



UPDATING THE DISTRIBUTION RANGE OF THE ENDANGERED BLACK-POLLED YELLOWTHROAT (*GEOTHYLPS SPECIOSA*)

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Abstract · The endemic and endangered Black-polled Yellowthroat (*Geothlypis speciosa*) resides in freshwater marshes within the Transvolcanic Belt in central Mexico. A decade-long extensive survey (2005–2015) on 238 wetlands within the historical species' range revealed that surviving populations are confined to five wetlands of central western Mexico. We provide an updated assessment of the actual distribution range of the species, including extant populations on the following wetlands: Ciénegas del Lerma, Lake Cuitzeo, Lake Yuriria, Lake Pátzcuaro, and Lake Zirahuén (a previously unreported location). The Cuitzeo, Yuriria, and Pátzcuaro populations are assumed to correspond to the distribution area of the *limnatis* subspecies, whereas the easternmost population confirmed at Ciénegas del Lerma correspond to the distribution area of the *speciosa* subspecies. We estimated the overall habitat availability for the species at 94.95 km², and more than half (59.2%) of it is found at Lake Cuitzeo, while Lake Zirahuén holds the lowest extent ($\leq 1\%$). The species long term survival will require urgent actions that include: (a) protection and restoration of marsh habitat for all the wetlands where the species remains, (b) implementation of specific controls for burning and illegal harvesting of aquatic plants, (c) an estimate of the population size at the five remaining sites, (d) an assessment of the degree of isolation among the remaining populations, (e) confirmation of its presence at Ciénega de Tláhuac, and (f) reintroduction to man-made and restored wetlands within the historical range. Research effort should continue to determine basic ecological requirements, the degree of inbreeding, and nesting requirements for all extant populations.

Resumen · Actualizando el rango de distribución de la Mascarita Transvolcánica (*Geothlypis speciosa*)

La Mascarita Transvolcánica (*Geothlypis speciosa*), una especie endémica y en peligro de extinción, reside en humedales del Eje Neovolcánico Transversal en el centro de México. Un muestreo a lo largo de una década (2005 a 2015) en 238 humedales dentro de su rango histórico, reveló que la mayoría de las poblaciones sobrevivientes se encuentran en cinco humedales del centro occidente de México. Proveemos una evaluación actualizada del rango de distribución de la especie, incluyendo poblaciones existentes en los siguientes humedales: Ciénegas del Lerma, Lago Cuitzeo, Laguna de Yuriria, Lago de Pátzcuaro y Lago Zirahuén (una localidad no reportada previamente). Asumimos que las poblaciones de Cuitzeo, Yuriria y Pátzcuaro corresponden al área de distribución de la subespecie *limnatis*, mientras que la población más oriental confirmada en Ciénegas del Lerma corresponde al área de distribución de la subespecie *speciosa*. Estimamos la disponibilidad de hábitat para la especie en 94,95 km², más de la mitad (59,2%) encontrándose en Lago Cuitzeo, mientras que Lago Zirahuén mantiene la más baja ($\leq 1\%$). La sobrevivencia a largo plazo de la especie requerirá acciones urgentes que incluyan: (a) protección y restauración de hábitat en todos los humedales donde la especie permanece, (b) implementación de controles específicos para quemas y cosecha ilegal de plantas acuáticas, (c) una estimación del tamaño poblacional en los cinco sitios restantes, (d) una evaluación del grado de aislamiento entre las poblaciones restantes, (e) la confirmación de su presencia en Ciénega de Tláhuac y (f) reintroducción a humedales artificiales y restaurados dentro del rango histórico de distribución. Los esfuerzos de investigación deben continuar para determinar los requerimientos ecológicos básicos, el grado de endogamia y los requerimientos de anidación en todas las poblaciones existentes.

Key words: Conservation · Distribution · *Geothlypis speciosa* · Mexico · Threatened species · Wetlands

INTRODUCTION

The Black-polled Yellowthroat (*Geothlypis speciosa*) is one of the most critically endangered species in Mexico and a flagship for bird conservation (Ramírez-Bastida et al. 2008). However, very little is known about its popula-

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tion abundance, life history traits, and habitat requirements (Chávez-León & Finch 1999, Morrone 2000, Talonia & Escalante 2013). It is a specialized wetland species with a limited distribution in central Mexico, restricted to lakeshore and river marshes comprising cattails and bulrushes within a small portion of the Transvolcanic Belt (Dickerman 1970, Escalante 1997, Morrone 2000, Escalante et al. 2009, Talonia & Escalante 2013, NatureServe & IUCN 2016). The species has been historically reported from 10 locations (east to west): Lake Texcoco (Estado de México), Ciénega de Tláhuac (Ciudad de México), Lake Zumpango (Estado de México), Ciénegas del Lerma (Estado de México), Presa Solís (Guanajuato), Lake Cuitzeo (Michoacán/Guanajuato), Álvaro Obregón (Michoacán), Lake Yuriria (Guanajuato), Rio Lerma around Salamanca (Guanajuato), and Lake Pátzcuaro, Michoacán (Edwards & Martin 1955, Dickerman 1970, Ayala-Pérez et al. 2013, Lecroy 2013, NatureServe & IUCN 2016). However, its actual range is unknown; Dickerson (1970) estimated the geographic distribution at approximately 3925 km², 16% (617 km²) corresponding to the *speciosa* subspecies and 84% (3308 km²) to the *limnatis* subspecies, while Navarro-Sigüenza & Peterson (2007) using niche modeling methods proposed a potential distribution area of 19,700 km², comprised of three large, discontinuous blocks (Figure 1).

Today, only populations from four areas seem to remain (Ciénegas del Lerma, Lake Pátzcuaro, Lake Cuitzeo, and Yuriria) while those from Lake Texcoco, Lake Zumpango, and Presa Solís have been extirpated (Collar et al. 1997, Alcántara & Escalante 2005, NatureServe & IUCN 2016). Although the species was recently reported in Ciénega de Tláhuac (Estado de México), no further information exists for this observation (Ayala-Pérez et al. 2013). While a global assessment of the species status is lacking (populations have not been surveyed since the 1980s), an estimation based on a close relative (*Geothlypis trichas*) with similar body size indicates that the population of mature individuals may range between 1500–7000 (Stattersfield et al. 1998, NatureServe & IUCN 2016). The species is believed to be declining rapidly because of habitat loss and degradation, particularly at the eastern and northern edge of their historical distribution, due to replacement of marshes with crops, increasing water supply for large cities, and falling water levels through drainage and natural build-up of organic material (Collar et al. 1997, NatureServe & IUCN 2016).

Geothlypis speciosa ranks at the top of vulnerability values among Mexican birds, being threatened by urbanization, agriculture, habitat degradation, and climate change. Due to its very small range and specific habitat requirements, the species is considered as endangered by the IUCN Red List, and is also considered as at risk of extinction under the Mexican legislation (Berlanga et al. 2010, SEMARNAT 2010, NatureServe & IUCN 2016). The priority actions for research and conservation of the species are to

determine its precise distribution, to estimate population size in extant areas, to detect new populations, and to propose areas for protection (Escalante 2000, NatureServe & IUCN 2016). Furthermore, conservation of endangered species greatly relies on the accurate estimation of its distribution range (Campos-Cerqueira & Aide 2016). Addressing those concerns, here we present the results from extensive field surveys to update its distribution range.

METHODS

We surveyed all potentially occupied wetland habitat in central Mexico (341 survey points within 238 distinct wetlands within a 50 km-radius of the 10 known extant and historical distribution areas), through a combination of look-see surveys and playback, starting at first light (around 06:30 h), systematically scanning with binoculars and telescopes from vantage points (Bibby et al. 2000). Playback was based on a recording obtained from a singing (reproductive) male in Ciénegas de Lerma, looped for a 10-minute interval and played through portable speakers and MP3 player. To maximize the chances of detecting singing males, we limited field surveys to March–October 2005–2014 (for reproductive records, see Lea & Edwards 1950, Edwards & Martin 1955, Dickerman 1970, Escalante 1997). We surveyed at least twice those sites with suitable habitat (emergent vegetation), and at least once all potential sites with no suitable habitat (e.g., devoid of vegetation), accessing them by vehicle, on foot, or by boat.

During March–June 2015–2017, we visited, on at least on two occasions, 17 additional sites where the species had been observed or collected (that we had not surveyed previously), as reported in databases, peer-reviewed papers, books, and reports. As *G. speciosa* can be easily confused with the sympatric *G. trichas* if the observer is not familiar with the species (see Howell & Webb 1995), we used only research-grade field records (uploaded by research personnel at established institutions, iNaturalist 2017) from online databases by CONABIO, GBIF, iNaturalist, UNAM Collections, and VertNet. To obtain a landscape level estimate of available habitat for the species, we consulted available sources that calculated the area of freshwater marshes where the species was recorded as present; if no information was available, we estimated the extent of the habitat using GPS units in the field, accessing the marshes by kayak.

RESULTS AND DISCUSSION

We noticed the absence of *G. speciosa* in 233 sites and obtained evidence of presence in 62 sites (the latter contained within five lakes: Ciénegas del Lerma, Lake Cuitzeo, Lake Yuriria, Lake Pátzcuaro, and Lake Zirahuén (Figure 1). The first four areas are known current distribution areas, but Lake Zirahuén (Michoacán) constitutes a new locality, not reported previously as a distribution area for the species, rep-

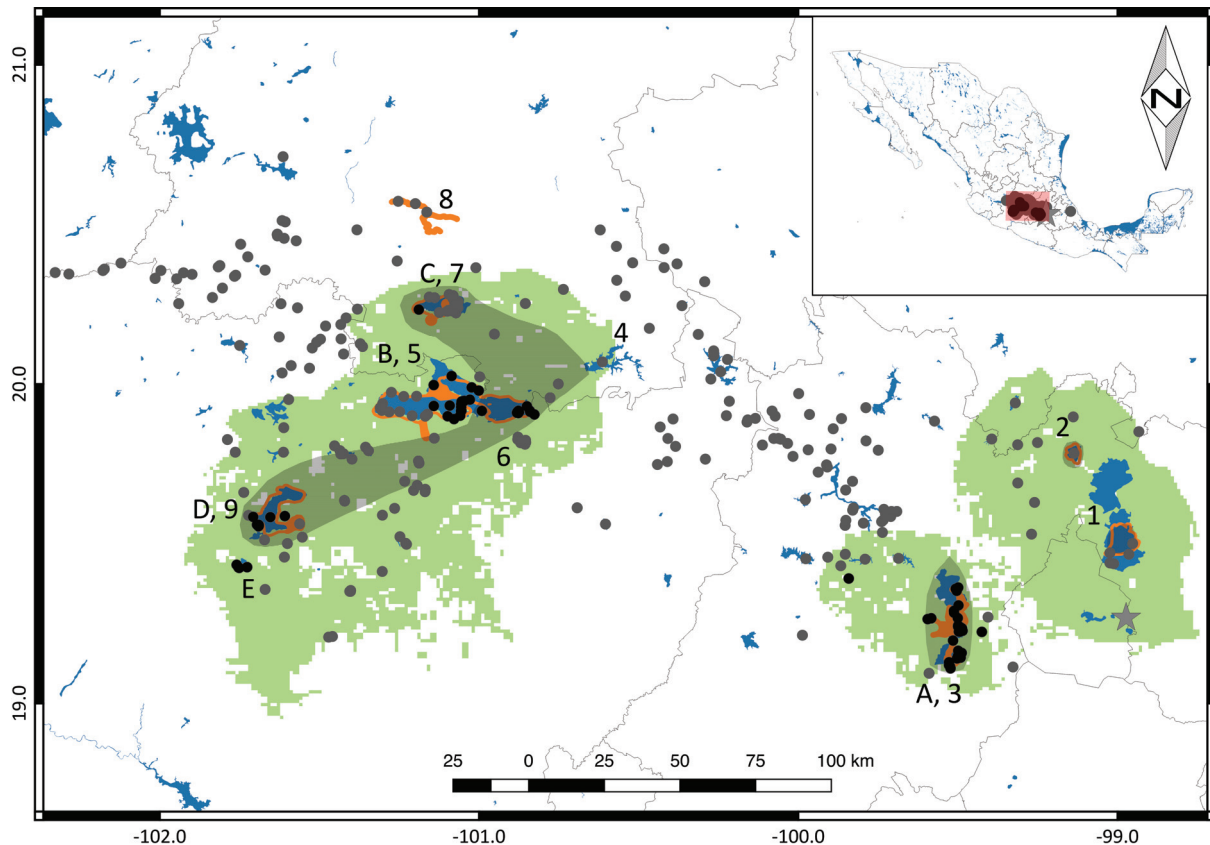


Figure 1. Records of absence (gray dots) and presence (black dots) of the Black-poll'd Yellowthroat (*Geothlypis speciosa*) in Mexico: A) Ciénegas de Lerma, B) Lake Cuitzeo, C) Lake Yuriria, D) Lake Pátzcuaro, E) Lake Zirahuén. Historical records sites: 1) Lake Texcoco, 2) Lake Zumpango, 3) Ciénegas del Lerma, 4) Presa Solís, 5) Lake Cuitzeo, 6) Álvaro Obregón, 7) Lake Yuriria, 8) Rio Lerma around Salamanca, 9) Lake Pátzcuaro. Historical distribution sites by NatureServe & IUCN (2016) in orange lines, potential distribution by Navarro-Sigüenza & Peterson (2007) in green; horizontal lines correspond to the distribution of *G. s. speciosa*, oblique lines correspond to *G. s. limnatis* (Dickerman 1970). Gray star represents an unconfirmed (by this study) location reported by Ayala-Pérez et al (2003).

representing the first record for this site. The historical distribution areas Lake Texcoco, Lake Zumpango, Álvaro Obregón, Presa Solís, and Rio Lerma around Salamanca, did not contain suitable habitat, and we did not record the presence of the species. The extent of freshwater marshes with suitable habitat for the species in the five areas with confirmed presence was estimated at 94.9 km² (Table 1). Lake Yuriria, Lake Cuitzeo, and Lake Pátzcuaro correspond to the distribution area of the *limnatis* subspecies; Ciénegas del Lerma corresponds to the distribution area of the *speciosa* subspecies (Dickerman 1970, Figure 1, Table 1).

In Lake Yuriria, we recorded a single male in 2008 in the marsh near the southwestern corner of the lake (20°14'0"N, 101°11'19"W) but since that first record, we were unable to obtain any further records for the species during the years after, despite intensive search efforts during 2009–2012, 2015, and 2016. We recommend that further search efforts take place to confirm its local status. In Lake Cuitzeo, we recorded groups of *G. speciosa* on marshes to the southeast near San Bartolomé Coro (19°54'47"N, 100°52'45"W), in the central portion near Chehuayo

(19°56'42"N, 101°03'12"W), and in the marshes on the northern lakeshore near Santa Ana Maya (19°59'23"N, 101°01'23"W). Despite intensive search efforts, we did not record the species in the lake west of Federal Highway 43D, and we assume that the distribution range should not include this zone. In Lake Pátzcuaro, we found the species on marshes around Jarácuaro Island (19°33'30"N, 101°41'24"W). In Ciénegas del Lerma, we observed them at marshes in Lerma (19°08'27"N, 99°30'11"W), Almoloya (19°14'27"N, 99°29'58"W), and Atarasquillo (19°21'09"N, 99°30'14"W). We consider the cluster of these three marshes as a single system (separated around 2300 m from each other). Their connectivity has to be evaluated in terms of the maximum distance that the individuals move among the sites, because the sites are separated by roads and, even though they form part of a protected area (Ciénegas de Lerma), human activity around the sites is intense (Ceballos 2003). A specimen collected in Zirahuén in 1985 and housed in the bird collection at the Universidad Michoacana de San Nicolás de Hidalgo, provided evidence to include Lake Zirahuén in the survey effort. Unfortunately, the specimen lacked geographi-

Table 1. Wetlands with current presence of Black-pollled Yellowthroat (*Geothlypis speciosa*) in Mexico, information on habitat extent, and proportion of survey points where the species was detected for each site and as a percentage of the total number of survey points. * Based on the distribution proposed by Dickerman (1970).

Extant population	State	Subspecies*	Freshwater marsh surface (km ²)	Proportion of marsh habitat in extant sites	Proportion of survey points with presence	Proportion of total presence records
Ciénegas del Lerma	Estado de México	<i>speciosa</i>	5.88 (SEMARNAP-UNAM 2000)	6.6%	93.8%	33.7%
Lake Cuitzeo	Michoacán, Guanajuato	<i>limnatis</i>	50.56 (Sagardia 2005)	56.6%	78.8%	46.1%
Lake Yuriria	Guanajuato	<i>limnatis</i>	14.19 (CONABIO 2012)	15.9%	6.7%	1.1%
Lake Pátzcuaro	Michoacán	<i>limnatis</i>	18.58 (Huerto et al. 2008)	20.8%	92.9%	14.6%
Lake Zirahuén	Michoacán	<i>limnatis</i>	0.11 (this study)	0.1%	100%	4.5%

cal references and habitat description, making it difficult to determine if the actual records confirming the species' presence correspond to marshes of the same section of the lake. In Zirahuén, we recorded the species consistently during 2005–2008, 2010–2014, and 2016–2017 in the southern marshes in Agua Verde (19°25'32"N, 101°45'12"W) and obtained photographic records (Figure 2). A study to determine the population size of the species in this lake is currently underway. Unfortunately, we were not able to survey Ciénega de Tláhuac to evaluate the species' occurrence (see report by Ayala-Pérez et al. 2013).

Marsh vegetation still remains in the sites where *G. speciosa* is present (Table 1); in Lake Zirahuén, where the habitat extension is the smallest, marshes are located in small strips along south and eastern shores, and in small fragments along other regions of the shoreline (Madrigal et al. 2004). The sites where the species is present are valuable and irreplaceable in terms of biodiversity. These sites are home to several endemic fish and amphibians and provide suitable wintering and stopover habitat for migrant North American waterbirds (Chacón & Rosas-Monge 1998, Manterola & Gurrola-Hidalgo 1999, Villaseñor et al. 1999, Ceballos 2003, Chacón et al. 2004, Rendón-López et al. 2005, López et al. 2010). Lake Yuriria, Lake Pátzcuaro, and Ciénegas de Lerma are listed as Ramsar sites; although not designated, Lake Cuitzeo surpasses waterbird population thresholds for designation as such (Pérez-Arteaga et al. 2002). These sites are Important Bird and Biodiversity Areas (IBA's) and Endemic Bird Areas (EBA's) (Villaseñor et al. 1999, NatureServe & IUCN 2016).

All sites have been under intense exploitation since pre-Columbian times, through drainage for human water consumption, road construction, deforestation, high sediment loads, invasive water hyacinth (*Eichornia crassipes*) and giant reed (*Arundo donax*), industrial, agricultural, and urban sewage and gar-

bage, and overexploitation of fish and emergent vegetation, which threaten flora and fauna in general (Rojas-Moreno & Novelo-Retana 1995, Villaseñor et al. 1999, Maderey & Jiménez 2000, Arriaga et al. 2002, Ceballos 2003, Chacón et al. 2004, Madrigal et al. 2004, Rzedowski 2006, López et al. 2010). During our field observations, we noticed that burning marshes at Lake Cuitzeo is a common practice, to open the lush marshes for navigation channels and to increase availability of cattail (*Typha* spp.) regrowth for harvest and cattle, which forage in the shallow margins of the lake throughout the year. Cattle also forage at Lake Pátzcuaro around Jarácuaro Island where *G. speciosa* is present. In Lake Yuriria, Lake Cuitzeo, and Lake Zirahuén, extraction of cattail for handcrafts occurs all year; at Lake Zirahuén it is not common, but extraction of bulrush (*Scirpus* spp.) also takes place occasionally. We did not obtain presence records from other sites where the species had been historically recorded, which constitute further evidence of the isolation of this species within wetlands and the critical importance of its conservation.

Even though central Mexico has been intensively studied from the ornithological perspective, updated assessments concerning the abundance and distribution of rare and endemic birds, such as *G. speciosa*, are still necessary. Without such information it is not possible to design specific conservation aims for this globally threatened species (Pérez-Arteaga et al. 2002, Sekercioglu 2006, Larsen 2016, Moreno et al. 2016). Updating presence records is fundamental for this endangered species, and future endeavors in addition to distributional assessments should also characterize seasonal habitat use and to determine the dispersion potential of individuals. We assume that the species persistence in the Lake Cuitzeo marshes may depend on their ability to disperse among suitable habitat fragments when some areas are affected by temporal human-caused fires. The



Figure 2. Photographic record of a Black-polled Yellowthroat (*Geothlypis speciosa*) adult male in Lake Zirahuén, Michoacán, Mexico, 2014 (photograph by A. Pérez-Arteaga).

species actual survival in the area is only explained by its adaptation to a habitat that is dynamic, changing its suitability in time and space. These records may constitute the base for the construction of sources and sinks models, focused on determining the limits of their potential distribution as occurs in other avian species that require similar habitats, or other warbler species with similar life history traits (Peterson et al. 2016, Toews 2017, Villagómez et al. 2017). The degree to which the species may resist an increase in disturbance and their minimum amount of suitable habitat required is unknown. Although the species seems to be moderately common at Lake Cuitzeo, Lake Pátzcuaro, and Ciénegas del Lerma, their populations located at Lake Yuriria and Lake Zirahuén exhibit a dangerously low abundance, indicating that human assistance may be required, including potential translocation and/or population reinforcements.

In general, our study presents the only range-wide and updated distribution assessment of this globally

endangered species supported by extensive field effort. In particular, we propose the following research and conservation recommendations for the species recovery and survival: (a) protect and restore marsh habitat for all the wetlands where the species remains, (b) implement specific controls for burning and illegal harvesting of aquatic plants, (c) estimate population size, nesting habitat, productivity, and survival at the five remaining populations, (d) assess the degree of isolation among the remaining populations, (e) confirm its presence at Ciénega de Tláhuac, and (f) evaluate status and, if feasible, reintroduce to man-made and restored wetlands within the historical range, to increase the number of populations.

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REFERENCES

- Alcántara, J & LP Escalante (2005) Current threats to the Lake Texcoco, Globally Important Bird Area. *USDA Forest Service General Technical Report* 191: 1143–1150.
- Arriaga, L, V Aguilar & J Alcocer (2002) *Aguas continentales y diversidad biológica de México*. Comisión Nacional para el Conocimiento y Uso de la Biodiversidad, Ciudad de México, México.
- Ayala-Pérez, A, N Arce & R Carmona (2013) Spatio-temporal distribution of wintering aquatic birds in the Ciénega de Tláhuac, Chalco lacustrine plain, Mexico. *Revista Mexicana de Biodiversidad* 84: 327–337.
- Berlanga, H, JA Kennedy, TD Rich, MC Arizmendi, CJ Beardmore, PJ Blancher, GS Butcher, AR Couturier, AA Dayer, DW Demarest, WE Easton, M Gustafson, E Iñigo-Elias, EA Krebs, AO Panjabi, V Rodríguez-Contreras, KV Rosenberg, JM Ruth, E Santana-Castellón, R Vidal & T Will (2010) *Conservando a nuestras aves compartidas: La visión trinacional de Compañeros en Vuelo para la conservación de las aves terrestres*. Cornell Lab of Ornithology, Ithaca, New York, USA.
- Bibby, CJ, ND Burgess, DA Hill & S Mustoe (2000) *Bird census techniques*, 2nd ed. Academic Press, London, UK.
- Campos-Cerqueira, M & TM Aide (2016) Improving distribution data of threatened species by combining acoustic monitoring and occupancy modelling. *Methods in Ecology and Evolution* 7: 1340–1348.
- Ceballos, G (2003) *Ficha informativa de las Ciénegas del Lerma*. Available at <https://rsis.ramsar.org/> [Accessed 10 June 2017].
- Chacón, A & C Rosas-Monge (1998) Water quality characteristics of a high altitude oligotrophic Mexican Lake. *Aquatic Ecosystem Health and Management Society* 1: 237–243.
- Chacón, A, GL Ayala, MB Rendón, C Rosas-Monge & G Ruiz (2004) *Ficha informativa de los humedales del Lago de Patzcuaro*. Available at <https://rsis.ramsar.org/> [Accessed 10 June 2017].
- Chávez-León, G & DM Finch (1999) *Rapid assessment of Endemic Bird Areas in Michoacan, Mexico*. U.S. Department of Agriculture, Washington, DC, USA.
- Collar, NJ, DC Wege & AJ Long (1997) Patterns and causes of endangerment in the New World avifauna. *Ornithological Monographs* 48: 237–260.
- Comisión Nacional para el Conocimiento y Uso de la Biodiversidad (CONABIO) (2012) *La biodiversidad en Guanajuato: estudio de estado*. CONABIO & Instituto de Ecología del Estado de Guanajuato, Ciudad de México & Guanajuato, México.
- Dickerman, RW (1970) A systematic revision of *Geothlypis speciosa*, the Black-pollled Yellowthroat. *Condor* 72: 95–98.
- Edwards, EP & PS Martin (1955) Further notes on birds of the Lake Patzcuaro region, Mexico. *Auk* 72: 174–178.
- Escalante, P (1997) *Estructura genética poblacional de las especies de tapajitos (Aves, Parulinae: Geothlypis) que ocurren en los humedales: uno de los habitats más amenazados de México*. Informe final SNIB-CONABIO Proyecto no. B018, Instituto de Biología, Univ. Nacional Autónoma de México, Ciudad de México, México.
- Escalante, P (2000) Mascarita transvolcánica. Pp 306–307 in Ceballos, G & L Márquez (eds). *Las aves de México en peligro de extinción*. Instituto de Ecología UNAM, Comisión Nacional para el Conocimiento y Uso de la Biodiversidad & Fondo de Cultura Económica, Ciudad de México, México.
- Escalante, P, L Márquez-Valdelamar, P de la Torre, JP Laclette & J Klicka (2009) Evolutionary history of a prominent North American warbler clade: the *Oporornis-Geothlypis* complex. *Molecular Phylogenetics and Evolution* 53: 668–678.
- Howell SNG & S Webb (1995) *A guide to the birds of México and northern Central America*. Oxford Univ. Press, New York, New York, USA.
- Huerto, ID, PE Alonso, S Vargas, MA Mijangos & A Amador (2008) *Manejo integral para el control de malezas acuáticas, especies invasoras y remoción de sedimentos en apoyo a la recuperación de especies emblemáticas y mejora de la calidad del agua del lago*. Instituto Mexicano de Tecnología del Agua & Fundación Gonzalo Río Arronte, Ciudad de México, México.
- iNaturalist (2017) *iNaturalist web application*. Available at <https://www.inaturalist.org/pages/help#quality/> [Accessed 20 March 2017].
- IUCN (2017) *IUCN Red List of Threatened Species*. Available at <http://www.iucnredlist.org/> [Accessed 20 February 2017].
- Larsen, TH (2016) *Core standardized methods for rapid biological field assessment*. Conservation International, Arlington, Virginia, USA.
- Lea, RB & EP Edwards (1950) Notes on birds of the Lake Patzcuaro Region, Michoacan, Mexico. *Condor* 52: 260–271.
- Lecroy, M (2013) *Type specimens of birds in The American Museum of Natural History, Part 11. Passeriformes: Parulidae, Drepanididae, Vireonidae, Icteridae, Fringillinae, Carduelinae, Estrildidae, and Viduinae*. American Museum of Natural History, New York, New York, USA.
- López, E, ME Mendoza & G Bocco (2010) Cobertura Vegetal y Uso del Terreno. Pp 54–59 in Cram, S, L Galicia & I Israde-Alcántara (eds). *Atlas de la Cuenca del lago de Cuitzeo: análisis de su geografía y entorno socioambiental*. Univ. Nacional Autónoma de México & Univ. Michoacana de San Nicolás de Hidalgo, Ciudad de México & Morelia, Michoacán, México.
- Maderey, LE & RA Jiménez (2000) Alteración del ciclo hidrológico en la parte baja de la cuenca alta del Río Lerma por la transferencia de agua a la Ciudad de México. *Boletín del Instituto de Geografía, UNAM* 45: 24–38.
- Madrigal-Guridi, X, A Novelo-Retana & A Chacón (2004) Flora y vegetación acuáticas del lago de Zirahuén, Michoacán, México. *Acta Botánica Mexicana* 68: 1–38.
- Manterola, C & MA Gurrrola-Hidalgo (1999) Descripción del AICA 9 Ciénegas del Lerma. Pp 83 in Arizmendi, MC & A Márquez-Valdelamar (eds). *Áreas de importancia para la conservación de las aves en México*. Comisión Nacional para el Conocimiento y uso de la Biodiversidad & CIPAMEX, Ciudad de México, México.
- Moreno, DM, JE Watson, O Venter & HP Possingham (2016) Global biodiversity targets requires both sufficiency and efficiency. *Conservation Letters*, doi:10.1111/conl.12299.
- Morrone, JJ (2000) Toward a cladistic model for the Caribbean subregion: delimitation of areas of endemism. *Caldasia* 23: 43–66.
- NatureServe & IUCN (International Union for Conservation of Nature) (2016) *Geothlypis speciosa*. *The IUCN Red List of Threatened Species. Version 14.1*. Available at <http://www.iucnredlist.org/> [Accessed 5 September 2016].

- Navarro-Sigüenza, AG & AT Peterson (2007) *Mapas de las aves de México basados en WWW*. Comisión Nacional para el Conocimiento y Uso de la Biodiversidad, Ciudad de México, México.
- Pérez-Arteaga, A, KJ Gaston & M Kershaw (2002) Undesignated sites in Mexico qualifying as wetlands of international importance. *Biological Conservation* 107: 47–57.
- Peterson, AT, AG Navarro-Sigüenza & A Gordillo (2016) Assumption versus data-based approaches to summarizing species' ranges. *Conservation Biology*, doi:10.1111/cobi.12801.
- Ramírez-Bastida, P, AG Navarro-Sigüenza & AT Peterson (2008) Aquatic bird distributions in Mexico: designing conservation approaches quantitatively. *Biodiversity Conservation* 17: 2525–2558.
- Rendón-López, MB, A Chacon, G Lariza-Ayala & G Ruiz-Sevilla (2005) *Ficha informativa de los humedales del Lago de Cuitzeo*. Available at <https://rsis.ramsar.org/> [Accessed 10 June 2017].
- Rojas-Moreno, J & A Novelo-Retana (1995) Flora y vegetación acuáticas del lago de Cuitzeo, Michoacán, México. *Acta Botánica Mexicana* 31: 1–17.
- Rzedowski, J (2006) *Vegetación de México*, 1ª ed. digital. Comisión Nacional para el Conocimiento y Uso de la Biodiversidad, Ciudad de México, México.
- Sagardia, R (2005) *Use of subpixel classifier for wetland mapping: a case study of the Cuitzeo Lake, Mexico*. M.Sc. thesis, International Institute for Geo-information Science and Earth Observation, Enschede, The Netherlands.
- SEMARNAP-UNAM (2000) *Resultados del inventario forestal nacional*. Secretaría de Medio Ambiente, Recursos Naturales y Pesca, Instituto de Geografía & Univ. Nacional Autónoma de México, Ciudad de México, México.
- Secretaría de Medio Ambiente y Recursos Naturales (SEMARNAT) (2010) *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*. Diario Oficial de la Federación, Segunda Sección, Ciudad de México, México.
- Sekercioglu, CH (2006) Increasing awareness of avian ecological function. *Trends in Ecology and Evolution* 21: 464–471.
- Stattersfield, AJ, MJ Crosby, AJ Long & DC Wege (1998) *Endemic bird areas of the world: priorities for bird conservation*. BirdLife International, Cambridge, UK.
- Talonia, CM & P Escalante (2013) Los nodos: el aporte de la panbiogeografía al entendimiento de la biodiversidad. *Bulletin of the Systematic and Evolutionary Biogeographical Association* 6: 30–42.
- Toews, DP (2017) Habitat suitability and the constraints of migration in New World warblers. *Journal of Avian Biology*, doi:10.1111/jav.01157.
- Villagómez, S, E Gámez & D Molina (2017) Primer registro del colimbo mayor (*Gavia immer* Brünnich, 1764) en Oaxaca, México. *Huitzil, Revista Mexicana de Ornitología* 18: 180–184.
- Villaseñor-Gómez, JF, LE Villaseñor-Gómez & G Chávez-León (1999) Descripción de las AICAS Cuitzeo 2, Pátzcuaro 3. Pp 359–360 in Arizmendi, MC & A Márquez-Valdelamar (eds). *Áreas de importancia para la conservación de las aves en México*. Comisión Nacional para el Conocimiento y uso de la Biodiversidad & CIPAMEX, Ciudad de México, México.

