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Density and habitat associations of the Altamira Yellowthroat *Geothlypis flavovelata* in Veracruz, Mexico: an endemic vulnerable species

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Summary

The Altamira Yellowthroat *Geothlypis flavovelata* is endemic to north-eastern Mexico, with a restricted distribution due to the spatial arrangement of its major habitat: wetlands. Given the lack of information regarding this vulnerable and endemic landbird, here we describe and analyse the sites where we recorded it in Northern Veracruz, as well as its population density, and natural history information. Our results show that the average density of this endemic yellowthroat is 1.006 ind/ha, with more individuals recorded in Tecolutla when compared to Tuxpan. We found a strong association between the Altamira Yellowthroat and southern cat-tail *Typha domingensis*, although we found scenarios under which the presence of the cat-tail was not a determinant of Altamira Yellowthroat presence. In light of the strong anthropogenic pressures on wetlands in the region, the Altamira Yellowthroat has become highly vulnerable. Thus, if we aim to preserve this endemic species, together with other wetland-dependent species, it is crucial to moderate –and even stop– human pressures on these ecosystems and mitigate past damages.

Introduction

Wetlands are ecosystems amongst the most impacted by human activities, such as agriculture and urbanisation (López-Saut *et al.* 2014, de Gortari-Ludlow *et al.* 2015). The intensive use of wetlands for housing and productive activities (e.g. agriculture, industry) throughout the globe has eliminated an important proportion of them and has modified the structure and functioning of those remaining, degrading their quality as habitat for wildlife species (Davidson and Rothwell 1993, Landgrave and Moreno-Casasola 2012).

Within wetlands, both resident and migratory birds play crucial ecological roles (e.g. arthropod population control, pollination, seed dispersion; Wongsriphuek *et al.* 2008, Amat and Green 2010). Additionally, they have often been used as bioindicators of human disturbance in such ecosystems (López-Portillo *et al.* 2011, Pérez-Arteaga *et al.* 2002), reflecting changes in vegetation cover and structure, as well water depth, quality, seasonality, and pollution, among others (see Mistry *et al.* 2008, Amat and Green 2010, Zhang and Ma 2011 and references therein). Interestingly, wetlands not only harbour important avian diversity, but also concentrate endemism (Rodríguez-Estrella *et al.* 1999, Ramírez-Bastida *et al.* 2008, Ayala-Pérez *et al.* 2013, SEMARNAT 2014). Woefully, human disturbances on Mexican wetlands have caused the extinction of endemic landbirds, such as the Slender-billed Grackle *Quiscalus palustris* (BirdLife International 2016). Yellowthroats (genus *Geothlypis*) are another group of landbirds closely associated with wetlands. Although some yellowthroats are distributed throughout the country (e.g. Common Yellowthroat *G. trichas*), other species are narrowly distributed (e.g. Belding's Yellowthroat *G. beldingi*, Altamira Yellowthroat *G. flavovelata*).

In particular, the Altamira Yellowthroat is endemic to north-eastern Mexico. Its distribution ranges from central Tamaulipas, Eastern San Luis Potosí, and Northern Veracruz, at an elevation range from sea level to 500 m asl (Hoffman 1989, Howell and Webb 1995, AOU 2019). Similarly to some of its sister species, the Altamira Yellowthroat is mostly restricted to wetlands (mostly freshwater marshes, typically cat-tail reedbed: *tulares*; Escalante-Pliego 2010a, Rodríguez-Ruiz and Banda-Valdez 2015), which is why its populations are currently facing drastic reductions (Escalante *et al.* 2009, Palacios and Galindo-Espinosa 2011, SEMARNAT 2014). Yet the species has been shown also to inhabit small ponds, irrigation ditches, sugar cane irrigation fields, and seasonally flooded agricultural fields (Curson 2019). Important numbers of the Altamira Yellowthroat in Veracruz have been reported in wetlands near the city of Tecolutla and within a Natural Protected Area (Ciénega del Fuerte), while other populations have been reported in the wetlands of Tuxpan (BirdLife International 2019, Curson 2019).

Although the geographic distribution of the Altamira Yellowthroat is well known on a broad scale (Figure 1), there is an important gap in knowledge regarding its numbers throughout its distribution. To our knowledge, there is no data-based density estimation for the Altamira Yellowthroat, though BirdLife International (2019) places the species in the 2,500–9,999 individuals band, even assuming densities of up to 20 individuals/km^2 given the high restriction of specialised habitat. Given the latter and the fact that the species is suspected to be declining at a slow rate with the recent loss of local populations, IUCN (2019) has assessed the Altamira Yellowthroat as 'Vulnerable'. However, the Mexican Government identifies this yellowthroat as *En Peligro de Extinción* (highest conservation category established by the Mexican Government and equivalent to the 'Critically Endangered' category defined by IUCN) through the NOM-059-SEMARNAT-2010 (DOF 2010).

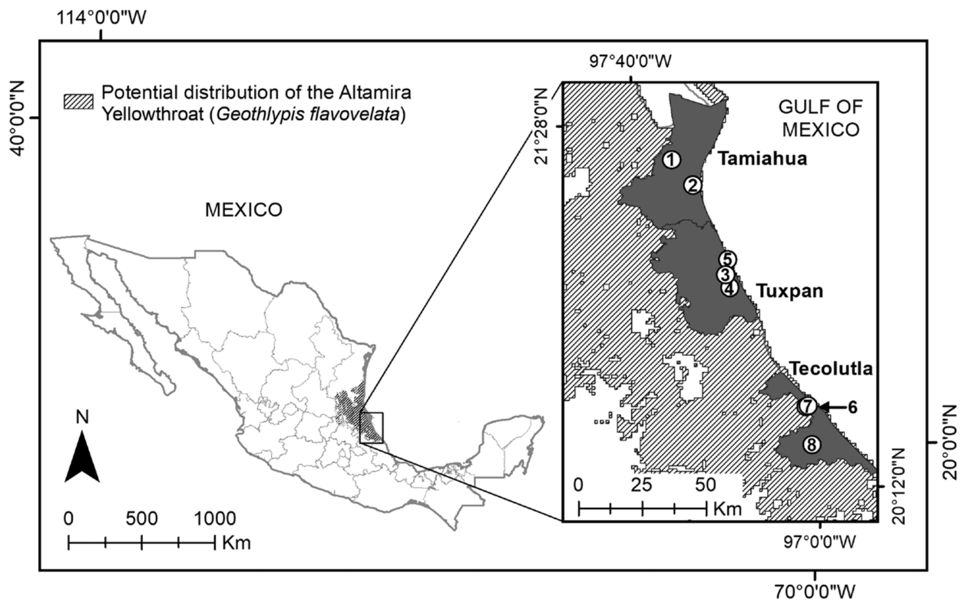

Figure 1. Potential distribution of the Altamira Yellowthroat *Geothlypis flavovelata* and location of study sites: 1: Tampache, 2: Tamiahua–Barra de Corazones, 3: Cobos, 4: Tumilco, 5: Tampamachoco, 6: Tecolutla, 7: Lagunas, and 8: Ciénegas del Fuerte.

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In spite of the restricted distribution range and conservation status of the Altamira Yellowthroat, little is known of its finer-scale distribution, or of reliable and quantitative local densities (Curson 2019). With the aim of filling such a knowledge gap, in this study we describe sites where we recorded Altamira Yellowthroats in three localities of Northern Veracruz (Tamiahua, Tuxpan, Tecolutla), estimating distance-sampling corrected densities for the species. Finally, we provide unpublished complementary natural history information, as well as observational information on the human-related factors threatening its habitats.

Methods

Study area

This study was performed in the central-northern distribution of the Altamira Yellowthroat, in the municipalities of Tamiahua, Tuxpan, and Tecolutla, located in Northern Veracruz. We chose these study sites based on their accessibility, previous knowledge on the presence of the species, and for safety reasons. This region has wetland relicts through its plains (0–200 m asl) where the Altamira Yellowthroat lives. The climate of the region is warm and sub-humid, with an annual average temperature of 22°C and a rainy season during summer (INEGI 2008). Vegetation in the area is mainly comprised of semi-deciduous tropical and dry forests, cattle pastures, mangrove, coastal dune, and hydrophilic vegetation (Ellis and Martínez-Bello 2010). Main hydrophilic vegetation types in the study area are: (1) 'tular', dominated by southern cat-tail *Typha domingensis*, (2) 'popal', dominated by species of the genera *Sagittaria* and *Pontederia*, (3) 'juncal', dominated by rush (*Juncus*) species, (4) 'carrizal', dominated by reed species (*Phragmites* sp.), (5) 'zapotal', low-flood vegetation dominated by Guiana chestnuts *Pachira aquatica*, and (6) 'juncos', dominated by species of the Cyperaceae family (e.g. *Cyperus articulatus*, *C. giganteus*, *Cladium jamaicense*). It is notable that these hydrophilic vegetation assemblages often occur heterogeneously in the landscape, forming associations among them. Three additional non-hydrophilic plant associations present in the study area are: (1) 'crucetas', dominated by *Dalbergia brownei*, (2) 'dormilonas', dominated by *Mimosa pigra*, and (3) 'dormilonas–cadillos', dominated by *Mimosa pigra*–*Echinochloa polystachya* associations. Besides the aforementioned dominant vegetation types and agricultural land-uses (e.g. sugar cane fields, livestock grasslands), other typical plants in the region include species of the families Cyperaceae (*Carex* sp., *Cladium* sp., *Cyperus* sp., *Eleocharis* sp., *Schoenoplectus* sp., *Scirpus* sp.), Maranthaceae (*Thalia* sp.), Poaceae (*Arundo* sp., *Paspalum* sp., *Spartina* sp.), and Typhaceae (*Rhynchospora* sp.) (Lot 2004).

Human settlements, including factories, as well as diverse agroecosystems are present in the study area, mainly in relation to the main development centres (e.g. Altamira in Tamaulipas; and Tamiahua, Tuxpan and Tecolutla in Veracruz). Although detailed resolution information is not available for our study area, studies performed at the state level have shown the loss of 47% of the wetlands of Tamaulipas and 58% of Veracruz (Landgrave and Moreno-Casasola 2012), highlighting the scenario threatening the Altamira Yellowthroat's main habitat in the study area.

Field surveys

With the aim of covering the widest area and representing all the habitats of our focal species, we established four linear transects at each of the studied localities for which we had prior knowledge of presence. Transect length varied in relation to accessibility to wetlands (Table 1). We located transects 400 m away from each other to avoid spatio-temporal pseudoreplication (Bibby *et al.* 2000). MH-S recorded Altamira Yellowthroats both visually and acoustically at a constant pace under similar weather conditions (open sky, low wind conditions) during the peak of landbird activity from 07h00 to 12h00 (Bibby *et al.* 2000). We surveyed Altamira Yellowthroats monthly for one year (April 2010–March 2011) and recorded for every sighting: vegetation type (considering the dominant plant species) and strata (herbaceous, shrub, tree),

Table 1. Transects where Altamira Yellowthroats were surveyed in the studied wetlands of Tamiahua, Tuxpan, and Tecolutla (Northern Veracruz, Mexico).

Municipality	Transect 1	Transect 2	Transect 3	Transect 4
Tamiahua	Tampache 1.350 km 2 h	Tamiahua 2.180 km 3 h	Tamiahua 0.780 km 0.5 h	Barra de Corazones 1.120 km 2.5 h
Tuxpan	Tumilco 0.970 km 1 h	Tumilco 1.360 km 2 h	Cobos 2.630 km 2.5 h	Tampamachoco 3.230 km 2.5 h
Tecolutla	Lagunas 2.460 km 3 h	Tecolutla 0.730 km 0.5 h	Ciénega del Fuerte 1.690 km 2 h	Ciénega del Fuerte 2.730 km 2.5 h

following Rodríguez-Estrella *et al.* (1999). The average length of transects was 1.8 km, which were surveyed for 2 h on average.

Habitat characterisation

We located 68 plots for habitat characterisation at the locations where we recorded Altamira Yellowthroats with the aim of describing the vegetation composition related to their presence (63 in Tecolutla, five in Tuxpan). Plots to describe low herbaceous plants (non-woody vegetation < 1.5 m) were 1 m^2, while those for tall herbaceous plants (non-woody vegetation > 1.5 m) and shrubs (woody vegetation 1.5–3 m) were 4 m^2, and for trees (woody vegetation > 3 m) 10 m^2, as suggested by Moreno-Casasola and López (2009). At each plot, we estimated plant species coverage, following Mueller-Dombois and Ellenberg (1974).

Although not systematically, we recorded anthropogenic disturbances in areas contiguous to the surveyed transects and plots to document some of the potential local impacts on Altamira Yellowthroat habitats. We gathered observational evidence for solid waste (organic waste, plastic, glass, metal), wetland filling (compacted soil, gravel, rubble), trails and roads, livestock raising, and urbanisation.

Data analyses

We calculated distance-sampling corrected densities for the Altamira Yellowthroat with Distance 6.0 (Thomas *et al.* 2009). Given that we georeferenced all records, we calculated perpendicular distances to the transect *a posteriori*. Briefly, Distance software calculates the probability of detection of the recorded individuals at increasing distances from the observer and standardises the number of detections along survey bands to estimate the number of individuals that exist within a surveyed area (Buckland *et al.* 1993).

To relate vegetation composition with Altamira Yellowthroat occurrence, we performed a non-metric multidimensional scaling (NMDS) analysis, considering the Bray-Curtis index to populate the similarity matrix, in R ('vegan' package; Oksanen *et al.* 2016; R Core Team 2019). We used an NMDS ordination approach to assess the association between vegetation species cover and Altamira Yellowthroat occurrence, as it represents one of the most robust unconstrained ordination methods in ecology, not restricted to sampling effort, scale, or parametric assumptions (Forcino *et al.* 2015).

Results

Distance-sampling corrected densities for the Altamira Yellowthroat in Northern Veracruz were 1.006 ind/ha (95 % CI = 0.24–4.06). The effective strip width was 14.7 m, and the best model, selected using the Akaike Information Criterion (AIC_c), was the one computed using the 'hazard-rate' function. Wide confidence intervals were the result of several factors, particularly: (1) we recorded no yellowthroats on 10% of the transects and (2) for 30% of the records ($n = 21$), the sighted yellowthroats were located at > 10 m from the observer, with a large number (52%; $n = 11$) detected at > 15 m. Such lack of data on some transects and the clumped number of records at 15–20 m from the observer seem to explain the wide confidence intervals.

It is noticeable that we recorded a low number of Altamira Yellowthroats during the 12-month survey period in Tuxpan ($n = 7$) and most of our records were from Tecolutla ($n = 63$). Temporally, we recorded a higher number of records from May–October ($n = 22$) and a low-to-null number of records from November to April (Figure 2). The low number of records during the non-breeding season was probably due to the yellowthroats being less conspicuous by rarely vocalising, which is why most results in that period were visual. Our results show that the Altamira Yellowthroat was mostly recorded using tall herbaceous plants (91% of records), as well as shrubs (9% of records), mainly those associated with ecotones with taller vegetation. We did not record any Altamira Yellowthroats in arboreal strata. Regarding its feeding, we recorded Altamira Yellowthroats foraging on 33 occasions on cat-tails and flat sedges, mostly on invertebrates. We were only able to identify the feeding source for two events: ants of the genus *Crematogaster* on catclaw mimosas and unidentified spiders.

Our Altamira Yellowthroat sightings occurred in seven vegetation assemblages and associations along the transects, which were composed of a heterogeneous mix: (1) 'crucetas', (2) 'dormilonas', (3) 'dormilonas'–'cadillos', (4) 'tular'–'juncos', (5) 'juncos', (6) 'carrizo'–'juncos', and (7) 'tular' (Table 2). The first three vegetation assemblages are not hydrophilic; they are associated with the vicinity of wetlands, forming dense thickets. Regarding the association between vegetation species cover and Altamira Yellowthroat records, the NMDS, which was fairly fit (stress = 0.086), showed a clear pattern: most records ($n = 50$) came from sites with > 50% southern cat-tail cover. Sites with < 50% southern cat-tail cover showed three scenarios: (1) c.14% of the records ($n = 9$), all without southern cat-tails, were dominated by plants of the genus *Cyperus* (*C. articulatus*, *C. giganteus*, *C. jamaicense*; 20–90% cover), (2) one record with total cover of Browne's Indian-rosewood *Dalbergia brownei*, and (3) c.12% of the records ($n = 8$) not dominated by any species, but rather a mix of species, of which the following head the list: catclaw mimosa *Mimosa pigra*, Guiana chestnut *Pachira aquatica*, giant flatsedge *Cyperus giganteus*, white mangrove *Laguncularia racemosa*, and bulltongue arrowhead *Sagittaria lancifolia* (Figure 3).

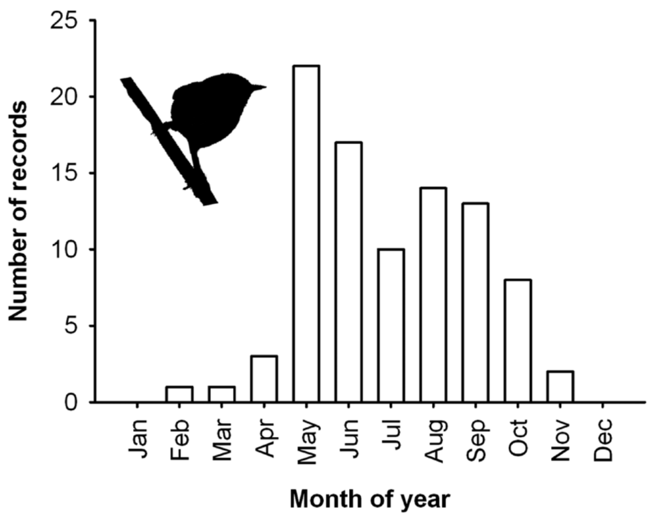

Figure 2. Monthly records for Altamira Yellowthroat *Geothlypis flavovelata* in Northern Veracruz.

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Table 2. Plant species recorded in the studied wetlands of Tamiahua, Tuxpan, and Tecolutla (Northern Veracruz, Mexico).

Family	Species	Tamiahua	Tuxpan	Tecolutla
Cyperaceae	*Cyperus articulatus* L. 1753	•	•	•
	Cyperus giganteus Vahl		•	•
	Cladium jamaicense Crantz, 1766			•
Fabaceae	*Mimosa pigra* L.	•	•	•
	Acacia farnesiana Willd, 1806	•	•	
	Dalbergia brownei (Jacq.) Schinz 1898	•	•	•
Malvaceae	*Pachira aquatica* Aubl, 1775		•	•
Typhaceae	*Typha domingensis* Pers.	•	•	•
Pteridaceae	*Acrostichum aureum* L. 1753	•	•	•
Combretaceae	*Laguncularia racemosa* (L.) Gaertn. f		•	•
Salviniaceae	*Salvinia minima* Baker, 1886			•
Alismataceae	*Sagittaria lancifolia* L. 1759	•	•	•
Poaceae	*Spartina spartinae* (Trin.) Merr. ex Hitchc.	•	•	•
Commelinaceae	*Commelina diffusa* Burm. f.			•
Pontederiaceae	*Eichhornia crassipes* (Mart.) Solms 1883	•	•	•

Discussion

Despite the conservation status of the Altamira Yellowthroat and the rate of habitat disturbance and destruction, there is still an important gap in knowledge of its biology and ecology that limits the generation and/or improvement of conservation strategies through evidence-based information

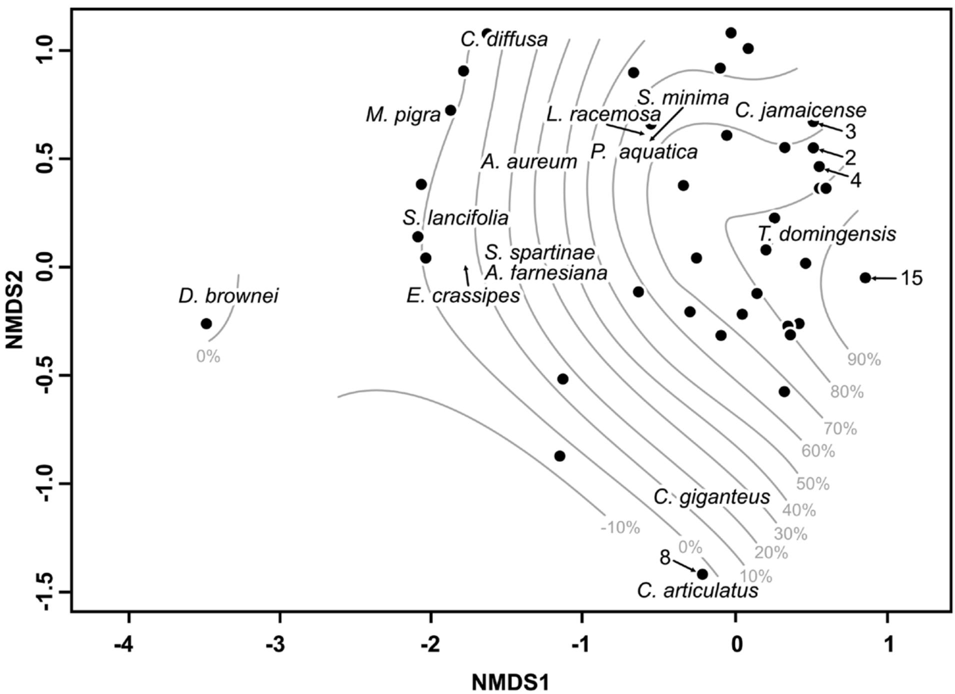

Figure 3. Non-metric multidimensional scaling (NMDS) analysis depicting the association between vegetation species cover and Altamira Yellowthroat records. Isolines represent a smoothed surface of southern cat-tail *Typha domingensis* cover (%). Numbers that point to dots in the graph represent the number of records in that specific position.

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(Escalante-Pliego 2010a, Curson 2019). Regarding density, our results are the first evidence-based estimations for the species, showing a potentially heterogeneous number of individuals in the study area ranging from 0.24 to 4.06 ind/ha.

Our natural history observations (habitat use, feeding) show that the Altamira Yellowthroat uses wetlands and other associated vegetation assemblages, and feeds similar to other wetland-related yellowthroats. Like the Belding's and Black-polled Yellowthroats *G. speciosa*, the Altamira Yellowthroat feeds mainly in freshwater wetlands, both in the interior and at the borders of flooded vegetation patches (Rodríguez-Estrella *et al.* 1999, Escalante-Pliego 2010b). It is notable that most of our yellowthroat sightings occurring on tall herbaceous plants could be the result of individuals flushing as a response to our sampling method (i.e. transects; Bibby *et al.* 2000). During the breeding season, Altamira Yellowthroat males are markedly territorial, explaining why they are highly conspicuous and easily detectable by song. However, when not breeding, their detectability drops as they are stealthier, likely explaining the lack of information in December and January.

Our results show a clear positive relationship between sites with southern cat-tails and the presence of Altamira Yellowthroats under two scenarios: when cat-tails were dominant and when they were in association with other wetland plants. Yet, wetlands without southern cat-tails were also habitat for Altamira Yellowthroats, as well as those dominated by jointed flatsedges. Thus, our results show that systems different from 'tulares' and 'popales', regularly present in disturbed areas where original wetlands occurred (Tucker 1994), currently comprise an important alternative habitat for this endemic yellowthroat.

Our non-systematic records of anthropogenic disturbances in the areas contiguous to our transects and plots are in agreement with previous suggestions of the worrisome human activities affecting Altamira Yellowthroat habitats (e.g. wetland filling, livestock raising, urbanisation; Curson 2019). All the aforementioned disturbances are related to the continuous land-use changes occurring in the area, although we became aware that the pace of urban sprawling of Tecolutla and Ciénega del Fuerte has decreased, as wetland areas are highly susceptible to flooding (Landgrave and Moreno-Casasola 2012). Yet land conversion for agriculture still occurs (e.g. ~40,000 ha were actively used for crop production in 2018 in the studied municipalities, mainly corn and citrus fruits; SAGARPA 2019).

Although our fieldwork did include the Municipality of Tamiahua, where historic records exist for the Altamira Yellowthroat and current isolated patches of suitable habitat for the species still remain, we did not record the species there. Although we do not have evidence of the causes of its alleged local extinction, filling-in related to extensive livestock and crop farming, as well as urban sprawl, have severely impacted wetlands in the region. This anthropogenic change indicates it is not far-fetched to suggest that they could have driven a local extinction, as has happened with other ecologically analogous species (Kattan *et al.* 1994, Rodríguez-Estrella *et al.* 1999).

Conservation action recommendations

The heavy anthropogenic pressure that wetlands are subjected to in northern Veracruz makes the Altamira Yellowthroat, as well as other wetland-related species, vulnerable and under high risk of becoming locally extinct where disturbances are frequent, intense, and long-lasting (Curson 2019). Recently, Curson (2019) suggested that the most important Altamira Yellowthroat population for Veracruz was located in Tecolutla, as well as some regions of the Ciénega del Fuerte Natural Protected Area, which is in agreement with our results. Thus, based on all the above, we provide evidence that adds to previously published information (e.g. Curson 2019) showing that the Municipality of Tecolutla is a focal and crucial part of the distribution of the Altamira Yellowthroat. This municipality represents a focal region if conservation strategies are to be applied in order to safeguard such an important population of this vulnerable species. Further collaborations between ornithologists, research centres, universities, and conservationists, as well as governmental and non-governmental organizations, will be critical for preserving this species in the southern part of its range. The implementation of standardised surveys to monitor the distribution and density of Altamira Yellowthroats throughout its known and historic distribution, together with well-designed studies assessing the potential drivers of their endangerment, will provide robust evidence-based information to implement efficient conservation strategies. It is noteworthy that this yellowthroat could be considered as a charismatic 'umbrella' species, and thus its conservation could benefit not only other wetland-endemic species, but even crucial ecosystem processes.

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