National Fish and Wildlife Foundation-CONABIO.

Perrins, C. 2005. La Gran Enciclopedia de las Aves. España: LIBSA.

Ramírez-Albores, J. E. 2008. Comunidad de aves de la Facultad de Estudios Superiores Zaragoza Campus II, UNAM, Ciudad de México. Huitzil Revista de Ornitología Mexicana 9(2), 12-19.

Reale, J. A., y Blair, R. B. 2005. Nesting success and life-history attributes of bird communities along an urbanization gradient. Urban Habitats 3(1), 1-24.

Sandström, U. G., Angelstam, P., y Mikusinski, G. 2006. Ecological diversity of birds in relation to the structure of urban green space. Landscape and Urban Planning 77, 39-53.

Santana C., E., Rodríguez-Parga, L. M., Contreras-Martínez, S., Verdugo-Munguía, H., Hernández-Vázquez, S., Reyna-Bustos, O., Vega Rivera, J. H., Renton, K., Schondube, J. E., Langle, A., Martínez-Martínez, E. E., García Ruvalcaba, S., Iñigo Elías, E., Rodríguez-Durán J. A. y Zermeño-Núñez, F. R. 2017. Aves. En: La biodiversidad en Jalisco. Estudio de Estado. vol. II (pp.309-325) México: CONABIO

Seress, G., y Liker, A. 2015. Habitat urbanization and its effects on birds. Acta Zoologica Academiae Scientiarum Hungaricae 61(4), 373–408.

Sulaiman, S., Nik Hanita, N. M. e Idilfriti, S. 2013. Contribution of vegetation in urban parks as habitat for selective bird community. Procedia. Social and Behavioral Sciences 85, 267-281.

Taylor, L., Taylor, C. y Davis, A. 2013. The impact of urbanization on avian species: The inextricable link between people and birds. Urban Ecosystem 16: 481-498.

White, T. H, Abreu-González, W., Toledo-González, M. y Torres-Báez, P. 2005. From the field: artificial cavities for Amazona parrots. Wildlife Society Bulletin 33(2), 756-760.

Capítulo II

Spatial and temporal variation in bird community in three different urban parks, Guadalajara, Jalisco, México

Spatial and temporal variation in bird community in three different urban parks, Guadalajara, Jalisco, Mexico

Kirey Aurora BARRAGÁN-FARÍAS[1,a], Aarón RODRÍGUEZ-CONTRERAS[1,b], Ana Luisa SANTIAGO-PÉREZ[1,c], Verónica Carolina ROSAS-ESPINOZA[1,d*]

[1] Universidad de Guadalajara, Centro Universitario de Ciencias Biológicas y Agropecuarias.

[a] kirey.barragan@alumnos.udg.mx,[b] aaron.rodriguez@cucba.udg.mx, [c]ana.santiago@academicos.udg.mx, [d*]veronica.rosas@academicos.udg.mx

*Camino Ramón Padilla Sánchez No. 2100 Nextipac, Zapopan, Jalisco, 45110, México.

Abstract

Urbanization transforms wildlands into man-made systems. Within the urban landscape, urban green areas represent the last remnants of greenery within large city boundaries. However, urban green areas, offer food and refugee to different bird species. Birds play an important ecological role as pollinators, predators and seed dispersers, but our understanding of the processes that determine how bird communities respond to urbanization is still basic. Urban parks differ in surface area, topography and vegetation structure, so, we analyzed how bird communities differed in space and time in three urban parks in the Guadalajara Metropolitan Area. The results show that site and landscape variables explained bird community's diversity. The strongest relationship was the distance to the nearest Natural Protected Area. But the presence of most of the species was related to tree and shrub species and abundance. Guadalajara Metropolitan Area parks showed to be different in their characteristics, making it a place with a wide array of resources available to the bird community.

Keywords: Urban Park; Adjacent landscape; Human disturbance; Urbanization; RDA.

Introduction

Urbanization is the process of human settlement that transforms uninhabited wildlands into man-made systems. The rapid increase of urbanization is results from the human population growth and migration from rural to urban environments (Marzluff, Bowman & Donnelly, 2001; Ortega-Álvarez & MacGregor-Fors, 2009). Urbanization is one of the major causes of regional landscape changes and represents a significant threat to local and global biodiversity (Clergeau, Croci, Jokimäki, Kaisanlahti-Jokimäki & Dinetti, 2006). The replacement, loss or modification of natural habitats decreases the presence of native species and increases exotic ones; which could lead to a biotic homogenization (Aronson et al, 2014; Blair, 2001; Clergeau et al, 2006; Marzluff et al, 2001; Taylor, Taylor & Davis, 2013).

Within large city boundaries, gardens, sport fields, parks, urban forests, preserves, golf courses, rights-of-way and cemeteries represent the last greenery remnants (MacGregor-Fors et al, 2016). Urban green areas support the ecological integrity of cities, but also protect the health of the animal urban population. They filter air, remove pollution, attenuate noise, cool temperatures, and replenish groundwater (Wolch, Byrne & Newell, 2014). Moreover, urban green areas provide food and shelter to preserve some of the original biodiversity and they are habitat for a higher biodiversity than heavily developed land (Carbó-Ramírez & Zuria, 2011; González-Oreja, de la Fuente-Díaz-Ordaz, Hernández-Santin, Bonache-Regidor & Buzo-Franco, 2012; MacGregor-Fors & Escobar, et al, 2016; MacGregor-Fors & Ortega-Álvarez, 2011). Among the urban wildlife, birds are the richest and most conspicuous group (Blair, 1999).

In response to urbanization bird species richness and evenness decrease and total bird density increases (Chace & Walsh, 2006; Marzluff et al, 2001). The size and diversity of bird communities to depend on city size, greenspace size, vegetation structure, distance from human structures, and human disturbance (Aronson et al, 2014; Carbó-Ramirez & Zuria, 2011; Clergeau et al, 2006; Donnely & Marzluff, 2004; MacGregor-Fors et al, 2016). Not all the bird species respond the same to urbanization, some species are commonly found in urban environment (Blair, 2001) but other are susceptible to landscape-level changes such as habitat fragmentation (Blair, 1999).

In addition to the biology of species and their sensitivity to human disturbance, historical uses, availability and type of habitat structure are factors that intervene in the richness and abundance of species (Carbó-Ramírez & Zuria, 2011; MacGregor-Fors et al., 2016). Bird respond in different ways to habitat changes and three main groups are recognized: urban exploiters exploit urban areas and their densities are higher in developed locations. Suburban adaptable, they are capable of using the additional resources that urbanization may bring. Lastly, urban avoiders are sensitive to human impacts and reach their highest densities in natural sites (Blair 1996, 2001; Chace & Walsh, 2006).

Mexico is one of the countries with larger human population in the world (UN, 2017). Guadalajara Metropolitan Area (GMA) is the second largest urban area. The GMA comprises the counties of El Salto, Guadalajara, Ixtlahuacán de los Membrillos, Juanacatlán, San Pedro Tlaquepaque, Tlajomulco de Zúñiga, Tonalá, Zapotlanejo and Zapopan. It covers 3,265.46 km^2. Finally, the GMA houses more than 4.4 million human inhabitants (IMEPLAN, 2016).). In a total area of 699.7 km^2 comprised in seven of the nine municipalities of the GMA of the conurbated zone (except Ixtlahuacán de los Membrillos and Zapotlanejo), it was evaluated that 42% of the surface is covered by green areas, however, the trees represent only 25% (IIEG & FIPRODEFO, 2018).

We analyzed the avian community structure variation in space and time related to different landscape and site characteristics in three urban parks within the urban matrix of GMA. The urban parks are located in different places of the metropolitan area and have different management practices and show different habitat structure. So we expect to find different bird species in each one. Also, we expect the bird community in each park to respond differently.

Methods

Study area

The GMA is located in western Mexico (22°45'01", 18°55'33" N; and 101°30'38", 105°41'43" W.). The mean elevation is1570m. It is limited by Natural Protected Areas (NPA): Área de Protección de Flora y Fauna La Primavera (APFFLP) on the west and Formación Natural de Interés Estatal Barrancas de los Ríos Santiago y Verde (FNIEBRSV) at the northeast, creating a barrier for human settlement (Fig. 1).

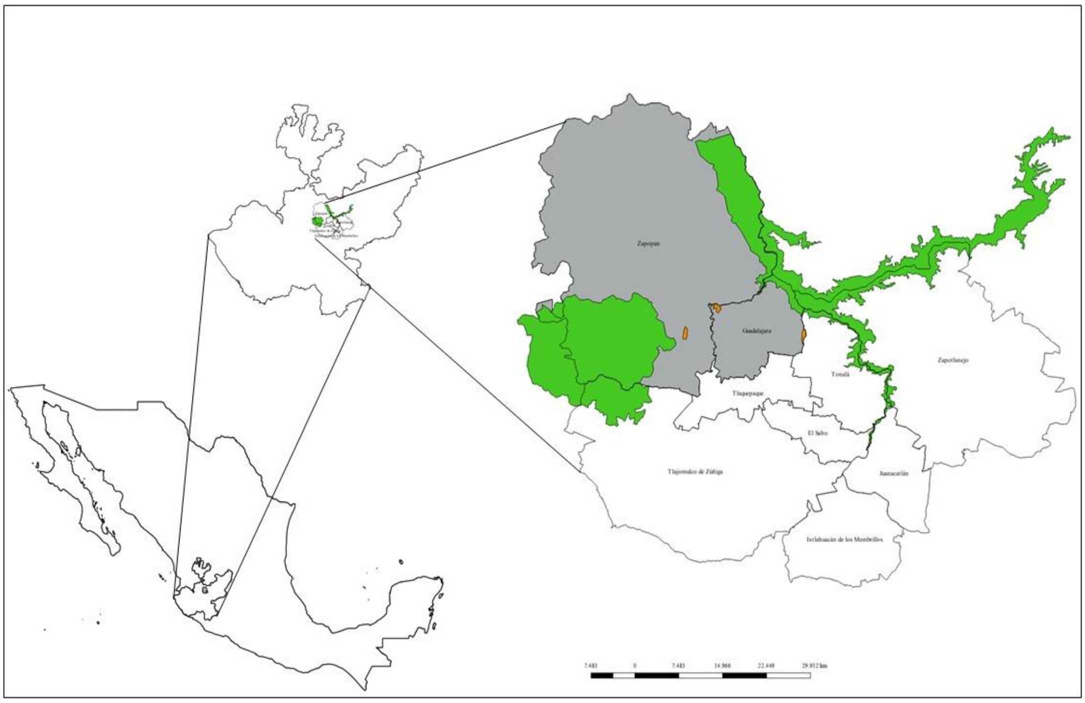

Fig 1. Location of the Guadalajara Metropolitan Area. Zapopan and Guadalajara municipalities are in gray. The Área de Protección de Flora y Fauna La Primavera, at the west and Formación Natural de Interés Estatal Barrancas de los Ríos Santiago y Verde at the northeast are highlighted in green.

This study was conducted in the northwestern part of the GMA (Guadalajara and Zapopan municipalities) (Fig. 1).We considered the three largest parks: Bosque Los Colomos (COL), Parque Metropolitano de Guadalajara (MET) and Parque de la Solidaridad (SOL) (Fig. 2). They vary in vegetation structure and composition as water source and quantity. COL is 92 ha. It has areas of pine forest and riparian vegetation; both mixed with exotic species such as *Eucalyptus* and *Casuarina* species (Guerrero-Nuño, 2009).

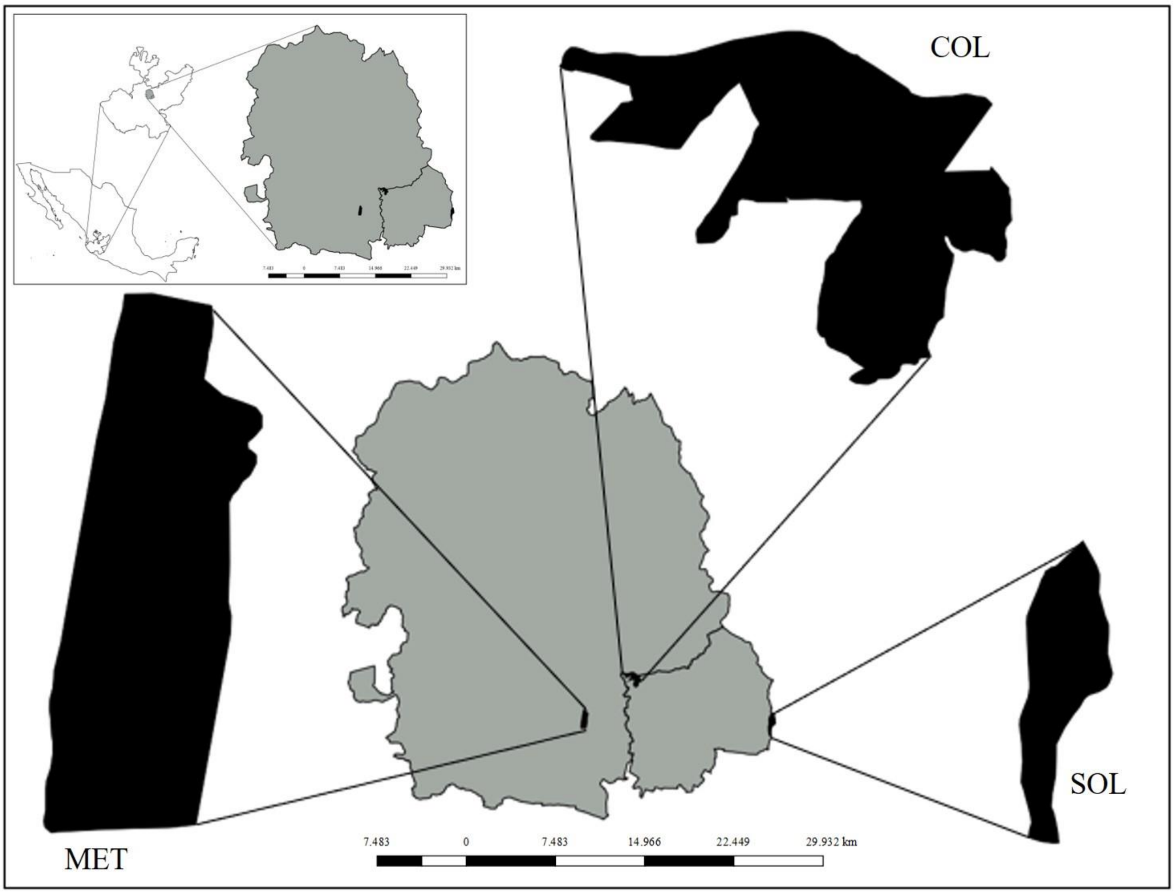

Fig 2. Location of the northwestern section of Guadalajara Metropolitan Area and the three urban parks where the study was conducted. COL= Bosque Los Colomos, MET= Parque Metropolitano, SOL= Parque de la Solidaridad.

The park has a natural small stream surrounded by riparian vegetation and two artificial lakes, with no aquatic vegetation inside or surrounding them. MET is 108 ha. It has open area of grass with a 35% tree cover, of native and exotic species, distributed all over the park (Larios, 2012). The park has an artificial lake surrounded by grass and with some aquatic vegetation. SOL is 110ha long, and has two parts. The small one is an open area with scarce trees. In contrast, the other half has soccer courts and a mix of native and exotic tree species. The park has two small springs and a lake with aquatic vegetation. It also has a channel that crosses the park throughout.

Park and site characterization

We measured landscape and site park characteristics. The landscape traits, included, the mean density of human population at neighboring house developments; the nearest distance from each point count (PC) in the park to the border of the city and to the nearest NPA.

For site characteristics, we considered eleven variables of vegetation traits: number of vegetation strata. For tree stratum: richness, abundance, diameter at breast height (DBH), height, and cover. For shrub stratum: richness, height, and cover. And for herbaceous stratum: height and cover. Additionally, for infrastructure cover we considered: roads, benches, or anything man-made. Passing pedestrian and predator presence were measured as the number of pedestrians, dogs or cats per minute. Finally, site management was measured using a categorical classification ranging from 0 to 3, being 0 without management activities and 3 highly managed parks (e.g., mowing, removal of fallen leaves, tree and shrub pruning).

Bird surveys

Bird surveys consisted of three methods to maximize detectability of species: point counts (PC), transects (T) and mist net (MN) (Ralph, Geupel, Pyle, Martin & DeSante, 1993). These were conducted on different days, once a month from November 2016 to December 2017. We established 12 fixed diameters PC (25m radius) separated by 400m from each other. In between PC and at the end of the last one, we established 200x20m band transects. We registered birds seen or heard within the point counts while 10 min stationary, as well as birds seen while walking at a regular calm pace within the band transect. Once a month, we operated seven MN (duration 6 hrs. beginning at sunrise). All birds captured were measured, weighted, photographed and freed at the site of capture.

We elaborated a taxonomic list following the American Ornithological Society (AOS, 2018) for scientific and English names. For distribution categories in Jalisco (residents, winter visitor, summer resident, accidental and transient migrant) we used Berlanga et al. (2017) list of birds of Mexico. For birds origin (tropical, neartic, wide distribution, exotic, semiendemic, quasiendemic and endemic) we used Palomera-García, Santana, Contreras-Martínez and Amparán (2007) and Berlanga et al. (2017). To establish trophic guild, we used Birds of North America (2018) and Neotropical Birds (2018). Lastly, for conservation status we used the Mexican government endangered species list, NOM-059-SEMARNAT-2010 (DOF, 2015) and The Red List (IUCN, 2018).

Data analysis

Sampling effort in each park was analyzed contrasting the observed richness (matrix species-abundance PC plus T and MN per month) with the one estimated by, Jacknife1, Jacknife2 and Bootstrap non-parametric procedures using EstimateS V.9.1.0 (Colwell 2016). Hill numbers: abundance (N), richness (N0), very abundant species (N1, e^H) and abundant species (N2, $1/\lambda$), and Pielou's evenness (J') were calculated with the matrix species-abundance PC plus T, also with EstimateS V.9.1.0 (Moreno et al., 2017).

Differences per park and among parks

To explore the bird community composition through time, we conducted a Hierarchical Agglomerative Clustering (CLUSTER Analysis) using data matrix species-abundance PC plus T per month. We applied a fourth root transformation to the original data. Next, we constructed a Bray-Curtis similarity matrix. The grouping method used was the group average linking. To identify groups, we applied a Similarity Profile Test (SIMPROF) with 1000 permutations, 999 simulations and a significance level of $\alpha \leq 0.05$ (Clarke, Gorley, Somefield & Warwick, 2014).

To know if there were differences in bird community between migratory and no migratory season in the parks and among parks; we considered the following two-way crossed and nested factor model with the PC + T data matrix as the replicate:

$$Y = \mu + park_i + season_j + park_i \text{ x } season_j + \mathcal{E}_i$$

where Y is the variability across the set of observations; μ is the average value of the observations; $park_i$ is the fixed factor that represents the three parks at GMA; *season* is the fixed factor that corresponds to migratory and non-migratory bird seasons; $park_i$ x $season_j$ is the interaction term that exists between the corresponding factors, and $\mathcal{E}_{ijk}$ is the accumulated error of model.

With this model, we performed a two-way non-parametric Permutational Multivariate Analyses of Variance (PERMANOVA) with the bird community data (matrix species-abundance, PC plus T) and a non-parametric two-way Analyses of Variance (ANOVA) to N, N0, N1, N2 and J'. The species abundance was fourth-root transformed prior to performing the multivariate analysis. PERMANOVA was conducted using a Bray-Curtis similarity matrix constructed based on the abundance of each species. Meanwhile, ANOVAs used the Euclidean distance matrix. The PERMANOVA and permutational ANOVAs were calculated with a type III sum of square. Statistical significance was tested with 9999 permutations and the method was: permutation of residuals under a reduced model (Anderson, Gorley & Clarke, 2008).

The CLUSTER with SIMPROF test, permutational ANOVAs, and PERMANOVA were run in the PRIMER v6.1 and PERMANOVA+ program (Clarke & Gorley 2015).

Bird community relationships within landscape and site characteristics

We performed a Detrended Correspondence Analysis (DCA) to identify the gradient length of the bird species composition variation in the three parks. DCA results showed a gradient length longer than four tolerances but we decided to perform a Redundancy Analysis (RDA) since we are not analyzing the complete distribution of the birds found in the parks, just a very punctual area (linear response). We used the species-abundance data (only PC results), which was fourth root transformed and the landscape and site characteristic data which was normalized. As a variance inflation factor (VIF) >10 has been identified as an indicator of collinearity in a multivariate analysis (Chatterjee, Hadi & Price, 2000); environmental variables with a VIF >10 were removed. Statistical significance was calculated using a Monte Carlo test with 9999 permutations. DCA and RDA were performed in CANOCO v4.5 (Ter Braak & Šmilauer, 2002).

Results

We registered 127 species; representing 93 genera, 34 families and 14 orders. The families with the highest number of members registered where Tyrannidae (18 spp.), Parulidae (13spp.) Cardinalidae (9 spp.) and Icteridae (9 spp.). From the total, 81 species were residents, 36 winter visitors, seven summer residents, two accidental and one transient migrant. In terms of origin we registered six endemic, 16 semiendemic, two quasiendemic, 7seven exotic 59 nearctic, 25 tropical and 13 wide distributed species. Based on trophic guilds we found 69 insectivores species, 29 granivores, 12 carnivores, 13 omnivores, five nectarivores, one frugivore and one herbivore. We identified 11 species listed in the Mexican government endangered species list, NOM-059-SEMARNAT-2010. The Lilac-crowned Parrot (*Amazona finschii)* and the Painted Bunting (*Passerina ciris)* appear in the Red List with a VU and NT category, respectively (Annex A).

Table 1. Distribution categories, origin, trophic guild, NOM-059 status and IUCN categories of the birds recorded at, COL= Bosque Los Colomos, MET= Parque Metropolitano de Guadalajara, SOL= Parque de la Solidaridad.

Distribution categories	**COL**	**MET**	**SOL**	**Total**
Residents	54	50	54	79
Winter visitors	26	18	21	35
Summer residents	7	4	4	7
Accidental	3	1	0	4
Transient migrant	1	1	0	2
Origin				
Endemic	5	2	1	5
Semiendemic	11	11	11	16
Quasiendemic	2	1	0	2
Exotic	3	5	6	7
Neartic	43	36	36	59
Tropical	18	14	17	25
Wide distribution	9	5	8	13
Trophic guild				
Insectivores	52	42	41	69
Granivores	24	16	18	29
Carnivores	6	5	8	12
Omnivores	5	6	7	10
Nectarivores	3	4	4	5
Frugivores	1	1	0	1
Herbivores	0	0	1	1
NOM-059				
Special protection	4	1	3	7
Threatened	3	1	1	3
Endangered	1	0	0	1
IUCN				
Vulnerable	1	0	0	1
Near Threatened	1	0	0	1

In COL, we registered 91 species, representing 67 genus, 27 families, 11 orders and 33 unique to the park. Hill's numbers calculate 20 very abundant species (N2), and 32 abundant species (N1). In MET, we had 74 species, representing 55 genus, 28 families, 12 orders, and 11 unique to the park. According to Hill numbers we have 12 very abundant and 20 abundant species. Similarly, in SOL, we registered 79 species, representing 65 genus, 31 families 13 orders and 15 unique species to the park. Hill numbers showed 10 very abundant and 16 abundant species (Table 1).

Based on the accumulation curves for COL, Bootstrap non-parametric estimator predicted 95 species, Jacknife1 105 and Jacknife2 110, which means that we registered between 77 and 89% of the expected species. For MET, Bootstrap predicted 86 species, Jacknife1 96 and Jacknife2 105, this means that we registered between 73 and 89% of the expected species. For SOL, Bootstrap predicted 92 species, Jacknife1 106 and Jacknife2 120, which means that we registered between 68 and 88% of the expected species. In summary, the cumulative curves confirmed an adequate sampling effort (Fig. 3).

Differences within and among parks

In each park richness and abundance were higher during the migratory season when winter migrants are in the area, and lower in summer when there are only residents and summer residents. COL registered the highest species richness, but SOL had the highest abundance, mainly due to the big flocks of Bronze Cowbirds (*Molothrus aeneus*) and Brown-headed Cowbird (*Molothrus ater*) registered in the park (Table 2).

Table 2. Species richness (N0), species abundance (N), abundant species (N1), very abundant species (N2) and Pielou's evenness (J') values per park. COL= Bosque Los Colomos, MET= Parque Metropolitano de Guadalajara, SOL=Parque de la Solidaridad.

Park	**N0**	**N**	**N1**	**N2**	**J'**
COL	80	1933	29	18	0.7683
MET	73	2794	19	12	0.6899
SOL	79	5348	15	9	0.6221
Season					
Migratory	116	6469	21	12	0.6399
Non-migratory	61	3606	16	11	0.6782

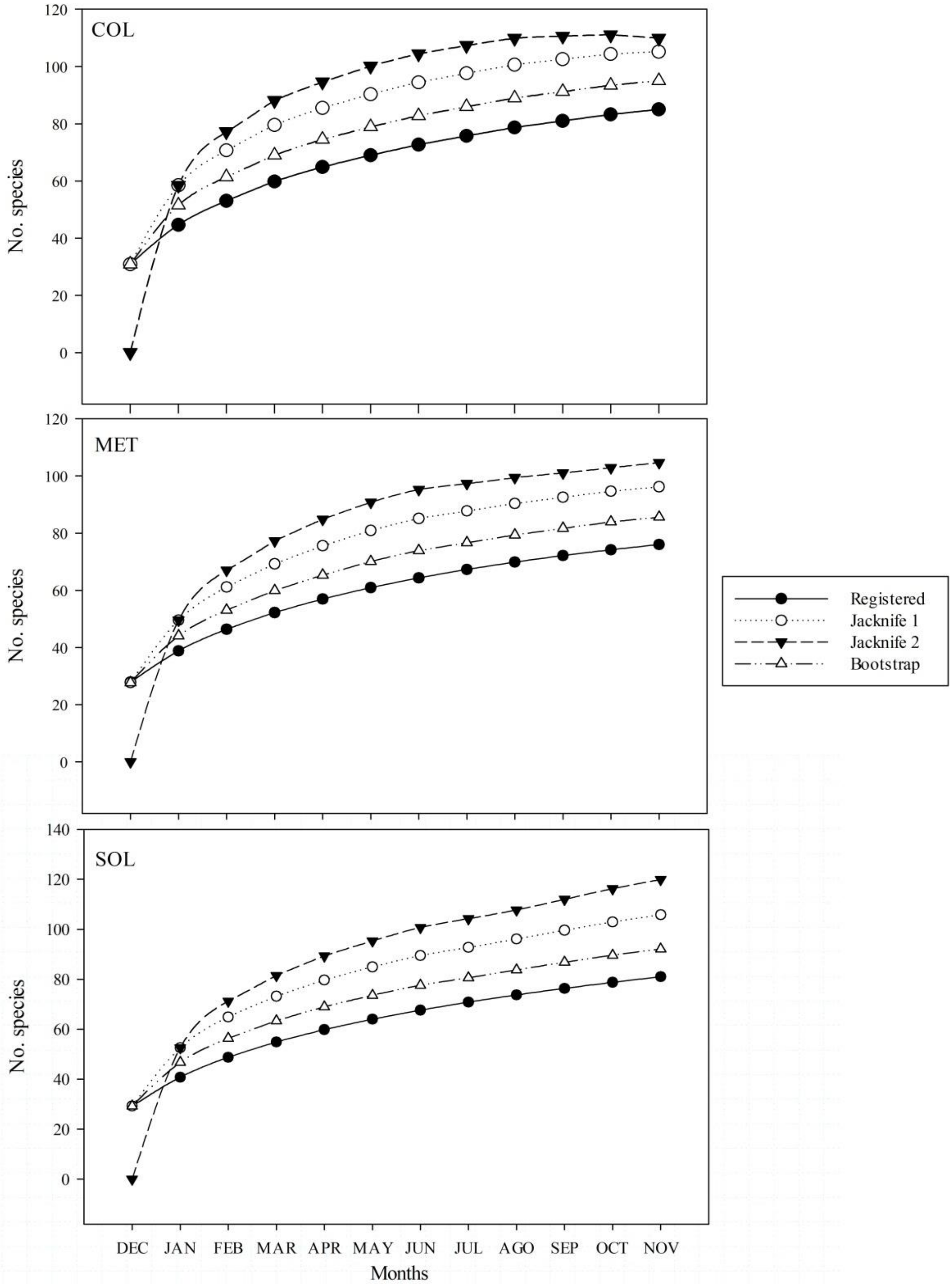

Fig. 3. Species-accumulation curve for every park using Jacknife1, Jacknife2 and Bootstrap non-parametric procedures. COL= Bosque Los Colomos, MET= Parque Metropolitano de Guadalajara, SOL= Parque de la Solidaridad.

CLUSTER Analysis with SIMPROF test clearly grouped months by park and two seasons: migratory (Jan-Apr and Oct-Dec), and residents (May-Sep). It is well known that bird community composition changes through time because the migration patterns (Able, 2011) (Fig. 4).

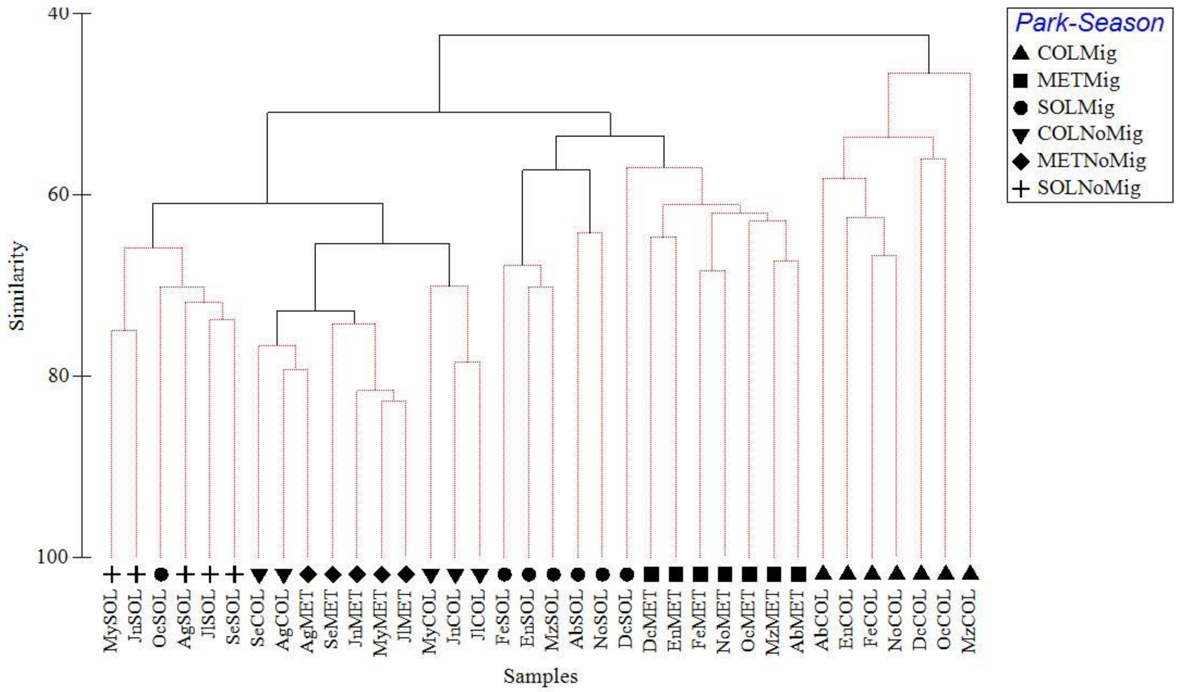

Fig. 4. CLUSTER analysis with SIMPROF test with migratory and non-migratory season in each park. Red lines show the groups formed by SIMPROF.

PERMANOVA analysis (Table 3) showed differences at the three levels. Permutational ANOVAs (Table 3) indicated that richness (N0), abundance (N), and abundant species (N1) are different at $park_i$ level. At $season_j$ level, N1, N2 and J’ were different. At $park_i$ x $season_j$ level only J’ was statistically different.

Table 3. PERMANOVA and permutational ANOVA analysis of the bird communities at GMA urban parks. The bold values indicate statistical significant P-values (α ≤0.05).

Analysis	Factors	Pseudo-F	P(perm)
Bird community	Park	18.004	**0.0001**
	Season	58.987	**0.0001**
	ParkxSeason	1.98	**0.0038**
Richness (N0)	Park	12.456	**0.001**
	Season	0.79616	0.385
	ParkxSeason	1.1109	0.33
Abundance (N)	Park	8.9151	**0.001**
	Season	1.6136	0.22
	ParkxSeason	2.0962	0.118
Abundant species (N1)	Park	3.547	**0.035**
	Season	7.8684	**0.004**
	ParkxSeason	1.133	0.345
Very abundant species (N2)	Park	0.87767	0.407
	Season	11.382	**0.002**
	ParkxSeason	2.6251	0.073
Pielou evenness (J’)	Park	2.741	0.069
	Season	6.7419	**0.014**
	ParkxSeason	4.6164	**0.007**

Bird community relationship with park and site characteristics

Landscape characteristics show differences among parks; for example: human density of SOL is four times higher than COL. Regarding site characteristics, we did not registered dog or cats in COL and SOL. COL has the highest values of tree and shrub characteristics: richness, abundance, DBH and cover. We did not found a shrub stratum in MET. SOL has the highest herbaceous cover (Table 4).

Table 4. Landscape and site characteristics (average ± SD, or median (Q1,Q3)) of the three studied parks. COL= Bosque Los Colomos, MET= Parque Metropolitano de Guadalajara, SOL= Parque de la Solidaridad.

Landscape		COL	MET	SOL
Human density of the house developments around the park (hab/ha)	Den	25.49	41.35	117.24
Distance to city border (m)	City	6039.00	2022	3409.00
Distance to natural protected area (m)	NPA	6486.00	2022	3103.00
Site				
Infrastructure (%)	Infra	9.83 ± 15.97	15.25 ± 10.20	14.50 ± 12.30
Number of pedestrians (per min)	Peds	2.92 ± 4.91	2.92 ± 1.98	2.50 ± 3-61
Dogs and cats (per min)	Pred	0	0.67 ± 1.07	0
Park management (0-3)	P_m	1.5 (1, 2)	3 (3, 3)	1 (0,25, 1)
Number of vegetation strata	Strata	2.92 ± 0.29	2.00 ± 0	2.58 ± 0.51
Tree species richness	T_spp	3.67 ± 1.30	2.25 ± 0.75	2.42 ± 1.38
Tree abundance	T_abu	12.67 ± 6.61	10.67 ± 7.27	8.92 ± 7.93
Tree diameter at breast height	T_dap	25.08 ± 12.26	21.41 ± 19.39	21.53 ± 8.60
Tree height (m)	T_h	12.07 ± 3.75	6.79 ± 3.42	10.51 ± 4.52
Tree cover (%)	T_c	53.75 ± 22.88	42.73 ± 21.61	28.58 ± 23.56
Shrub species richness	S_spp	6.17 ± 9.10	0	1.55 ± 1.57
Shrub cover (%)	S_c	23.25 ± 22.95	0	3.36 ± 5.03
Shrub height (m)	S_h	1.77 ± 0.96	0	1.26 ± 1.46
Herbaceous plant cover (%)	H_c	44.58 ± 27.01	64.17 ± 8.75	70.09 ± 22.10
Herbaceous plant height (cm)	H_h	45.14 ± 30.19	14.38 ± 9.78	42.46 ± 16.51

The VIF of the RDA showed collinearity among variables. Therefore vegetation strata and distance to the border to the city where removed. The first two axes explained 25.1% of the variance in bird species and 44.1% of the variation on species-habitat relationship (Table 5). The R^2 percentage values, after being adjusted, resulted in a 19% explain variation of the model. The model was significant (Test of significance of all canonical axes: F-ratio= 1.544, P-value= 0.0001).

Table 5. Results of RDA analysis for landscape and site characteristics.

Axes	1	2	3	4	Total variance
Eigenvalues	0.164	0.087	0.052	0.043	1.000
Species-environment correlations	0.951	0.955	0.903	0.841	
Cumulative percentage variance					
of species data	16.4	25.1	30.4	34.7	
of species-environment relation	28.8	44.1	53.2	60.8	
Sum of all eigenvalues					1.000
Sum of all canonical eigenvalues					0.571

RDA sites-environmental biplot (Fig. 5) shows that the first axe has a strong correlation with human density (Den) in a positive way, and with tree cover (T_cov) in a negative way. Axe 2 positive correlation is with park management (P_m) and negatively with herbs height (H_h). It also shows that the samples from each park are associated between them. COL sites are associated with the distance to the nearest Natural Protected Area, shrub abundance (S_abu) and tree species (T_spp). MET is related to park management (since it has the highest values), and SOL sites are associated with human density (den) and herbs traits (H_c and H_h).

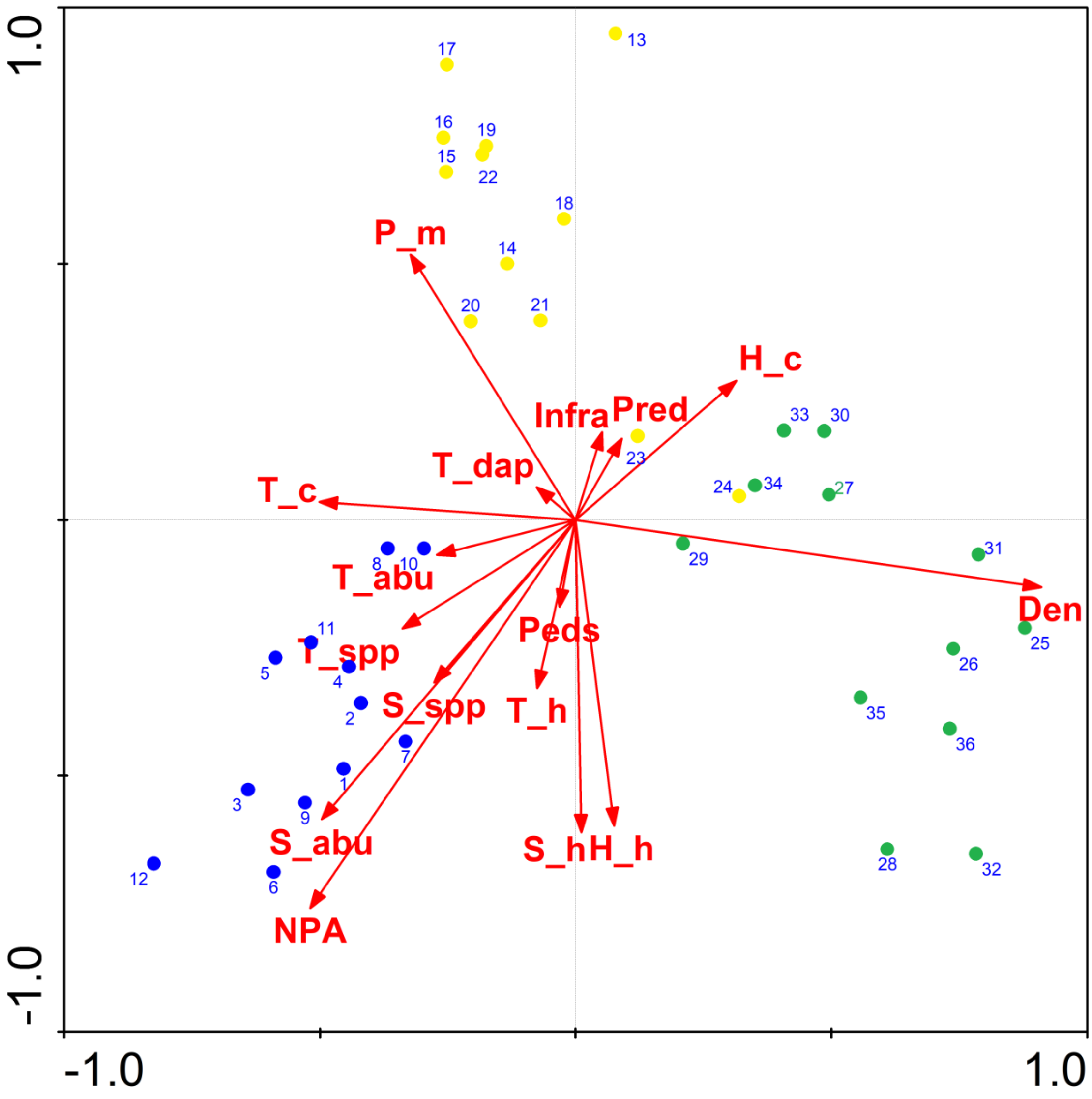

Fig. 5. Park sites, landscape and site characteristics biplot. Blue=COL, Yellow= MET and Green=SOL.

The RDA park, in-site and parks characteristics and species triplot (Fig. 6) shows that most of the species are associated with tree species and abundance (T_spp and T_abu) and shrub species and abundance (S_spp and S_abu).

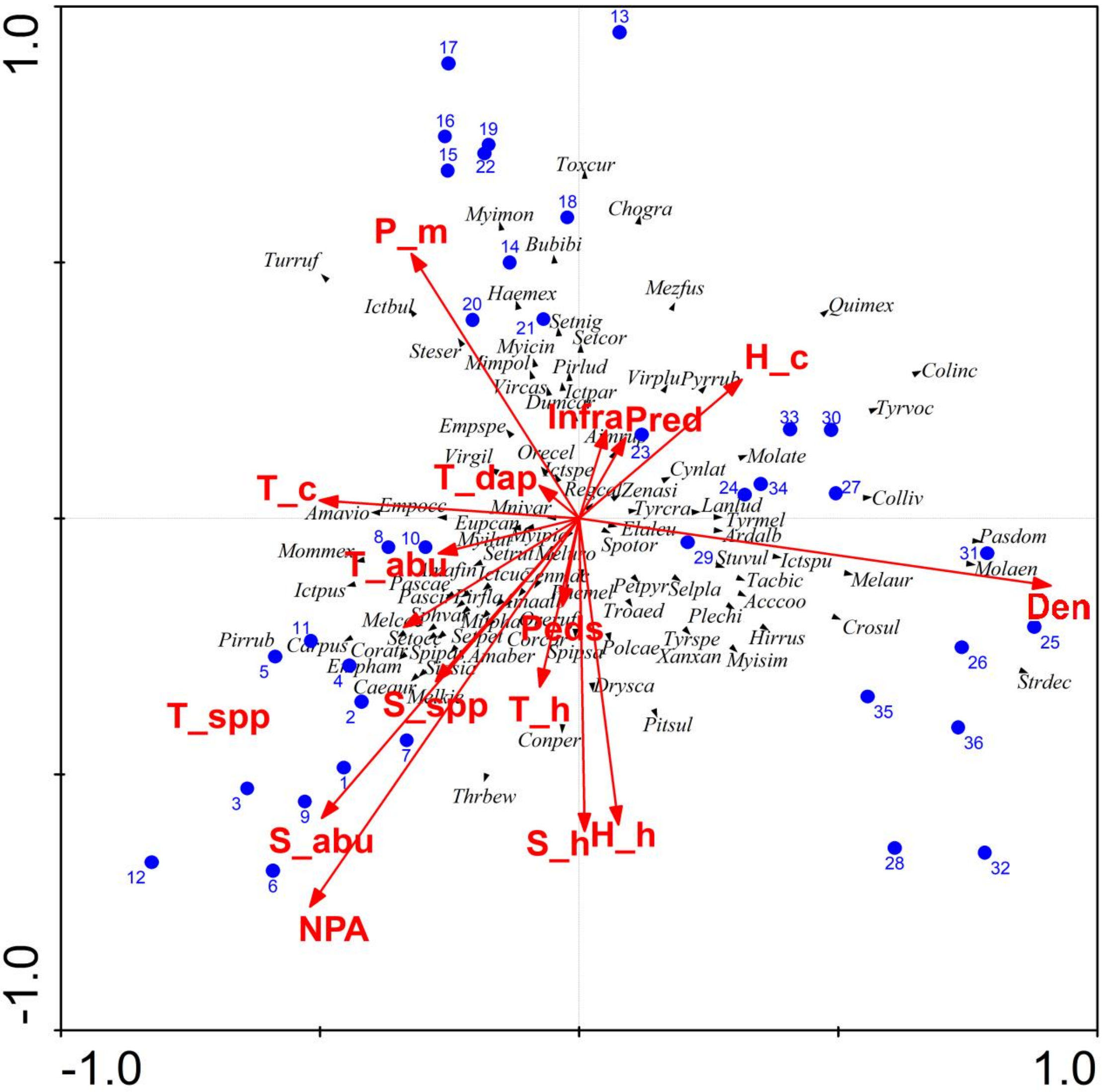

Fig. 6. Park sites, landscape and site characteristics, and species triplot.

Most exotic species were associated with SOL (4 of 6). They related positively with human density and negatively with tree cover. Most of the endemic and threatened species were found in COL samples and associated with vegetation traits. The only endemic species that does not follow this pattern is the Rufous-backed Robin (*Turdus rufopalliatus*) which is associated with park management (P_m).

Discussion

The 127 species registered in the three parks during the study correspond to 22.4% of the species registered in Jalisco (565) (Santana et al, 2017). This is an important number of species considering that the parks are embedded in an urban matrix. The presence of water bodies in all parks allow aquatic birds such as Great Egret (*Ardea alba*) or Blue-winged Teal (*Spatula discors*) to be present in the area. We did not observed species from the Strigiformes family or any other nocturnal birds, due to the lack of night counts. However, there are records of Barn Owl (*Tyto alba*) and Mottled Owl (*Ciccaba virgata*) in COL (Naturalista, 2018; MacGregor-Fors, 2010a).

The GMA is located in the Mexican Transitional Zone between the Nearctic and Neotropical biogeographic regions, which contributes to its great natural richness (Santana et al, 2017).We registered more species here than similar studies in other cities. For instance, Carbó-Ramírez & Zuria (2011) found 39 species in Pachuca, Hidalgo and González-Oreja, De La Fuente-Díaz-Ordaz, Hernández-Santin, Bonache-Regidor & Buzo-Franco (2007) observed 52 species in Puebla, Puebla. Further, Castro-Torreblanca & Blancas (2014) reported 76 species in Chilpancingo, Guerrero.

Bird diversity is lower in urban areas compared with nearby NPA (Chace & Walsh, 2006; McKinney, 2005; Seress & Liker, 2015). A comparison among the GMA and the surrounding: APFFLP and FNIEBRSV show the same pattern. The bird inventory for APFFLP sum 205 species (Bosque La Primavera, 2018) and FNIEBRSV have 208 (Maya-Elizarrarás et al, 2011). These numbers mean that few species manage to live inside the urban area, as a consequence of the decrease in resource variety and availability for birds (MacGregor-Fors & Ortega-Álvarez, 2011; Puga-Caballero, MacGregor-Fors & Ortega-Álvarez, 2014).

In average, the non-parametric estimators resulted in a value of 82.55% of the species for COL, for MET 80.15% and for SOL 77.37%. We did a yearlong study, but there are still species to be recorded; this could be attributed to the species that avoid urbanization due to the ecological barrier that urban areas represent (MacGregor-Fors, 2010b).

Our study supports that local and landscape characteristics relate to avian ecological pattern within urban areas (MacGregor-Fors & Ortega-Álvarez, 2011). In the GMA, COL, MET and SOL respond to both characteristics in a different way, allowing different species to set in.

Results show that tree species richness, tree abundance, and shrub abundance, relates to a higher diversity of bird species and diversity tends to correlate with vegetative complexity and plant species-richness (Savard, Clergeau & Mennechez, 2000). Similar results were obtained by Carbó-Ramírez & Zuria (2011) and MacGregor & Ortega-Álvarez (2011). Vegetation must be maintained or even favored, in order to have a rich and abundant community or birds. The association with vegetation traits is stronger in COL sites. There tree and shrub diversity is higher and all vegetation strata are present, offering different habitats. It may explain the presence of 31 species unique to the park. Especially important to the bird community in MET is the lack of shrubs and the high values of park management, making it a suitable habitat for species that need open areas such as the Northern Mockingbird (*Mimus polyglottos*), Ash-throated Flycatcher (*Myiarchus cinerascens*) or the exotic Monk Parakeet (*Myiopsitta* *monachus*). The same argument could also be the cause that MET presented the lowest richness among the parks. Birds not registered in MET include species that need a more complex or a specific vegetation, such is the case of the Groove-billed Ani (*Crotophaga sulcirostris*) that can be found in areas with tall grass, and was not registered at MET; since grass is mowed in a continue manner. SOL is strongly influenced by human density in the surrounding areas. Since more intense development could decrease the amount of resources available to birds, the ones that could exploit this resource are often exotic species; that is why four out of six exotic species show a strong relation with SOL sites.

Vegetation traits were associated with a higher number of species. However, distance to the border of the city was strongly and positively associated with COL sites. Although COL is the farthest and the more isolated within the urban matrix. Because of the richer and more complex vegetation this park presents, it is an “island of habitat” that function as a barrier for birds from adjacent landscapes to arrive to the park, it works as a barrier for birds leaving. It might not be other site or park that can offer the resources that species such as Rusty-crowned Ground-Sparrow (*Melozone kieneri*) or Ovenbird (*Seirus auracapilla*) need to establish.

Human disturbance is another factor that influences bird species diversity (Fernández-Jurícic & Jokimäki, 2001). In our study, except for human density, we observed low correlation among human disturbance variables (Pedestrian, infrastructure cover) in the RDA triplot. Our study was conducted in big urban parks, where human disturbance is lower or can be attenuated by positive variables as tree species. In the future, it is necessary to include other human disturbances such as passing cars, noise levels, buildings height and cover.

Migratory and non-migratory bird communities show different patterns, even among parks. During the migratory season, richness and abundance were higher. Besides resident species there were winter migrants from North America, one of the most threatened groups of birds (Berlanga et al, 2010). We registered some transient and accidental species that may be using urban parks as a “refueling” habitat in route to their wintering areas making them a critical habitat for these birds (Homayoun & Blair, 2015). More studies are needed on the requirements of winter migrants, since understanding the role of city parks as potential migration habitat is a key element of building comprehensive conservation strategies that address the year round needs of migratory bird species in an increasingly urban world (Homayoun & Blair, 2015).

During the non-migratory season, richness and abundance decreases as winter migrants return to their breeding areas. There is a slight increment in richness (Jul-Ago) due to summer migrants. In the GMA we registered seven of them. Moreover, their abundance increased due to reproductive season when matting displays and juvenile sightings make them easier to spot.

Often, urban landscapes are overlooked and regarded as unimportant. Nevertheless, endemic species like the Rusty-crowned Ground-Sparrow and endangered species, nationally and internationally like the Painted Bunting., were found in urban parks, thus providing opportunities for regional and global biodiversity conservation.

Exotic species, whereas human introduced and cage-bird escapees, play an important role in the composition of urban bird communities within Latin American urban systems (Ortega-Álvarez & MacGregor-Fors, 2011). Besides the normal exotics species; we registered a Budgerigar (*Melopsittacus undulatus*), a White-fronted Parrot (*Amazona albifrons*) and a Brown-hooded Parrot (*Pyrilia haematotis*). The last two are native in Mexico, but are exotic species to the state of Jalisco. These three species are thought to be escaped but now are part of the resident community in the parks.

Urbanization favors granivores and insectivores (Chace & Walsh, 2016). The GMA parks support this pattern. Half of the species, 69 species, are insectivores and quarter, 29 species, are granivores.

Unlike González-Oreja et al (2007) that found in Puebla city that the dominant species were the Great-Tailed Grackle (*Quiscalus mexicanus*), the House Finch (*Haemorhous mexicanus*) and the House Sparrow (*Passer domesticus*), we found Bronzed Cowbird (*Molothrus aeneus*), Inca Dove (*Columbina inca*) and Great-Tailed Grackle as the dominant ones. Native species typically drop out of the community along the gradient from native to completely urban environments (Blair, 1996). But, in this case the dominant species are native species. These parks are classified as suburban areas, where despite the disturbance there is a peak of avian diversity (Blair, 1999; Chace & Walsh, 2016; Marzluff, 2001). This pattern may be explained by the intermediate disturbance hypothesis which predicts that areas with moderate levels of disturbance harbor higher species diversity than areas with higher degree of disturbance. The regular, low-scale disturbances promote landscape heterogeneity, create novel communities (because different habitats occur alongside to each other), and also prevent the strongest competitors rising to competitive exclusion (Seress & Liker, 2015).

Conclusion

Although the GMA is the second largest urban area of the country, there is little information about changes through time in the bird community. We analyzed the bird community only on big urban parks, but future studies should include smaller parks, streets, downtown areas, to assess human disturbance in different degrees. To improve our understanding of how birds respond to urbanization, we need community-level studies. We also need demographic studies, including fecundity and survivorship. Population dynamics, including immigration and emigration would be helpful.

As the GMA grows, a continuous study of the urban bird community is needed. Efforts directed towards conservation and restoration of native vegetation within urban parks or urban green areas could help to support greater concentrations of bird species. These decisions will determine in large part how much and what type of biological diversity survives in the face of a growing and increasingly urban human population.

References

1. Able, K. P. (2011). Birds on the move: flight and migration. In S. Podulka, R. W. Rohrbaugh Jr. & R. Bonney (Eds.), *Handbook of bird biology* (pp. 5.1-5.95). Ithaca – The Cornell Lab of Ornithology.
2. American Ornithological Society (AOS). Online Checklist of North & Middle American Birds, Retrieved July 23, 2018 from http://checklist.aou.org/.
3. Anderson, M. J., Gorley, R.N. & Clarke, K. R. (2008). *PERMANOVA + for PRIMER: Guide to Software and Statistical Methods.* Devon – PRIMER-E Ltd.
4. Aronson, M. F. J., La Sorte, F. A., Nilon, C. H., Katti, M., Goddard, M. A., Lepczyk, C. A., Warren, P. S., Williams, N. S. G., Cilliers, S., Clarkson, B., Dobbs, C., Dolan, R., Hedblom, M., Klotz, S., Kooijmans, J. L., Kuhn, I., MacGregor-Fors, I., McDonnell, M., Mortberg, U., Pysek, P., Siebert, S., Sushinsky, J., Werner, P. & Winter, M. (2014). A global analysis of the impacts of urbanization on bird and plant diversity reveals key anthropogenic drivers. *Proceedings of the Royal Society B-Biological Sciences,* 281(1780), 1-8. doi - 10.1098/rspb.2013.3330.
5. Berlanga, H., Gómez de Silva, H., Vargas-Canales, V.M., Rodríguez-Contreras, V., Sánchez-González, L. A., Ortega-Álvarez, R. & Calderón-Parra, R. (2017). *Aves de México - Lista actualizada de especies y nombres comunes* (Birds of Mexico – updated list of species and common names). Mexico City–CONABIO.
6. Berlanga, H., Kennedy, J.A., Rich, T. D., Arizmendi, M. C., Beardmore, C. J., Blancher, P. J., Butcher, G. S., Couturier, A. R., Dayer, A. A., Demarest, D. W., Easton, W. E., Gustafson, M., Iñigo-Elias, E., Krebs, E. A., Panjabi, A.O.,

Rodriguez Contreras, V., Rosenberg, K. V., Ruth, J. M., Santana Castellón, E., Ma. Vidal, R. & Will, T. (2010). *Saving Our Shared Birds: Partners in Flight Tri-National Vision for Landbird Conservation.* Ithaca– The Cornell Lab of Ornithology.

7. Birds of North America, Retrieved July 22, 2018 from https://birdsna-org.bnaproxy.birds.cornell.edu.
8. Blair, R. B. (1996). Land use and avian species diversity along an urban gradient, *Ecological Applications,* 6(2), 506-519.
9. Blair, R. B. (1999). Birds and butterflies along an urban gradient: surrogate taxa for assessing biodiversity? *Ecological Applications,* 9(1), 164-170.
10. Blair, R. B. (2001). Creating a homogeneous avifauna. In: Marzluff, J. M., Bowman, R., Donnely, R. (Eds.), *Avian Conservation and Ecology in an Urbanizing World* (pp. 459-486). Boston - Kluwer Academic.
11. Bosque La Primavera, Retrieved July 16, 2018 from http://www.bosquelaprimavera.com.
12. Castro-Torreblanca, M. & Blanca Calva, E. (2014). Aves de Ciudad Universitaria campus Sur de la Universidad Autónoma de Guerrero, Chilpancingo, Guerrero, México (Birds from Ciudad Universitaria south campus of Universidad Autónoma of Guerrero, Chilpancingo, Guerrero, Mexico). *Huitzil*, 15(2), 82-92.
13. Carbó-Ramírez, P. & Zuria, I. (2011). The value of small urban greenspaces for birds in a Mexican city. *Landscape and Urban Planning,* 100(3), 213-222. doi - 10.1016/j.landurbplan.2010.12.008.
14. Chace, J. F. & Walsh, J. J. (2006). Urban effects on native avifauna: a review. *Landscape and Urban Planning*, 74(1), 46–69. doi - 10.1016/j.landurbplan.2004.08.007.
15. Chatterjee, S. A., Hadi, A. S. & Price, B. (2000) *Regression analysis by example*. New York – John Wiley and Sons.
16. Clarke, K. R. & Gorley, R. N. (2015). *Getting started with PRIMER v7*. Devon – PRIMER-E Ltd.
17. Clarke, K. R., Gorley, R.N., Somerfield, P. J., &. Warwick, R. M. (2014*). Change in Marine Communities - an approach to statistical analysis and interpretation*. Devon – PRIMER-E Ltd.

18. Clergeau, P., Croci, S., Jokimäki, J., Kaisanlahti-Jokimäki, M. L. & Dinetti, M. (2006). Avifauna homogenization by urbanization - analysis at different European latitudes. *Biological Conservation*, 127, 336–344. doi - 10.1016/j.biocon.2005.06.035.
19. Colwell, R. K. (2016). EstimateS: Statistical estimation of species richness and shared species from samples. Retrieved from http://viceroy.eeb.uconn.edu/estimates/.
20. Diario Oficial de la Federación, DOF (2002). *Norma Oficial Mexicana NOM-059-SEMARNAT-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.* Ciudad de México – Gobierno de México.
21. Donnelly, R. & Marzluff, J. M. (2004). The importance of reserve size and landscape context to urban bird conservation. *Conservation Biology*, 18(3), 733-745. doi www.jstor.org/stable/3589084.
22. Fernández-Juricic, E. & Jokimäki, J. (2001). A habitat island approach to conserving birds in urban landscapes: case studies from southern and northern Europe. *Biodiversity and Conservation*, 10(12), 2023-2043. doi - 10.1023/A:1013133308987.
23. González-Oreja, J. A., Bonache-Regidor, C., Buzo-Franco, D., De la Fuente-Díaz-Ordaz, A. A. & Hernández-Santín, L. (2007). Caracterización ecológica de la avifauna de los parques urbanos de la Ciudad de Puebla (México) (Ecological characterization of urban park avifauna in the city of Puebla). *Ardeola*, 54(1), 53–67.
24. González-Oreja, J. A., De La Fuente-Díaz-Ordaz, A. A., Hernández-Santin, L., Bonache-Regidor, C. & Buzo-Franco, D. (2012). Can human disturbance promote nestedness? - Songbirds and noise in urban parks as a case study. *Landscape and Urban Planning*, 104(1), 9-18. doi - 10.1016/j.landurbplan.2011.09.001.
25. Guerrero-Nuño, J. J. (2009). Vegetación y flora del Bosque Los Colomos, Guadalajara, Jalisco (Vegetation and flora of Bosque Los Colomos, Guadalajara, Jalisco). In: Anaya-Corona, M., Cordero Viramontes, O.M., Ramírez Quintana-Carr, A.I. and Guerrero-Nuño, J. J. (Eds.), *Bosque Los Colomos Guadalajara-Una visión integral para su conservación* (Bosque Los Colomos Guadalajara –

An integral vision for its conservation) (pp. 171-204). Guadalajara-Patronato del Bosque Los Colomos.

26. Homayoun, T. Z. & Blair, R. B. (2016). Value of park reserves to migrating and breeding landbirds in an urban important bird area, *Urban Ecosystems* 19(4):1579-1596.
27. Instituto de Información Estadística y Geografíca IIEG & Fideicomiso del Programa de Desarrollo Forestal del Estado FIPRODEFO (2018). *Programa de ordenamiento de arbolado y áreas verdes urbanas* (Program for the organization of trees and urban green areas). Gobierno de Jalisco.
28. Instituto Metropolitano de Planeación IMEPLAN (2016). *Plan de ordenamiento territorial metropolitano del Área Metropolitana de Guadalajara* (Guadalajara Metropolitan Area Arrangement Plan). Gobierno de Jalisco. Retrieved from-http://imeplan.mx/.
29. International Union for Conservation of Nature and Natural Resources, IUCN. *The IUCN Red List of Threatened Species. Version 2018-1*. Retrieved July 7, 2018 from http://www.iucnredlist.org.
30. Larios Gómez, A. (2012) *Experiencias de Manejo Forestal con Especies Nativas en el Parque Metropolitano de Guadalajara* (Forest management with native species in Parque Metropolitano de Guadalajara). In A.I. Ramírez Q., M. Anaya C., F. D. Rentería R., J. G. Ruvalcaba S. & M. A. González V. (Comp.), *Propuestas para la Gestión de los Parques en México 2012 (Proposals for the management of parks in Mexico 2012)* (pp. 72-94).
31. MacGregor-Fors, I. (2010a). *Guía de aves del Bosque Los Colomos* (Bird guide of Bosque Los colomos). Guadalajara-CONABIO.
32. MacGregor-Fors, I. (2010b). How to measure the urban-wildland ecotone: redefining “periurban” areas. *Ecological Research*, 25, 883-887.
33. MacGregor-Fors, I., Escobar, F., Rueda-Hernández, R., Avendaño-Reyes, S., Baena, M. L., Bandala, V. M., Chacón-Zapata, S., Guillén-Servent, A., González-García, F., Lorea-Hernández, F., de Oca, E. M., Montoya, L., Pineda, E., Ramírez-Restrepo, L., Rivera-García, E. & Utrera-Barrillas, E. (2016). City "Green" Contributions –The Role of Urban Greenspaces as Reservoirs for Biodiversity. *Forests*, 7(7), 1-14. doi -10.3390/f7070146.

34. MacGregor-Fors, I. & Ortega-Alvarez, R. (2011) Fading from the forest: Bird community shifts related to urban park site-specific and landscape traits. *Urban Forestry & Urban Greening,* 10(3), 239-246. doi -10.1016/j.ufug.2011.03.004
35. MacGregor-Fors, I. & Schondube, J. E. (2011). Gray vs. green urbanization - Relative importance of urban features for urban bird communities. *Basic and Applied Ecology,* 12(4), 372-381. doi -10.1016/j.baae.2011.04.003.
36. Marzluff, J. M., Bowman, R. & Donnely, R. (2001). A historical perspective on urban bird research: trends, terms, and approaches. In: Marzluff, J. M., Bowman, R. & Donnely, R. (Eds.), *Avian Conservation and Ecology in an Urbanizing World* (pp. 1-17). Boston - Kluwer Academic.
37. Maya-Elizarrarás, E. (2011). Aves explotadoras de áreas verdes urbanas: un ejemplo de la Zona Metropolitana de Guadalajara, Jalisco (Exploiter birds from urban Green areas-an example from the Metropolitan Zone of Guadalajara, Jalisco) *El canto del Centzontle,* 2(1), 104-109.
38. McKinney, M. L. (2006). Urbanization as a major cause of biotic homogenization. *Biological Conservation,* 127(3), 247-260. doi - 10.1016/j.biocon.2005.09.005.
39. Moreno, C. E., Calderon-Patron, J. M., Arroyo-Rodriguez, V., Barragan, F., Escobar, F., Gomez-Ortiz, Y., Martin-Regalado, N., Martinez-Falcon, A. P., Martinez-Morales, M. A., Mendoza, E., Ortega-Martinez, I. J., Perez-Hernandez, C. X., Pineda, E., Pineda-Lopez, R., Rios-Diaz, C. L., Rodriguez, P., Rosas, F., Schondube, J. E. & Zuria, I. (2017) Measuring biodiversity in the Anthropocene - a simple guide to helpful methods, *Biodiversity and Conservation,* 26(12), 2993-2998. doi -10.1007/s10531-017-1401-1.
40. Naturalista, Retrieved August 3, 2018 from https://www.naturalista.mx
41. Neotropical Birds, Retrieved August 5, 2018 from https://neotropical.birds.cornell.edu.
42. Ortega-Álvarez, R. & MacGregor-Fors, I. (2009). Living in the big city: effects of urban land-use on bird community structure, diversity, and composition. *Landscape Urban Planning,* 90, 189–195. doi - 10.1016/j.landurbplan.2008.11.003.
43. Ortega-Álvarez, R. & MacGregor-Fors, I. (2011). Dusting-off the file - A review of knowledge on urban ornithology in Latin America. *Landscape and Urban Planning,* 101(1), 1-10. doi -.1016/j.landurbplan.2010.12.020.

44. Palomera-García, C., Santana, E., Contreras-Martínez, S. & Amparán, R. (2007). Jalisco. In Ortiz-Pulido, R., Navarro-Sigüenza, A., Gómez de Silva, H., Rojas-Soto, O. & Peterson, T. A. (Eds.), *Avifaunas Estatales de México* (pp. 1-48). Pachuca- CIPAMEX.
45. Puga-Caballero, A., MacGregor-Fors, I. & Ortega-Álvarez, R. (2014). Birds at the urban fringe: avian community shifts in different peri-urban ecotones of a megacity. *Ecological Research*, 29(4), 619-628. doi -10.1007/s11284-014-1145-2.
46. Ralph, C. J., Geupel, G. R., Pyle, P., Martin, T. E. & DeSante, D.F. (1993). *Handbook of Field Methods for Monitoring Landbirds*. Albany –U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station.
47. Santana C., E., L. M. Rodríguez-Parga, S. Contreras-Martínez, H. Verdugo-Munguía, S. Hernández-Vázquez, O. Reyna-Bustos, J. H. Vega Rivera, K. Renton, J. E. Schondube, A. Langle, E. E. Martínez-Martínez, S. García Ruvalcaba, E. Iñigo Elías, J. A. Rodríguez-Durán y F. R. Zermeño-Núñez (2017). Aves. In: Comisión Nacional para el Conocimiento y Uso de la Biodiversidad (Ed.) *La biodiversidad en Jalisco* (pp. 309-325). Guadalajara –Gobierno de Jalisco.
48. Savard, J. P. L., Clergeau, P. & Mennechez, G.(2000). Biodiversity concepts and urban ecosystems. *Landscape and Urban Planning*, 48(3), 131-142.
49. Seress, G. & Liker, A. (2015). Habitat urbanization and its effects on birds. *Acta Zoologica Academiae Scientiarum Hungaricae,* 61(4), 373-408. doi -10.17109/AZH.61.4.373.2015.
50. Taylor, L., Taylor, C. & Davis, A. (2013). The impact of urbanization on avian species - The inextricable link between people and birds. *Urban Ecosystems,* 16(3), 481-498. doi -10.1007/s11252-012-0283-y.
51. Ter Braak, C. J. F. & Šmilauer, P. (2002). CANOCO reference manual and Cano Draw for Windows user’s guide: software for canonical community ordination (version 4.5) Microcomputer Power, USA.
52. United Nations (2017). *World Population Prospects. The 2017 revision*. New York –United Nations
53. Wolch, J. R., Byrne, J., & Newell, J. P. (2014). Urban green space, public health, and environmental justice: The challenge of making cities 'just green

enough'. *Landscape and Urban Planning*, 125, 234-244. doi - 10.1016/j.landurbplan.2014.01.017.

Appendix A. Species list of the species recorded in urban parks at GMA. Distribution= residents (R), winter visitor (W), summer resident (S), transient migrant (T), accidental (A). Origin= endemic (EN), exotic (EX), quasiendemic (QE), semiendemic (SE), nearctic (N), tropical (T), wide distribution (WD). NOM-059-SEMARNAT-2010= endangered (P), threatened (A), special protection (Pr), no category (SC). IUCN= vulnerable (VU), near threatened (NT), least concern (LC). Parks= Bosque Los Colomos (COL), Parque Metropolitano de Guadalajara (MET), Parque de la Solidaridad (SOL)

FAMILY **Order** Common name *Scientific name*	**Distribution**	**Origin**	**Trophic guild**	**Nom-059**	**The red list**	**Park**
ANSERIFORMES						
Anatidae						
Muscovy Duck *Cairina moschata*	R	T	O	P	LC	COL MET SOL
Blue-winged Teal *Spatula discors*	W	N	O	SC	LC	SOL
Mallard *Anas platyrhynchos*	R	N	O	SC	LC	MET SOL
PODICIPEDIFORMES						
Podicipedidae						
Least Grebe *Tachybaptus dominicus*	R	T	I	Pr	LC	SOL
COLUMBIFORMES						
Columbinae						
Rock Pidgeon *Columba livia*	R	EX	G	SC	LC	COL MET SOL
Eurasian Collared-Pidgeon *Streptopelia decaocto*	R	EX	G	SC	LC	MET SOL
Inca Dove *Columbina inca*	R	T	G	SC	LC	COL MET SOL
White-winged Dove *Zenaida asiatica*	R	T	G	SC	LC	COL MET SOL
Mourning Dove *Zenaida macroura*	R	WD	G	SC	LC	COL MET
CUCULIFORMES						
Cuculidae						
Squirrel Cuckoo *Piaya cayana*	R	T	I	SC	LC	COL
Groove-billed Ani	R	T	I	SC	LC	SOL

Crotophaga sulcirostris						
APODIFORMES						
Trochilidae						
Black-chinned Hummingbird *Archilochus alexandri*	W	SE	N		II	MET
Broad-tailed Hummingbird *Selasphorus platycercus*	W	SE	N	SC	LC	SOL
Broad-billed Hummingbird *Cynanthus latirostris*	R	SE	N	SC	LC	COL MET SOL
Berylline Hummingbird *Amazilia beryllina*	R	N	N	SC	LC	COL MET SOL
Violet-crowned Hummingbird *Amazilia violiceps*	R	SE	N	SC	LC	COL MET SOL
GRUIFORMES						
Rallidae						
Common Gallinule *Gallinula galeata*	R	WD		SC	LC	SOL
American Coot *Fulica americana*	R	WD		SC	LC	MET SOL
CHARADRIIFORMES						
Charadriidae						
Killdeer *Charadrius vociferus*	R	N	I	SC	LC	MET SOL
PELECANIFORMES						
Ardeidae						
Great Egret *Ardea alba*	R	WD	C	SC	LC	COL SOL
Cattle Egret *Bubulcus ibis*	R	EX	I	SC	LC	MET
Green Heron *Butorides virescens*	R	WD	C	SC	LC	SOL
Black-crowned Night-Heron *Nycticorax nycticorax*	R	WD	C	SC	LC	COL
Threskiornithidae						
White-faced Ibis *Plegadis chihi*	R	T	C	SC	LC	MET SOL
CATHARTIFORMES						
Cathartidae						
Black Vulture	R	WD	C	SC	LC	COL

Coragyps atratus						
Turkey Vulture *Cathartes aura*	R	WD	C	SC	LC	COL MET SOL
ACCIPITRIFORMES						
Accipitridae						
White-tailed Kite *Elanus leucurus*	R	T	C	SC	LC	SOL
Cooper's Hawk *Accipiter cooperii*	W	N	C	Pr	LC	COL SOL
White-tailed Hawk *Geranoaetus albicaudatus*	R	T	C	Pr	LC	MET
Zone-tailed Hawk *Buteo albonotatus*	W	T	C	Pr	LC	SOL
Red-tailed Hawk *Buteo jamaicensis*	R	N	C	SC	LC	COL MET
CORACIIFORMES						
Momotidae						
Russet-crowned Motmot *Momotus mexicanus*	R	QE	F	SC	LC	COL MET
PICIFORMES						
Picidae						
Acorn Woodpecker *Melanerpes formicivorus*	R	N	O	SC	LC	MET
Gila Woodpecker *Melanerpes uropygialis*	R	N	I	SC	LC	COL MET SOL
Golden-fronted Woodpecker *Melanerpes aurifrons*	R	N	I	SC	LC	SOL
Yellow-bellied Sapsucker *Sphyrapicus varius*	W	N	I	SC	LC	COL
Ladder-backed Woodpecker *Dryocopus scalaris*	R	N	I	SC	LC	COL SOL
PSITTACIFORMES						
Psittacidae						
Monk Parakeet *Myiopsitta monachus*	R	EX	G	SC	LC	MET SOL
Orange-fronted Parakeet *Eupsittula canicularis*	R	T	G	Pr	LC	COL
Brown-hooded Parrot *Pyrilia haematotis*	A	T	G	P	LC	COL
White-fronted Parrot	A	T	G	Pr	LC	COL

Amazona albifrons						
Lilac-crowned Parrot *Amazona finschi*	R	EN	G	P	VU	COL
Psittaculidae						
Budgerigar *Melopsittacus undulatus*	R	EX	G	SC	LC	SOL
PASSERIFORMES						
Tyrannidae						
Tufted Flycatcher *Mitrephanes phaeocercus*	R	T	I	SC	LC	COL
Greater Pewee *Contopus pertinax*	R	N	I	SC	LC	COL MET SOL
Western Wood-Pewee *Contopus sordidulus*	S	N	I	SC	LC	COL
Least Flycatcher *Empidonax minimus*	W	N	I	SC	LC	MET
Hammond's Flycatcher *Empidonax hammondii*	W	N	I	SC	LC	COL SOL
Gray Flycatcher *Empidonax wrightii*	W	SE	I	SC	LC	COL
Pine Flycatcher *Empidonax affinis*	R	QE	I	SC	LC	COL
Cordilleran Flycatcher *Empidonax occidentalis*	R	SE	I	SC	LC	COL MET
Black Phoebe *Sayornis nigricans*	R	WD	I	SC	LC	SOL
Vermillion Flycatcher *Pyrocephalus rubinus*	R	T	I	SC	LC	COL MET SOL
Ash-throated Flycatcher *Myiarchus cinerascens*	R	N	I	SC	LC	MET
Great Kiskadee *Pitangus sulphuratus*	R	T	O	SC	LC	COL MET SOL
Social Flycatcher *Myiozetetes similis*	R	T	I	SC	LC	COL MET SOL
Sulphur-bellied Flycatcher *Myiodynastes luteiventris*	S	T	I	SC	LC	COL
Tropical Kingbird *Tyrannus melancholicus*	R	T	I	SC	LC	SOL
Cassin's Kingbird *Tyrannus vociferans*	R	SE	I	SC	LC	COL MET SOL
Thick-billed Kingbird	R	SE	I	SC	LC	MET SOL

Tyrannus crassirostris						
Western Kingbird *Tyrannus verticalis*	T	N	I	SC	LC	MET
Laniidae						
Loggerhead Shrike *Lanius ludovicianus*	R	N	C	SC	LC	MET SOL
Vireonidae						
Hutton's Vireo *Vireo huttoni*	R	N	I	SC	LC	COL
Cassin's Vireo *Vireo cassinii*	W	SE	I	SC	LC	MET
Plumbeous Vireo *Vireo plumbeus*	R	N	I	SC	LC	MET SOL
Warbling Vireo *Vireo gilvus*	S	N	I	SC	LC	COL MET
Corvidae						
Black-throated Jay *Calocitta colliei*	R	EN	O	SC	LC	COL
Common Raven *Corvus corax*	R	N	O	SC	LC	COL
Hirundinidae						
Tree Swallow *Tachycineta bicolor*	W	N	I	SC	LC	SOL
Northern Rough-winged Swallow *Stelgidopteryx serripennis*	R	N	I	SC	LC	COL MET SOL
Cliff Swallow *Petrochelidon pyrrhonota*	S	N	I	SC	LC	COL MET SOL
Barn Swallow *Hirundo rustica*	R	WD	I	SC	LC	COL MET SOL
Troglodytidae						
House Wren *Troglodytes aedon*	R	N	I	SC	LC	COL SOL
Bewick's Wren *Thryomanes bewickii*	R	N	I	SC	LC	COL MET SOL
Polioptilidae						
Blue-gray Gnatcatcher *Polioptila caerulea*	W	WD	I	SC	LC	COL MET SOL
Regulidae						
Ruby-crowned Kinglet *Regulus calendula*	W	N	I	SC	LC	COL MET SOL

Turdidae						
Eastern Bluebird *Sialia sialis*	R	WD	I	SC	LC	COL
Swainson's Thrush *Catharus ustullatus*	W	N	I	SC	LC	COL
Rufous-backed Robin *Turdus rufopalliatus*	R	EN	I	SC	LC	COL MET SOL
Mimidae						
Blue Mockingbird *Melanotis caerulescens*	R	EN	I	SC	LC	COL MET
Gray Catbird *Dumetella carolinensis*	A	N	I	SC	LC	MET
Curve-billed Thrasher *Toxostoma curvirostre*	R	N	I	SC	LC	COL MET SOL
Northern Mockingbird *Mimus polyglottos*	R	N	I	SC	LC	MET
Sturnidae						
European Starling *Sturnus vulgaris*	R	EX	O	SC	LC	SOL
Passeridae						
House Sparrow *Passer domesticus*	R	EX	G	SC	LC	COL MET SOL
Fringillidae						
House Finch *Haemorhous mexicanus*	R	N	G	SC	LC	COL MET SOL
Lesser Goldfinch *Spinus psaltria*	R	T	G	SC	LC	MET SOL
Passerellidae						
Rufous-crowned Sparrow *Aimophila ruficeps*	R	N	G	SC	LC	MET SOL
Rusty-crowned Ground-Sparrow *Melozone kieneri*	R	EN	G	SC	LC	COL
Canyon Towhee *Melozone fusca*	R	N	G	SC	LC	COL MET SOL
Stripe-headed Sparrow *Peucaea ruficauda*	R	T	G	SC	LC	COL
Chipping Sparrow *Spizella passerina*	S	N	G	SC	LC	COL SOL
Lark Sparrow *Chondestes grammacus*	W	N	G	SC	LC	MET SOL

Lincoln's Sparrow *Melospiza lincolnii*	W	N	G	SC	LC	COL
Icteriidae						
Wellow-breasted Chat *Icteria virens*	T	N	I	SC	LC	COL
Icteridae						
Yellow-headed Blackbird *Xantocephalus xanthocephalus*	W	N	G	SC	LC	SOL
Orchard Oriole *Icterus spurius*	S	N	I	SC	LC	COL MET SOL
Hooded Oriole *Icterus cucullatus*	W	SE	I	SC	LC	COL MET SOL
Streak-backed Oriole *Icterus pustulatus*	R	T	I	SC	LC	COL MET SOL
Bullock's Oriole *Icterus bullockii*	W	SE	I	SC	LC	COL MET SOL
Scott's Oriole *Icterus parisorum*	R	SE	I	SC	LC	MET
Bronzed Cowbird *Molothrus aeneus*	R	N	G	SC	LC	COL MET SOL
Brown-headed Cowbird *Molothrus ater*	W	N	G	SC	LC	COL MET SOL
Great-tailed Grackle *Quiscalus mexicanus*	R	T	O	SC	LC	COL MET SOL
Parulidae						
Ovenbird *Seiurus aurocapilla*	W	N	I	SC	LC	COL
Black-and-white Warbler *Mniotilta varia*	W	N	I	SC	LC	COL MET SOL
Orange-crowned Warbler *Oreothlypis celata*	W	N	I	SC	LC	COL MET SOL
Nashville Warbler *Oreothlypis ruficapilla*	W	N	I	SC	LC	COL MET SOL
MacGillivray's Warbler *Geothlypis tolmiei*	W	N	I	A	LC	COL
American Redstart *Setophaga ruticilla*	W	N	I	SC	LC	COL SOL
Yellow Warbler *Setophaga petechia*	S	N	I	SC	LC	COL SOL
Yellow-rumped Warbler *Setophaga coronata*	W	N	I	SC	LC	COL MET SOL

Black-throated Gray Warbler *Setophaga nigrescens*	W	SE	I	SC	LC	COL MET SOL
Townsend's Warbler *Setophaga townsendi*	W	N	I	SC	LC	COL
Hermit Warbler *Setophaga occidentalis*	W	N	I	SC	LC	COL
Wilson's Warbler *Cardellina pusilla*	W	N	I	SC	LC	COL MET SOL
Painted Redstart *Myioborus pictus*	R	N	I	SC	LC	COL
Cardinalidae						
Hepatic Tanager *Piranga flava*	R	T	I	SC	LC	COL
Summer Tanager *Piranga rubra*	W	N	I	SC	LC	COL SOL
Western Tanager *Piranga ludoviciana*	W	N	I	SC	LC	COL MET SOL
Northern Cardinal *Cardinalis cardinalis*	A	N	G	SC	LC	COL
Black-headed Grosbeak *Pheucticus melanocephalus*	R	SE	I	SC	LC	COL SOL
Blue Grosbeak *Passerina caerulea*	R	WD	I	SC	LC	COL
Lazuli Bunting *Passerina amoena*	W	SE	G	SC	LC	COL
Varied Bunting *Passerina versicolor*	R	SE	G	SC	LC	COL SOL
Painted Bunting *Passerina ciris*	W	N	G	Pr	NT	COL
Thraupidae						
White-collared Seedeater *Sporophila torqueola*	R	EN	G	SC	LC	COL MET SOL

Capítulo III

Nest-site selection of birds in urban parks of Guadalajara, Jalisco, Mexico

Nest-site selection of birds in urban parks of Guadalajara, Jalisco, México

Kirey Aurora Barragán-Farías, Rudit Athziri Pérez-Casanova, Ana Luisa Santiago-Pérez, Francisco Javier Padilla-Ramírez, Verónica Carolina Rosas-Espinoza

K. A. Barragán-Farías, R. A. Pérez-Casanova, A. L. Santiago. Pérez, F. J. Padilla-Ramírez and V. C. Rosas-Espinoza (veronica.rosas@academicos.udg.mx), Centro Universitario de Ciencias Biológicas y Agropecuarias, Universidad de Guadalajara, Zapopan, Jalisco.

Abstract

Green spaces in urban areas offer opportunities for bird conservation. We present data on the nest-site characteristics of birds in urban parks of Guadalajara Metropolitan Area. We found 98 nests grouped into three categories. In the first group, we identified 17 species, the second group included several species of *Icterus,* and some species of the family Trochilidae formed the third group. The Parque Metropolitano had the highest number of nests with 39 followed by Parque de la Solidaridad and Bosque Los Colomos with 34 and 25, respectively. Nests were found mainly on Tasmanian Blue Gum (*Eucalyptus globulus*). Data on plant used for nesting, their height and DBH, as nest height was obtained. We also found two nests built on man-made structures. The analysis showed that species shared among parks, such as the Inca Dove (*Columbina inca*), look for the same characteristics to build their nest, regardless of the different resources offered by the park.

Keywords: urbanization, nest, breeding biology, bird reproduction, urban parks.

Introduction

Nests come in a wide variety of forms, structures and materials (Gill 2006). They vary from simple scrapes on the ground without any structure, to deep cups formed by a variety of natural materials or even artificial ones (Gill 2006; Hansell 2000). The form and material used to construct the nest depend on the bird species or genus (Collias 1997), the available resources (Ehrlich et al. 1988) and the habitat conditions (Reale and Blair 2005). The nest is a place for dependent young to develop, provision of a roosting chamber for adults tending their eggs and for young to be protected from predators (Gill 2006). Its structural characteristics, including size, thickness, mass, and volume influence nest thermal and humidity properties (Whittow and Berger 1977, Deeming 2011, Windsor et al. 2013). Birds build nests to provide a microclimate suitable for egg incubation (Gill 2006).

Besides nest material, birds select the nest site based on sun light, shade, prevailing breezes, and sheltering objects (Gill 2006). The site nest traits and the nest characteristics influence the risk of flooding, collapse, fall, predation (Cockle et al. 2011, Bailey et al. 2015) and competition (White et al. 2005). For example, cavity nesters, like woodpeckers, have preference for certain trees with specific characteristics in term of height, size, age, condition or specie (Acosta-Pérez et al. 2013). Minimally, a cavity must be sufficiently large to contain the nestlings (Cockle et al. 2011). All these factors determine the breeding success of the nesters (Gill 2006).

Urbanization leads to loss or modification of natural habitats (Marzluff et al. 2001), and exposes organisms to a new array of stressors that impose substantial constraints on their biology (Ditchkoff et al. 2006). Nonetheless, some birds, the urban exploiters, take advantage of the resources cities offer (Blair 1996).

Finding a proper nest site is a major factor for birds to settle and reproduce successfully. Especially, in urban environments where suitable nesting sites are reduced (Reale and Blair 2005, Jokimäki et al. 2017). Birds are forced to choose nesting locations that decrease their chances of success. Human disturbance influences decisions about nest locations either within or among seasons (Smith-Castro and Rodewald 2010) and represents a force that negatively affects the nesting success of several bird species, in particular those that require natural vegetation (López-Flores et al. 2009). For example, in urban condition, bird building nests at greater heights is caused by the absence of a well-developed understory of bushes and also by the impact of strollers, dogs and cats (Wysocki 2005). On the other side, the overall frequency of nest predation decreased with increasing levels of urbanization, because fewer predators exist (Reale and Blair 2005). Cavity-nesting birds may be especially sensitive to urbanization because they depend on snags for nesting, roosting, and foraging (Blewett and Marzluff 2005, Cockle et al. 2011).

Although descriptions of nest-site, nests and other aspects of the breeding biology are important aspects. We lack information for many species that breed in Mexico, especially in urban parks. The aim of this study is twofold: first to determine which bird species nest in the Guadalajara Metropolitan Area and second, to describe the nest-site characteristics. We anticipate that different species nest in every park due to its characteristics. In addition, Bosque Los Colomos and Parque de la Solidaridad harbor more nesting species due to their vegetation structure. Finally, more urban exploiters nest in the urban parks.

Methods

Study area

The study was conducted in the northwestern part of the Guadalajara Metropolitan Area (GMA). It is the second largest metropolitan area of Mexico and includes the counties of Guadalajara, Zapopan, Tonalá, San Pedro Tlaquepaque, Tlajomulco de Zúñiga, El Salto, Zapotlanejo e Ixtlahuacán de los Membrillos. The GMA covers 3,265.46 km^2 and houses more than 4.4 million habitants. However, only 22% of the GMA area is urbanized, yet 92.82% of the population lives there (IMEPLAN 2016). We chose the three largest urban parks of GMA; Bosque Los Colomos (COL) Parque Metropolitano de Guadalajara (MET) and Parque de la Solidaridad (SOL). They have almost the same size, between 90 and 110ha, but vegetation composition and structure are different. COL has vegetation like Pine Forest combined with patches of Eucalyptus trees (*Eucalyptus spp.*) and other species. MET has open grass areas with wooded areas. SOL has open areas with football fields, and some wooded areas of exotic and native species. The three parks also have a permanent source of water.

The avifauna found in each park is 91 species in COL with 61 resident species that could potentially nest in the park; MET with 74 and 54 reproductive; and SOL with 79 and 58 reproductive species (Barragán-Farías et al. unpublished data).

Nest search

From December 2016 to November 2017 we did a two-people search (6 hr.) beginning an hour after sunrise, once a month on each park. We followed the methods described by Ralph et al. (1993) for locating nests, and search in all different area of the park every month. Once we located a nest we recorded: date, location, nest substrate (tree, shrub, ground, and wall), plant species, life form, and plant condition (death or alive). In addition, we measured the diameter at breast height (DBH), and the tree height. We also recorded the bird species (if seen), nest type, nest localization (trunk, branch, end of branch), nest height, orientation. Lastly, we documented the nest with photos.

Nest type and location were described following Ehrlich et al. (1988). For nest and plant height we used a clinometer, and the data is in meters. For DBH we measured the perimeter and further calculated the diameter. We obtained the DBH for all trunks (at 1.30m), but only the one, were the nest was found, was used for analysis. Orientation was measured using the trunk as the center.

Statistical analysis

We used a Chi-square goodness of fit to compare the number of nesting species, total number of nests, month when nest was found, nest type, nest substrate and plant condition among parks. To compare tree height, nest height and DBH between species of the same park and shared species between parks we used a one-way Analysis of Variance (ANOVA). In case data did not fill homogeneity and normality assumptions, we did a Kruskal-Wallis non-parametric test. The Tukey test was used for a posteriori comparisons of means when the previous analyses indicated a significant difference. Analyses were performed using Minitab® Statistical Software (2010). We used Rayleigh's Test to test the null hypothesis that there is no sample mean direction in the nests of the species found in each park and between parks. For shared species among parks, we used the Watson-Williams Test for the equality of the means of two or more samples (Zar 2010). Due to the low number of nests of some species, the tests were realized only when there was enough data to analyze.

Results

We found 424 nests, including woodpecker's cavities in the three parks. MET had the highest number of nests with 178, followed by SOL and COL with 157 and 89, respectively. We only considered active and well identified nest for the study. For that reason, woodpecker's holes were eliminated since we were unable to differentiate between roosting and nesting cavities. There are three resident species of Orioles; the Orchard Oriole (*Icterus spurius*), the Streak-backed Oriole (*Icterus pustulatus*) and the Scott's Oriole (*Icterus parisorum*), when we were unable to identify which one built the nest, we designated it as *Icterus spp*. (Orioles). We could not specify an active month for these nests.

Table 1. Values or mean values (and standard error or mean angular deviation) of characteristics obtained from every species at every park. COL= Bosque Los Colomos, MET= Parque Metropolitano and SOL= Parque de la Solidaridad.

	Number nests	Three height (m)	DBH (cm^2)	Nest height (m)	Orientation
COL	25				
Columbina inca	4	16.71±7.32	37.08±21.15	9.69 ±3.79	226, 53.86
Trochilidae	1	16.09	43.61	3.32	173
Pyrocephalus rubinus	1	22.76	30.88	8.35	298
Pitangus sulphuratus	2	24.57±7.04	59.05±2.93	11.09 ±6.16	–
Myiozetetes similis	1	26.05	45.20	18.70	321
Thryomanes bewickii	3	26.92±13.58	50.77±20.35	16.06 ±8.83	156, 57.12
Turdus rufopalliatus	5	23.16±6.95	32.85±19.90	9.57 ±4.62	152, 54.95
Icterus sp.	7	25.49±11.86	50.77±20.35	16.06 ±8.83	221, 75.95
Icterus pustulatus	1	26.83	44.56	14.00	195
MET	39				
Columbina inca	11	17.04±9.89	43.81±45.9	7.95 ±3.88	203, 64.74
Trochilidae	1	5.19	18.78	4.65	100
Amazilia violiceps	1	19.7	64.30	9.92	16
Myiopsitta monachus	7	30.37±5.26	79.76±22.29	20.98 ±5.43	135, 63.56
Tyrannus vociferans	2	24.27±13.74	65.25±9.90	16.23 ±9.49	183, 16.94
Turdus rufopalliatus	10	17.68±12.89	30.68±22.13	10.61 ±7.51	284, 71.13
Melozone fusca	1	15.6	51.57	9.16	117
Icterus sp.	3	17.77±10.38	41.91±23.35	7.81 ±3.84	75, 39.19
Icterus pustulatus	3	30.09±2.71	60.96±1.11	14.36±1.79	171, 50.51
SOL	34				
Columbina inca	16	18.15±11.39	30.07±16.18	9.51 ±7.50	198, 64.93
Streptopelia decaocto	1	14.07	20.37	9.27	156
Trochilidae	2	15.11±0.39	28.65±3.60	8.44±3.68	100, 22.36
Cynanthus latirostris	1	13.09	21.33	4.69	165
Amazilia violiceps	1	15.79	35.01	9.94	52
Pyrocephalus rubinus	1	8.47	10.5	3.6	55
Turdus rufopalliatus	2	20.22±0.31	61.75±59.87	8.33 ±0.49	290
Toxostoma curvirostre	1	13.03	34.06	8.94	277
Passer domesticus	5	23.58±10.46	43.54±15.05	13.55±3.20	166, 68.92
Haemorhous mexicanus	1	34.19	49.02	18.77	49
Quiscalus mexicanus	1	19.67	41.06	16.11	217
Icterus sp.	2	34.52±6.16	53.48±21.61	25.64 ±8.34	324, 78.15

Also, we found a couple of nests that because of its size we labeled them as Trochilidae. We could not specify an active month for these nests. That left us with 98 nest total: 39 in MET, 34 in SOL and, 25 in COL, 39 in MET and 34 in SOL. In summary, the nests belonged to 17 species, Icterus spp. and Trochilidae (Table 1).

Bosque Los Colomos

We found 25 nests grouped in seven species, one genus and one family (Table 1). Breeding season in the park was from March to September (Table 2). There was differences among the number of nest found per month, being July the most numerous (Xi^2=23.4, gl=10, P<0.05). Of the nests 28% were constructed by Orioles, 20% by Rufous-backed Robin (*Turdus rufopalliatus*) and 16% by Inca Dove (*Columbina inca*). Based on nest form, we had eight pendant nests, eight cup ones, four saucer, three cavities and two spherical. There was no significant difference among the numbers of nest types. Most of the nests were constructed over three no-native tree species: Tasmanian Blue Gum (*Eucalyptus globulus*) (28%), Eucalyptus tree (*Eucalyptus spp*.)(24%), and Australian pine (*Casuarina equisetifolia*) (16%). The rest of the nests (32%) were found in four other species. Inca Dove and Rufous-backed Robin were the ones that used a greater number of different tree species as nest substrates (Table 3).

All but two nest where found in live trees and most of the nests (61%) were found on the trees secondary branches. The other two nests were found in man-made structures; inside an aluminum pipe of a fence and in a hole on a wall, and both were inhabited by Bewick's Wrens (*Thryomanes bewickii*).

Inca Dove, Orioles, Great Kiskadee and Rufous-backed Robin showed no difference at nest height, tree height or DBH. The Orioles showed no particular orientation when building their nest.

Table 2. Breeding calendar for the birds found in urban parks. Rectangles in gray indicate the extent of the breeding season reported in the literature for each species. Our

observations of breeding activities in the park are indicated with the number of nest found. COL= Bosque Los Colomos, MET= Parque Metropolitano and SOL= Parque de la Solidaridad.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
COL												
Columbina inca					1	1	1		1			
Pyrocephalus rubinus					1							
Pitangus sulphuratus			1				1					
Myiozetetes similis							1					
Thryomanes bewickii					1	1	1					
Turdus rufopalliatus					1	1	3					
Icterus pustulatus						1						
Total			1		4	4	7		1			
MET												
Columbina inca		1	1	2	2	1		1	2	1		
Amazilia violiceps							1					
Tyrannus vociferans						2						
Turdus rufopalliatus					1	4	5					
Melozone fusca						1						
Icterus pustulatus						1	2					
Total		1	1	2	3	9	8	1	2	1		
SOL												
Columbina inca	1		4			4	1	2	2	2		
Streptopelia decaocto								1				
Cynanthus latirostris								1				
Amazilia violiceps								1				
Pyrocephalus rubinus			1									
Turdus rufopalliatus					2							
Toxostoma curvirostre						1						
Passer domesticus			2	1	1				1			
Haemorhous mexicanus					1							
Quiscalus mexicanus				1								
Total	1		7	2	4	5	1	5	3	2		

Table 3. Nest type and nest substrate of each species found in urban parks. COL= Bosque Los Colomos, MET= Parque Metropolitano and SOL= Parque de la Solidaridad.

	Nest type	Nest substrate
COL		
Columbina inca	saucer	*Casuarina equisetifolia*
		Eucalyptus sp.
		Eucalyptus camaldulensis
		Pinus oocarpa
Trochilidae	cup	*Casuarina equisetifolia*
Pyrocephalus rubinus	cup	*Casuarina equisetifolia*
Pitangus sulphuratus	spherical	*Eucalyptus sp.*
		Eucalyptus globulus
Myiozetetes similis	spherical	*Eucalyptus globulus*
Thryomanes bewickii	cavity	*Eucalyptus sp.*
		Aluminum tube
		Wall
Turdus rufopalliatus	cup	*Eucalyptus globulus*
		Casuarina equisetifolia
		Fraxinus uhdei
		Eucalyptus sp.
Icterus sp.	pendant	*Eucalyptus sp.*
		Eucalyptus citrodora
		Eucalyptus globulus
Icterus pustulatus	pendant	*Eucalyptus globulus*
MET		
Columbina inca	saucer	*Eucalyptus camaldulensis*
		Eucalyptus globulus
		Ficus pertusa
		Jacaranda mimosifolia
		Pinus greggi
		Pithecellobium dulce
		Quercus magnoliifolia
Trochilidae	cup	*Lysiloma acapulcense*
Amazilia violiceps	cup	*Jacaranda mimosifolia*
Myiopsitta monachus	spherical	*Eucalyptus sp.*
		Eucalyptus globulus
Tyrannus vociferans	cup	*Eucalyptus globulus*
		Fraxinus uhdei
Turdus rufopalliatus	cup	*Cupressus lusitanica*
		Cupressus sempervirens
		Eucalyptus globulus
		Hibiscus tiliaceus
		Jacaranda mimosifolia
		Sapindus saponaria
Melozone fusca	cup	*Kigelia africana*
Icterus sp.	pendant	*Eucalyptus globulus*
		Lysiloma acapulcense
Icterus pustulatus	pendant	*Eucalyptus globulus*
SOL		
Columbina inca	saucer	*Ailanthus altissima*
		Bauhinia variegata
		Cedrela odorata
		Citrus aurantium

		Eucalyptus sp.
		Eucalyptus globulus
		Ficus benjamina
		Fraxinus uhdei
		Grevillea robusta
		Hura polyandra
		Jacaranda mimosifolia
		Pithecellobium dulce
Trochilidae	cup	*Casuarina equisetifolia*
		Jacaranda mimosifolia
Streptopelia decaocto	saucer	*Fraxinus uhdei*
Cynanthus latirostris	cup	*Jacaranda mimosifolia*
Amazilia violiceps	cup	*Jacaranda mimosifolia*
Pyrocephalus rubinus	cup	*Pithecellobium dulce*
Turdus rufopalliatus	cup	*Casuarina equisetifolia*
		Salix bonplandiana
Toxostoma curvirostre	cup	*Fraxinus uhdei*
Passer domesticus	spherical	*Eucalyptus sp.*
		Eucalyptus globulus
		Ficus benjamina
Haemorhous mexicanus	cup	*Eucalyptus sp.*
Quiscalus mexicanus	cup	*Grevillea robusta*
Icterus sp.	pendant	*Eucalyptus sp.*

Parque Metropolitano de Guadalajara

We found seven species, one genus and one family nesting in the park (Table 1). Breeding season comprise from February to October. Most of nests were founded in June (Table 2). For Monk Parakeets nest we were unable to determine breeding season, since they live in the nest year around (Navarro et al. 1992). The test showed difference among the number of nest found per month (Xi^2=20.23, gl=9, P<0.05). The majority of the nests found belong to Inca Dove (28%), Rufous-backed Robin (26%) and Monk Parakeet (*Myiopsitta monachus*) (18%). We found 15 cup nest, 11 saucer, seven spheres and six pendants. There was no significant difference between the number of nest types. All nests were found in live trees: 33%, in Tasmanian Blue Gum, 13% in Jacaranda (*Jacaranda mimosifolia*), and 10% in Eucalyptus trees. The remaining 44% belongs to 13 different species. Test show that frequencies in between trees are not equal. Sixty-nine percent of the nest were founded on trees secondary branches. Inca Dove used a greater number of tree species followed by Rufous-backed Robin (Table 3). Inca Dove, Streak-backed Oriole, Orioles, Monk Parakeet, Rufous-backed Robin and Cassin's Kingbird showed no difference among species in regard to tree height and DBH measurements, but there was a difference at nest height ($F=5.42$, gl=35, $P=0.001$). Tukey test for nest height indicated that Monk Parakeets build the higher nests, and Rufous-backed Robin, Inca Dove and Orioles formed a group with the lowest nest height. Inca Dove's nest do not distribute uniformly around the circle ($Z=2.92$, $P<0.05$); but Rufous-backed Robin and Monk Parakeets nest do.

Parque de la Solidaridad

We found 12 species, Orioles and Trochilidae nesting (Table 1). Breeding season in the park was from January to October, there was no difference among months. Most of the nests were found in March (Table 2). The more common species found nesting was Inca Dove (47%) and House Sparrow (*Passer domesticus*) (15%). We found 20 saucers nest, seven cups, five spheres and two pendants nest type. Test showed differences between the numbers of nest type found ($Xi^2=22.24$, gl=3, $P<0.05$). Like in MET all nest were founded in live trees, 94% of the nests were found in a secondary branch. The most common tree used as substrate was Eucalyptus trees (21%), Jacaranda (15%) and Weeping Fig (*Ficus benjamina*) (12%); the remaining 53% was founded in 11 other. There was no difference in the number of trees used by birds. Inca Dove was the one that used a greater number of different plant species (12 spp.). Orioles, House Sparrow, Inca Dove, Trochilidae and Rufous-backed Robin, showed no difference in regard to tree height and DBH measurements, but there was a difference at nest height ($F=2.96$, gl=26, $P=0.042$). Tukey test indicated that Orioles built the higher nest and Inca Dove the lowest ones. Inca Dove test of uniformity showed that this species orientation is distributed uniformity around the circle.

Differences among parks.

There was no statistically significant differences between the numbers of active nest, bird species, nest type or plant species between parks. The numbers of nest per month among parks are not statistically different. Only Inca Dove, Rufous-backed Robin and Orioles where present in all parks and had enough data to make a comparison among them regarding nest height, three height and DBH. There were no significant differences among the parks. The Watson-Williams test also showed no differences among nest orientation among parks.

Discussion

Even though there is a high number of species that could potentially nest in GMA urban parks, we only found 11% in COL, 13% in MET and 21% of SOL, and they were mostly common species to the urban areas (MacGregor 2010, Maya-Elizarrarás 2011). Among them we found the Rufous-backed Robin. This is a relevant species to Mexico's diversity since it is endemic. Considering that nest tend to be cryptic, isolated and hidden it was hard to find them; nest could be higher or nearer to the trunk. We saw a fledgling of a Black-headed Grosbeak (*Pheucticus melanocephalus*), and juveniles of Blue Mockingbird (*Melanotis caerulescens*) an endemic species to Mexico and Bronzed Cowbird (*Molothrus aeneus*) a parasitic species, among other, indicating that more species that the ones in this study nest and reproduce in the urban parks.

Most of the active nests were found in May-July, which corresponds to the breeding season of most resident birds in México (Howell and Webb 1995). Information from breeding seasons came from North America; there is a lack of information on the breeding season and biology in general for birds in Mexico. Information from tropical species that do not nest in North America as the Social Flycatcher or endemic as the Rufous-backed Robin is scarce (Carbó-Ramírez et al. 2015). Climate and habitat characteristics differences between other countries and Mexico could result in misleading information about breeding seasons or nesting requirements; resulting in poor management and conservation activities and the detrimental of Mexico's breeding species.

Overall, the most frequently used tree species in the parks was Tasmanian Blue Gum and Eucalyptus trees, which are the most common species in the parks. All but two nests (96/98) were founded in live trees. This could be the results of the scarcity of snags and dead trees, probably due to park management.

In the case of the remaining two nests, they were found in man-made structures, both of the same species, Bewick's Wren, a secondary cavity nester. The use of man-made structures by this species could be the result of the lack of appropriate natural cavities or a cavity of opportunity that does not affect its reproductive success. Although we did not analyze Woodpeckers holes (they are primary cavity nesters), we did registered them while on field. It is recommended, in order to enhance the productivity of cavity-nesting birds to leave dead trees that pose little safety risk, allowing snags to decay and fall where they will not harm property or endanger people, and replacing lost snags with appropriate nest boxes (Brewett and Marzluff 2005). This is also important since cavity nest left by woodpeckers are important for secondary cavity-nesters such as the Bewick's Wren or the Eastern Bluebird (*Sialia sialis*). The reproduction of this species is limited by available spaces, making them especially sensitive to some kinds of anthropogenic disturbance (Cockle et al. 2011).

Although we suggested that because of its vegetation complexity and that in a previous study COL bird richness was greater that in MET and SOL, we would found more nest and nesting species in that park, we did not. We think that because of that complexity; nest were not that easy to distinguish in COL. For example, the absence of

Trochilidae nests in COL could be related to limited floral resources. MET had the higher number of nest, it is a park with open areas, making it easier to detect them.

We suggested that due to the differences in vegetation structure, there will be different species nesting in each park. Parks shared three species and a family (Trochilidae), COL and MET shared one (Streak-backed Oriole), COL and SOL, and SOL and MET also one; Vermilion Flycatcher and Violet-crowned Hummingbird (*Amazilia violiceps*) respectively. The unique species in each park could be associated to a specific need that the park provides. For example, we found two exotic and urban exploiter species nesting in SOL: Eurasian Collared-Dove (*Streptopelia* decaocto) and House Sparrow (*Passer domesticus*), which are associated to more highly urbanized areas such as the surrounding of SOL, (which has an estimated of 93 inhabitant per hectare compared to the 25hab/ha of COL) (Blair, 1996). We only found Monk Parakeet in MET, which is a bird that prefers higher trees and has showed a preference for nesting in *Eucalyptus* trees (Navarro et al. 1992).

Although parks offer different habitat, food resources and nesting substrates, the Inca Dove, the Rufous-backed Robin and the Orioles; chose trees with the same height and DAP and built their nest at the same height. For example, the range of nest height average of the Rufous-backed Robin between parks was 2.28m (Max=10.6m, min=8.32m). COL has higher trees, but the Rufous-backed Robin built the nest at a height that is intrinsic to them.

Our study provides information about nesting sites in urban parks; it is important to continue the study of human impact in breeding birds, which is relevant especially in areas with high urbanization rates and where urban growth is not well planned or regulated, resulting in the reduction and degradation of habitat. Knowledge of the breeding season as well as nesting requirements, breeding biology and performance, causes of nest failure and reproductive success is fundamental in order to design adequate management and conservation strategies in urban parks to maintain resident breeding populations.

Although cities are not the best habitat, birds' adaptability allows them to tolerate disturbances such as human presence and noise (González-Oreja et al. 2012), lights (Lee et al. 2017), or trash (Suárez-Rodríguez et al. 2013) in order to reproduce in them. Urban parks are potential reservoir for biodiversity (Escobar-Ibáñez and MacGregor 2015) and can represent the only places where birds can find suitable nesting sites, along with resting and feeding opportunities. Because park managers must balance the competing interests of wildlife and recreational visitors at urban parks, understanding the ways that human disturbance can impact breeding birds is essential when making management decisions (Smith-Castro and Rodewald 2010). There is an urgent need to comprehend urbanization effects in wildlife in order to understand the ecological implication of it and learn how to mitigate its consequences.

It is possible to maintain or even improve breeding condition for bird in urban parks. After our study, we recommend maintenance activity in the parks should be adapted to avoid pruning in breeding season. Also, nest boxes can be provided in order to remedy the lack of dead trees in the parks; studies have shown that the provision of nest boxes often results in population increases, thereby making them a widely used and effective conservation tool (Mainwaring 2015).

References

Acosta-Pérez, V., Zuria, I., Castellanos, I. and Morena C. E. 2013. Características de las cavidades y los sustratos de anidación utilizados por el Carpintero Mexicano (*Picoides scalaris*) en dos localidades del centro de México. –Ornitol. Neotrop. 24: 107-111.

Bailey, I. E., Muth, F., Morgan, K., Meddle, S. L. And Healy, S. D. 2015. Birds build camouflaged nests. –Auk 132: 11-15.

Blair, R. B. 1996. Land use and avian species diversity along an urban gradient. –Ecol. Appl. 6: 506-519.

Blewett, C. M. And Marzluff, J. M. 2005. Effects of urban sprawl on snags and the abundance and productivity of cavity-nesting birds. –Condor 107: 678-693.

Cockle, K., Martin, K. And Wiebe, K. 2011. Selection of Nest Trees by Cavity-nesting Birds in the Neotropical Atlantic Forest. –Biotropica 43: 228-236.

Collias, N. E. 1997. On the origin and evolution of nest building by passerine birds. –Condor 99: 253-270.

Deeming, D. C. 2011. Importance of nest type on the regulation of humidity in bird nests. –Avian Biol. Res. 4: 23-31.

Ehrlich, P.R., Dobkin, D.S. and Wheye, D. 1988. The birder's handbook. A field guide to the natural history of north American birds. –Simon and Schuster Inc.

Escobar-Ibanez, J. F. and Macgregor-Fors, I. 2015. On a Tightrope: Use of Open Sky Urban Telephone Wires by Azure-crowned Hummingbirds (*Amazilia cyanocephala*) for Nesting. –Wilson J. Ornithol. 127: 297-302

Carbó-Ramírez, P., González-Arrieta, R. A. and Zuria, I. 2015. Breeding biology of the Rufous-backed Robin (*Turdus rufopalliatus*) in an urban area outside its original distribution range. –Wilson J. Ornithol.127: 515-521

Gill, F. 2006. Ornithology. –W. H. Freeman & Co.

González-Oreja, J. A., De La Fuente-Díaz-Ordaz, A. A., Hernández-Santin, L., Bonache-Regidor, C. and Buzo-Franco, D. 2012. Can human disturbance promote nestedness? Songbirds and noise in urban parks as a case study. –Landscape Urban Plan. 104: 9-18.

Hansell, M. 2000. Bird nest and construction behavior. –Cambridge University Press.

Howell, S. N. G. and Webb, S. 1995. A guide to birds of Mexico and Northern Central America. Oxford –Oxford University Press.

Instituto Metropolitano de Planeación (IMEPLAN). 2016. Plan de ordenamiento territorial metropolitano del Área Metropolitana de Guadalajara. –Instituto Metropolitano de Planeación.

Jokimäki, J., Suhonen, J., Vuorisalo, T., Kover, L. And Kaisanlahti-Jokimaki, M. L. 2017. Urbanization and nest-site selection of the Black-billed Magpie (Pica pica) populations in two Finnish cities: From a persecuted species to an urban exploiter. –Landscape Urban Plan. 157: 577-585.

Lee, J. G. H., MacGregor-Fors, I. and Yeh, P. J. 2017. Sunrise in the city: disentangling drivers of the avian dawn chorus onset in urban greenspaces. –J. Avian Biol. 48: 955-964.

López-Flores, V., MacGregor-Fors, I. and Schondube, J. E. 2009. Artificial nest predation along a Neotropical urban gradient. –Landscape Urban Plan. 92: 90-95.

MacGregor, I. 2010. Guía de aves del Bosque Los Colomos. –Comisión Nacional para el Conocimiento y Uso de la Biodiversidad.

Mainwaring, M. C. 2015. The use of man-made structures as nesting sites by birds: A review of the costs and benefits. –J. Nat. Conserv. 25: 17-22.

Mainwaring, M. C., Hartley, I. R., Lambrechts, M. M. and Deeming, D. C. 2014. The design and function of birds' nests. –Ecol. Evol. 4: 3909-3928.
Marzluff, J. M., Bowman, R. and Donnely, R. 2001. A historical perspective on urban bird research: trends, terms and approaches. –In: Marzluff, J. M., Bowman, R. and Donnely, R. (eds.), Avian ecology and conservation in an urbanizing world. Springer, pp. 19-47.
Maya-Elizarrarás, E. 2011. Aves explotadoras de áreas verdes urbanas: un ejemplo de la zona metropolitana de Guadalajara, Jalisco. –El canto del Centzontle 2: 104-109.
Minitab 17 Statistical Software. 2010. –Minitab, Inc.
Navarro, J. L., Martella, M. B. and Bucher, E.H. 1992. Breeding season and productivity of Monk Parakeets in Cordoba, Argentina. –Wilson J. Ornithol.103: 413-424.
Ralph, C. J., Geupel, G. R., Pyle, P., Martin, T. E. and DeSante, D.F. 1993. Handbook of Field Methods for Monitoring Landbirds. –U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station.
Reale, J.A. and Blair, R. B. 2005. Nesting success and life history attributes of bird communities along an urbanization gradient. –Urb. Hab. 3:1-24.
Smith-Castro, J. R. And Rodewald, A. D. 2010. Behavioral responses of nesting birds to human disturbance along recreational trails. –J. Field Ornithol. 81: 130-138.
Suárez-Rodríguez, M., López-Rull, I. and Macías G., C. 2016. Incorporation of cigarette butts into nests reduces nest ectoparasite load in urban birds: new ingredients for an old recipe? –Biol. Letters 9: 20120931.
White, T.H., Abreu-González, W., Toledo-González, M. and Torres-Báez, P. 2005. From the field: artificial nest cavities for *Amazona* parrots. –Wildlife Soc. B. 33: 756-760.
Whittow, G., and Berger, A. 1977. Heat loss from the nest of the Hawaiian Honeycreeper, "Amakihi". –Wilson J Ornithol. 89: 480-483.
Windsor, R. L., Fegely, J. L. And Ardia, D. R. 2013. The effects of nest size and insulation on thermal properties of tree swallow nests. –J. Avian Biol. 44: 305-310.
Wysocki, D. 2005. Nest site selection in the urban population of Blackbirds Turdus *merula* of Szczecin (NW Poland). -Acta Ornithol. 40: 61-69.
Zar, J. 2010. Biostatistical Analysis.New Jersey –Prentice Hall.
Zuria, I. and Rendón-Hernández, G. 2010. Notes on the breeding biology of common resident birds in an urbanized area of Hidalgo, México. –Huitzil 11: 35-41.

Capítulo IV

Description of a xanthochroic House Finch (*Haemorhous mexicanus*) from Jalisco, Mexico

Description of a xanthochroic House Finch (*Haemorhous mexicanus*) from Jalisco, Mexico

Kirey Aurora Barragán-Farías[1], Rudit Athziri Pérez-Casanova[1], Alejandra Galindo-Cruz[1], Jocelyn Hudon[2] and Verónica Carolina Rosas-Espinoza[1, 3]

[1]Centro Universitario de Ciencias Biológicas y Agropecuarias, Universidad de Guadalajara. Km 15.5 carretera Guadalajara-Nogales, Zapopan, Jalisco, C.P. 45110, México.

[2] Royal Alberta Museum, 9810 103A Ave NW, Edmonton, Alberta T5J 0G2, Canada.

[3]Corresponding author email: veronica.rosas@academicos.udg.mx

Abstract

Plumage coloration is important to birds for communication, camouflage, physiological processes and mate selection. In rare individuals the coloration is disrupted, which provides opportunities to scrutinize the processes that normally produce it. Male House Finches *(Haemorhous mexicanus)* normally sport a red head and chest, a brown back and whitish underparts with light brown streaks. We captured a House Finch with disruptions in both melanin and carotenoid pigmentation in an urban park in Guadalajara, a city in west-central Mexico. The bird was largely orange with little eumelanin pigmentation. This is the first record of which we are aware of a hypomelanistic House Finch with carotenoids that are abnormally distributed and with an overexpression of carotenoid pigments or pheomelanins or both.

Key words: carotenism, coloration, hypomelanism, Passeriformes, urban park, xanthochroism

Plumage coloration is important to birds for camouflage, various physiological processes (Bortolotti 2006), mate selection (Hill et al. 1999), and social signaling (Rohwer 1977, Senar 2006). In rare individuals, normal color patterns are disrupted, resulting in novel, aberrant phenotypes (van Grouw 2012, 2013). While these color variants are often one-off events, they can provide important clues about the processes involved in the normal development and expression of common phenotypes (van Grouw 2013). Some of these disruptions have genetic (Sage 1962, van Grouw 2006), while others have non-genetic bases (Sage 1962, van Grouw 2006, 2013).

Melanin produces most color patterns in birds (McGraw 2006b, van Grouw 2013, Galván et al. 2017), and a great number of genes control their expression (Mundy 2006, Roulin and Ducrest 2013, Bourgeois et al. 2016) and can potentially be disrupted. Non-genetic factors, like disease, injury, diet, or even age can also affect melanin pigmentation (Sage 1962, van Grouw 2006). Melanins exist in feathers as either eumelanin responsible for black, gray and dark brown tones, or pheomelanin, which produce reddish-brown to pale buff colors (van Grouw 2006, McGraw 2006b). In many birds, colors produced by melanins are enhanced by brightly-colored carotenoid pigments, which produce bright yellow, orange and red colors, and in combination with melanins, greenish tones (McGraw 2006a).

Most color abnormalities in birds involve the modification or absence of melanins, which makes birds appear lighter (Gross 1965a, van Grouw 2006, 2012), or an increase in melanins, resulting in darker phenotypes (Gross 1965b, van Grouw 2006, 2012). The total absence of melanins in feathers, eyes and skin is referred to as albinism; whereas the total lack of melanin in all or a subset of feathers or part of the skin is often referred to as leucism (van Grouw 2006, 2013). Hypomelanism is also sometimes used to describe this condition (Davis 2007). In Mexico, reports of bird color abnormalities such as albinism or leucism are not that uncommon, examples having been reported in Canyon Towhee (*Melozone fusca*) (López- Ortega and Carbó-Ramírez 2010), Curve-billed Thrasher (*Toxostoma curvirostre)* (Carbó-Ramírez et al. 2011), House Sparrow (*Passer domesticus*) (Rodríguez-Ruíz et al. 2014), and House Finch (*Haemorhous mexicanus*) (González-Arrieta and Zuria 2015).

Less commonly, pigment abnormalities affect the pigmentation by carotenoids. Since birds cannot synthesize these pigments on their own and must acquire them in their diet, aberrant yellow, orange, or red colors can result from dietary factors (Hill 1992, van Grouw 2006, Davis 2007). But abnormalities in carotenoid pigmentation, also called carotenism, can involve genetic changes resulting in (1) changes in the normal distribution of carotenoid pigments (Hudon 1997, Pittaway and Iron 2006, LeValley and Davis 2013); (2) increases or decreases in carotenoid concentration, resulting in a change in color or color intensity (Davis 2007); (3) changes in carotenoid pigment types and therefore a change in color (McGraw et al. 2004, Hudon et al. 2007) or a (4) total absence of carotenoids from all or part of the plumage or skin (Ericksson et al. 2008, Toomey et al. 2017). Carotenism is commonly registered in captive birds (van Grouw 2006), less so in the wild.

Rarely do color abnormalities in birds affect both plumage melanins and carotenoids (van Grouw 2006). We wish to report one such example, one where much of the eumelanin is missing and has been replaced by carotenoids or pheomelanin or both, so that carotenoids are not found where they normally would. To our knowledge this is the first report of a color variant of House Finch with changes in both melanins and carotenoids.

Observations

The city of Guadalajara is located in west-central Mexico. As part of a project on urban birds in the city, we made observations in fixed radius point counts and operated mist-nets in the city's three biggest parks (Metropolitano Park, Solidaridad Park and Bosque Los Colomos). On 8 July 2017 in Bosque Los Colomos (20°42'14.9" N, 103°23'32.5"

W) we observed several House Finches flying and moving between the shrubs and the ground. All of them had a normal coloration but at 10:50 am we captured in a mist net an individual House Finch with a very odd coloration. The bird presented an orange coloration over most of its body: head, chest, underparts, underwings, and amongst large gaps in melanin pigmentation on the back and wings (Fig. 1a-d). The residual eumelanin pigmentation appeared somewhat faded, except for the actively growing rectrices (Fig. 1b and 1e). The tips of the orange feathers on the head and back also appeared somewhat faded compared to their bases (Fig. 1a and 1b). The quality of the orange color varied somewhat across the bird's body. That on the head, rump, lesser wing coverts, underwings and underparts showed somewhat higher saturations (purity) than that on the flight feathers. The orange pigment appeared suffused amidst the feather matrix on some of the feathers, for example the shaft of the outermost left primary (Fig. 1c and 1d). The gaps in eumelanin on the wings and the back were largely non-symmetrical. The beak and legs were normally colored. Measurements were: bill, 12 mm; tarsus, 22 mm; wing chord, 81 mm; tail, 45 mm; mass, 23.3 g. Since we could not use color to sex the bird, we used Pyle's (1997) measurements; wing chord is consistent with the bird being a male (female: 70-80 mm, male: 73-83 mm). Tail length was shorter than expected because it was still growing (Fig. 1e). The individual was let go after we measured and photographed it. Unfortunately, we did not take any blood or feather sample at the time of the capture. Efforts to recapture the aberrant House Finch to sample feathers for chemical analysis failed even after we continued with our observations in fixed radius point counts and operating mist-nets in Bosque Los Colomos for four more months.

Discussion

House Finches are widely distributed in Mexico, occurring from the north to the south up to the states of Oaxaca and Veracruz. They are common in anthropic spaces such as parks or other green areas in urban centers. The House Finch is sexually dimorphic in color (Howell and Webb 1995). Both sexes produce melanins; males display, in addition, carotenoid-based ornamental plumage coloration (Hill et al. 1999), although some females can also have a light red color (Hill 1993).

The ventral carotenoid pigmentation varies in extent between populations across the species' distribution range, due to genetic differences (Hill 1993). Mexico has populations with small, medium and large red patches, although in the west-central part of the country the males show a medium-sized red patch (Hill 1993). The medium-sized patch in the males in our area varies in coloration from intense red to yellow (Fig. 1f, g). Variation in the color patch of male House Finches in general (from yellow to intense red) may partly reflect dietary intake of carotenoids or nutritional condition at the time of molt (Hill 1992, Hill and Montgomerie 1994). However, the type of variation exhibited by the aberrant male we captured was not of this nature, and also very different from a previous Mexican record from Pachuca city of a partial leucistic House Finch with whitish color on the nape, throat, belly, breast, wings, back, tail, and spots on the beak and legs' scales (González-Arrieta and Zuria 2015) or other examples of leucistic House Finches from North America (Ross 1963, 1973, Kielb 1996).

Indeed, the captured individual not only lacked the normal melanin pigmentation on its auriculars and underparts, it also lacked dark coloration on large areas of the wings and back. These areas instead had mostly orange tones, as did much of the rest of the plumage. The changes were such that the color patterns were hardly recognizable for a House Finch, with no discernable pattern on the face and underparts. Unfortunately, we were not able to conclusively establish the nature of the orange pigments involved. The orange coloration on the wings could conceivably be the product of pheomelanin, because of its relatively low saturation (Lubnow 1963). However, the orange coloration on much of the body, being more saturated, and not unlike that on some male House Finches in the area (Fig. 1f , g), advocates for the involvement of carotenoid pigments, even though the two types of pigments can be hard to differentiate based solely on color (see McGraw et al. 2004). Perceptible fading of the orange color on parts of the plumage and the diffuse distribution of the pigment apparent on some of the feathers (Fig. 1c, d) also support the contribution of carotenoids.

Since carotenoids did not only appear where they normally would on the plumage, especially if this is a male, both melanin and carotenoid deposition are affected in both color and place in this individual. Because the bird doesn’t simply lack one or the other or both types of melanins on parts of its plumage, and it did not consistently fail to produce one or the other melanin, it cannot be called leucistic or a dilution mutation (pastel or isabel) (van Grouw 2012, 2013). The apparent sensitivity of the melanin to sunlight may indicate a change in the quality of the pigment (van Grouw 2012, 2103), but since the color of the tail is not unusual, the bird probably is not an ino mutant either. The most significant aspect of this bird, a wide-ranging orange coloration, certainly qualifies it as xanthochroic, and if it is partly as a result of the loss of some of the melanins, also as schizochroic (Harrison 1963).

Given the complex mix of features exhibited by this bird, we are tempted to invoke a mutation in a regulatory gene controlling the expression of downstream “pigment” genes, some controlling melanin, others carotenoid, pigmentation. Generally, mutations in genes controlling melanin pigmentation do not affect carotenoid pigmentation (van Grouw 2006). However, there are examples of variant cardueline finches with disruptions in both melanin and carotenoid pigments. Yellow variants of the Evening Grosbeak (*Coccothraustes vespertinus*) that lack most of their melanin pigments and are largely yellow except for white flight feathers are occasionally observed in North America (Saunders 1958, Groesbeck 1969, Helleiner 1979, Hudon 1997). The distribution of yellow carotenoids on the body of these variants is quite uniform, including on the head, where typically the concentration of carotenoids varies markedly spatially (Hudon 1997).

In the Evening Grosbeak carotenoids are found in feathers where they are already suspected to occur naturally, if only in small amounts. But that is not always the case. In the Canary (*Serinus canaria*) for example, some varieties can be relatively uniformly yellow, when the wild type displays a variety of markings with little or no contribution from carotenoids, e.g., on the back. We note that the aberrant House Finch is not unlike some of the yellow variants in the Phaeo series of domesticated canaries (Cuevas 2010). Harrison (1963) provides additional examples of variant Eurasian Siskins (*Spinus spinus*) and European Greenfinches (*Chloris chloris*), also cardueline finches, with mostly yellow plumages. It is possible that in the absence of eumelanins, carotenoids could spread out; for example if carotenoid deposition were partly or largely under the epigenetic (indirect) control of melanin deposition in cardueline finches (Hudon 1997). It is unclear whether this process operates in birds other than cardueline finches.

Acknowledgments

We thank CONACYT and the University of Guadalajara for financial and logistic support. We especially thank Bosque Los Colomos to allow us to do bird surveys inside the park.

Literature cited

Bourgeois YXC, Bertrand JAM, Delahaie B, Cornuault J, Duval T, Milá B, Thébaud C. 2016. Candidate gene analysis suggests untapped genetic complexity in melanin-based pigmentation in birds. Journal of Heredity. 107:327–335.

Bortolotti GR. 2006. Natural selection and coloration: protection, concealment, advertisement, or deception? In: Hill GE, McGraw KJ, editors. Bird Coloration. Volume 2: Function and Evolution. Cambridge (Massachusetts): Harvard University Press. p. 3-35.

Carbó-Ramírez P, Romero-González P, Zuria I. 2011. Primer reporte para México de coloración aberrante (leucismo parcial) en el cuitlacoche pico curvo (*Toxostoma curvirostre*) [First report for Mexico of aberrant coloration (partial leucism) in Curve-billed Thrasher (*Toxostoma curvirostre*)]. Huitzil. 12:1–4.

Cuevas MR. 2010. Canarios de color. Los canarios lipocrómicos y melánicos. Barcelona (Spain): Hispano Europea.

Davis JN. 2007. Color abnormalities in birds: A proposed nomenclature for birders. Birding. 39:36–46.

Eriksson J, Larson G, Gunnarsson U, Bed'hom B, Tixier-Boichard M, Strömstedt L, Wright D, Jungerius A, Vereijken A, Randi E, Jensen P, Andersson L. 2008. Identification of the yellow skin gene reveals a hybrid origin of the domestic chicken. PLoS Genetics. 4:e1000010.

Galván I, García-Campa J, Negro JJ. 2017. Complex plumage patterns can be produced only with the contribution of melanins. Physiological and Biochemical Zoology. 90:600–604.

González-Arrieta RA, Zuria I. 2015. Coloración aberrante (leucismo parcial) en el pinzón mexicano (*Haemorhous mexicanus*) en una zona urbana del centro de México [Aberrant coloration (partial leucism) in the House Finch (*Haemorhous mexicanus*) in an urban area of central Mexico]. Acta Zoológica Mexicana (nueva serie). 31:318–320.

Groesbeck WM. 1969. Evening Grosbeak in unusual plumage at Hornell. Kingbird. 19:90-96.

Gross AO. 1965a. The incidence of albinism in North American birds. Bird Banding. 36:67–71.

Gross AO. 1965b. Melanism in North American birds. Bird Banding. 36:240–242.

Harrison CJO. 1963. Non-melanic, carotenistic, and allied variant plumages in birds. Bulletin of the British Ornithological Club. 83:90–96.

Helleiner CW. 1979. Xanthochroism in the Evening Grosbeak. Canadian Field-Naturalist. 93:66–67.

Hill GE. 1992. Proximate basis of variation in carotenoid pigmentation in male House Finches. The Auk. 109:1–12.

Hill GE. 1993. Geographic variation in the carotenoid plumage pigmentation of male house finches (*Carpodacus mexicanus*). Biological Journal of the Linnean Society. 49:63–86.

Hill GE, Montgomerie R. 1994. Plumage colour signals nutritional condition in the House Finch. Proceedings of the Royal Society of London B. 258:47-52.

Hill GE, Nolan PM, Stoehr AM. 1999. Pairing success relative to male plumage redness and pigment symmetry in the House Finch: temporal and geographic constancy. Behavioral Ecology. 1:48–53.

Howell SNG, Webb S. 1995. A guide to the birds of Mexico and northern Central America. New York (NY): Oxford University Press.

Hudon J. 1997. Non-melanic schizochroism in Alberta Evening Grosbeaks, *Coccothraustes vespertinus*. Canadian Field-Naturalist. 111:652–654.

Hudon J, Anciães M, Bertacche V, Stradi R. 2007. Plumage carotenoids of the Pintailed Manakin (*Ilicura militaris*): Evidence for the endogenous production of rhodoxanthin from a colour variant. Comparative Biochemistry and Physiology. 147: 402-411.

Inouye CY, Hill GE, Stradi RD, Montgomerie R. 2001. Carotenoid pigments in male House Finch plumage in relation to age, subspecies, and ornamental coloration. The Auk. 118:900-915.

Johnson DH, Krapu GL, Reinecke KJ, Jorde DG. 1985. An evaluation of condition indices for birds. Journal of Wildlife Management. 49:569–575.

Kielb MA. 1996. Nearly complete albino House Finch. Michigan Birds and Natural History. 3:234.

LeValley R, Davis JN. 2013. Carotenism in the Hairy Woodpecker. Western Birds. 44:85–87.

López-Ortega G, Carbó-Ramírez P. 2010. Primer caso de leucismo en un ave de la familia Emberizidae (*Pipilo fuscus*) para la ciudad de México [First case of leucism in a bird of Emberezidae family (*Pipilo fuscus*) in Mexico City]. Vertebrata Mexicana. 23:9–12.

Lubnow E. 1963. Melanine bei Vogel und Saugetieren [Melanin at bird and mammals]. Journal für Ornithologie. 104:69–81.

McGraw KJ. 2006a. Mechanics of carotenoid-based coloration. In: Hill GE, McGraw KJ, editors. Bird Coloration. Volume 1: Mechanisms and Measurements. Cambridge (Massachusetts): Harvard University Press. p. 177-242.

McGraw KJ. 2006b. Mechanics of melanin-based coloration. In: Hill GE, McGraw KJ, editors. Bird Coloration. Volume 1: Mechanisms and Measurements. Cambridge (Massachusetts): Harvard University Press. p. 243–294.

McGraw KJ, Wakamatsu K, Ito S, Nolan PM, Jouventin P, Dobson FS, Austic RE, Safran RJ, Siefferman LM, Hill GE, Parker RS. 2004. You can't judge a pigment by its color: Carotenoid and melanin content of yellow and brown feathers in swallows, bluebirds, penguins, and domestic chickens. Condor. 106:390–395.

Mundy NI. 2006. Genetic basis of color variation in wild birds. In: Hill GE, McGraw KJ, editors. Bird Coloration. Volume 1: Mechanisms and Measurements. Cambridge (Massachusetts): Harvard University Press. p. 469-506.

Pittaway R, Iron J. 2006. Erythristic Rose-breasted Grosbeak. Ontario Birds. 24:2–5.

Pyle P. 1997. Identification guide to North America birds. Part I. Point Reyes Station (CA): The Institute for Bird Populations.

Rodríguez-Ruiz ER, Valencia-Herverth J, Garza-Torres HA, Aguilar-Pérez C, López-Moctezuma L. 2014. Leucismo parcial en el gorrión casero *Passer domesticus* (Passeriformes: Passeridae) en México [Partial leucism in the House Sparrow *Passer domesticus* (Passeriformes: Passeridae) in Mexico]. Acta Zoológica Mexicana. 30:692–695.

Ross CC. 1963. Albinism among North American birds. Cassinia. 47:2–21.

Ross CC. 1973. Some additional records of albinism in North American birds. Cassinia. 54: 18–19.

Roulin A, Ducrest AL. 2013. Genetics of colouration in birds. Seminars in Cell and Developmental Biology. 24:594–608.

Rohwer S. 1977. Status signaling in Harris sparrows: some experiments in deception. Behavior. 61:107–129.

Sage BL. 1962. Albinism and melanism in birds. British Birds. 55:201–225.

Saunders AA. 1958. A yellow mutant of the Evening Grosbeak. The Auk. 75:101.

Senar JC. 2006. Color displays as intrasexual signals of aggression and dominance. In: Hill GE, McGraw KJ, editors. Bird Coloration. Volume 2: Function and Evolution. Cambridge (Massachusetts): Harvard University Press. p. 87-136.

Toomey MB, Lopes RJ, Araújo PM, Johnson JD, Gazda MA, Afonso S, Mota PG, Koch RE, Hill GE, Corbo JC, Carneiro M. 2017. High-density lipoprotein receptor SCARB1 is required for carotenoid coloration in birds. Proceedings of the National Academy of Sciences of the United States of America. 114:5219-5224.

van Grouw H. 2006. Not every white bird is an albino: sense and nonsense about colour aberrations in birds. Dutch Birding. 28:79–89.

van Grouw H. 2012. What colour is that sparrow? A case study: colour aberrations in the House Sparrow *Passer domesticus*. International Study of Sparrows. 36:30–55.

van Grouw H. 2013. What colour is that bird? The causes and recognition of common colour aberrations in birds. British Birds. 106:17–29.

Figure 1. a-e. Xanthochroic House Finch found in an urban park in Guadalajara, Jalisco, México. Photos by Kirey Barragán. f-g. Example of an orange male House Finch from the area. h. Example of a red male from the area.

Capítulo V

Conclusiones

Conclusiones

El presente estudio generó conocimiento acerca de las características y patrones de la comunidad de aves dentro de tres grandes parques urbanos en el Área Metropolitana de Guadalajara (AMG).

El objetivo general es describir las características y patrones de la comunidad de aves dentro del AMG. A pesar de ser la segunda urbe más grande del país, el conocimiento de la avifauna urbana del AMG es deficiente. Hay inventarios de algunos lugares como Bosque Los Colomos y la colonia Seattle, y estudios sobre las especies más comunes del AMG. Sin embargo, no existe un análisis de las variables que moldean a la comunidad de aves en el AMG

Como parte del primer objetivo, se determinó el efecto de las características de sitio y de paisaje en la comunidad de aves. Donde la abundancia y riqueza de árboles, y de arbustos son las variables que más influyeron en la comunidad de aves de los parques urbanos. Las diferencia en la estructura, composición y complejidad vegetal entre los parques muestreados permiten una mayor riqueza de aves. Se identificaron especies de aves que requieren de áreas abiertas como las que ofrece el Parque Metropolitano, y otras con requerimientos específicos asociados a arbustos y vegetación riparia como la que se encuentra en Bosque Los Colomos.

Como parte del segundo objetivo se describieron los sitios de anidación de 17 especies de aves en los parques urbanos. Se encontró que si bien los parques tienen una estructura y composición vegetal, y los recursos que ofrecen son diferentes, las aves eligen árboles con características similares a la hora de anidar y construyen su nido a la misma altura. Podemos afirmar que los parques urbanos ofrecen los recursos alimenticios y sitios de anidación necesarios para que las aves se reproduzcan en ellos.

En general, podemos concluir que la diversidad de especies arbóreas y, la presencia de diferentes estratos; son las variables más importante para la comunidad de aves en los parques urbanos del AMG. La vegetación determina la presencia o ausencia de ciertas especies, ofrece sitios para anidar, proporciona alimento y ofrece refugio. Los parques urbanos no son el hábitat ideal pero ofrecen a las aves un área donde alimentarse, refugiarse y reproducirse, por lo cual no deberían de subestimarse. Y es necesario mantener esas características para que las poblaciones de aves se mantengan.

Es importante, que esta información se incorpore al diseño, construcción y manejo de los parques urbanos; Aunque la mayoría de las actividades dentro de ellos están pensadas para seres humanos; sin tomar en cuenta las necesidades cualquier otro grupo biológico, estas recomendaciones determinarán la diversidad que sobrevive al continuo crecimiento urbano.

También es importante generar más información ya que este estudio solo aborda un par de aspectos dentro de la ecología urbana. Es importante conocer las repercusiones de la urbanización dentro de otros grupos biológicos como son mamíferos o insectos. También se recomienda analizar las afectaciones de otras actividades humanas como el ruido y las luces de la ciudad, y extender los estudios a otras áreas dentro y fuera de la matriz urbana.

Incluimos recomendaciones que pudieran incluirse en un futuro dentro Programa de Manejo de los parques urbanos, para mantener la comunidad de aves.

– *Preservar la vegetación de los parques urbanos.* es la característica principal que moldea a la comunidad de aves dentro de los parques urbanos, por lo que es necesario mantenerla o incluso incrementarla. La selección de especies de plantas podrían incrementan la diversidad de aves.
– *Manejo selectivo de la vegetación.* Las podas de pasto y arbustos afecta la presencia (o ausencia) de las aves. Por ejemplo: la presencia de pasto largo permite que especies granívoras tengan alimento.
– *Podas planificadas.* La cobertura vegetal ofrece materiales para la construcción del nido y disminuye su visibilidad. En consecuencia, las podas deben ejecutarse después de la época de anidación de la mayoría de las especies. Se recomienda a partir de septiembre.
– *Árboles muertos en pie*. Para las especies que anidan en cavidades este es un componente crítico para su reproducción y es escaso en los parques, lo cual puede llevar a una disminución en las poblaciones de estas aves. Para subsanar esta deficiencia se podrán ofrecer cajas nido para especies que anidan en cavidades, y ayudar a incrementar las tasas reproductivas de estas especies.
– *Mantenimiento de los cuerpos de agua.* Es necesario que se mantengan en buenas condiciones ya que esto favorece la presencia de especies acuáticas.
– *Monitoreo de poblaciones de aves.* El monitoreo continuo permitirá detectar conocer bajas y altas en las poblaciones residentes y también en las migratorias
– *Más estudios sobre la fauna urbana.* Este estudio solo involucró a las aves, pero es importante conocer la situación de otros grupos biológicos.

– *Educación ambiental.* Los parques urbanos tienen una función social, es importante tener dentro de ellos actividades de cultura ambiental que permitan no solo disfrutar de la naturaleza sino también aprender de ella. Los parques son el único contacto que muchos habitantes de la AMG tienen con la naturaleza.