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# The Pleistocene bird record of México

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Abstract. The Pleistocene bird record is one of the most important records of vertebrate fossils in Mexico, and thus far includes already 10% of the bird species currently recorded in the country. This paper provides an initial appraisal of the fossil record on Mexican Pleistocene birds based on a summary of all the known sources published from the 19th century until today. In addition, a list of the identified species is presented and a brief discussion to highlight the importance of some localities and regions.

Key words: fossil birds, Pleistocene, Mexico, paleornithology, paleoecology.

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## I. INTRODUCTION

In recent years fossil bird studies have destroyed the myth of the scarcity of bird remains in fossil localities due to the fragility of the bones, in particular the analyses by OLSON (1985) and TYRBERG (1998) further confirmed this statement.

In the case of Mexico, no up-to-date systematic catalogue for fossil birds has been published, for the Quaternary or for other periods. A few compilations have been documented previously as either unpublished undergraduate theses (i.e. BARRIOS 1985; MENA DE LA PEÑA 1975), or specimen records based on materials from deposits at paleontological collections, such as the one from the Instituto de Geología of the Universidad Nacional Autónoma de México (SILVA-BÁRCENAS 1969). Most of these surveys, however, emphasised mammals rather than birds.

During recent years, a review of scientific literature on the fossil birds in México has been carried out. The main goal of this paper is that of providing scholars with an initial appraisal of the knowledge on Mexican Pleistocene birds, dealing with aspects including literature produced from the XIX century onwards, identified species and the importance of some localities and regions.

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## II. MATERIAL AND METHODS

All available documents, published or unpublished, concerning the fossil birds of the Mexican Pleistocene have been reviewed. This paper includes only those references that describe a locality for first time, or has a list of all identified taxa. In order to obtain a better comparison with Recent birds only the taxa identified at species level, including tentative identifications were used.

Scientific names were taken from those sources and, if necessary, updated following the American Ornithologist´s Union (A.O.U. 1998) for the recent species. The names of the extinct species were retained, and it is not the intention here to discuss their taxonomic status or their phylogenetic relationships with extant taxa.

The basic data for each locality includes their name, pertaining to a state of the country, and a relative age. When available, any other data is included. As for the chronology, the Pleistocene, lasting between 1.8 million years to 10,000 B.P., was divided into the Early, Middle or Late, according to the data provided in the references. Two sites from the Early Holocene were also included because they were commonly missed.

## III. RESULTS AND COMMENTS

### Literature

The references considering Mexican Pleistocene birds were reviewed; they range from the late 19th century to the present. In those papers various methods of analysis were employed, but the most frequent were the taxonomic lists; other less frequent methods incorporated information on depositional aspects and paleoecological inferences.

Between the end of the 19th century and the 1970's research was scarce and irregular. Most of the taxa recorded during those years come from the San Josecito Cave in Nuevo León, so far the most important Mexican locality for fossil birds.

From an historical perspective, the research done by COPE (1896) constitutes the first paleornithological study carried out on Mexican specimens. He identified the faunal remains retrieved by Henry C. MERCER, an American archaeologist searching for evidence on early man in the Yucatán Peninsula, and among them the bones of turkey (*Meleagris* sp.), and six to eight additional unidentified taxa. This material was associated with Late Pleistocene mammals.

Since the 1970's, the work has been slow but uninterrupted, with an increased interest for systematic research. This was the consequence of the formation of working teams in the Universidad Nacional Autónoma de Mexico (UNAM) and at the Instituto Nacional de Antropología e Historia (INAH). In the latter the Laboratorio de Paleozoología was created in 1963, focusing their study on Quaternary archaeozoology and creating the main comparative osteological collection in México (ARROYO-CABRALES & POLACO 1992).

However, most of the interest has centred on megafaunas, i.e. mammals and reptiles. Because of that most fossil bird specialists came from North America, i.e. Hildegarde HOWARD, Pierce BRODKORB, and Allan R. PHILLIPS.

### Localities and Chronology

Twenty-nine Pleistocene localities were recorded scattered among approximately half of the Mexican states (Fig. 1). Of these, seven lie in the México Basin (Distrito Federal and State of México), and four others in the State of Jalisco, mainly in the Chapala-Zacoalco region. These two areas constitute the most important palaeontological regions in the country. Additionally, other localities of importance are: San Josecito Cave, in the State of Nuevo León, by far the most important locality for fossil birds, and El Cedral, State of San Luis Potosí, until now the second most important locality (Table I).


Fig. 1. Localities for Pleistocene birds in México. Aguascalientes: 1 – Cedazo (N). Baja California: 2 – Isla Guadalupe (EP). Chihuahua: 3 – Miñaca (N); 4 – Cueva Jiménez (LP). Estado de México: 5 – "Lago de Texcoco" (H); 6 – Tequixquiac (LP); 7 – Tepexpan (LP); 8 – Tlapacoya (LP); 9 – Tocuila (LP); 10 – Zumpango (H); 11 – Chimalhuacán (LP). Hidalgo: 12 – Epazoyucan (LP). Jalisco: 13 – Jocotepec (LP); 14 – Chapala (EP); 15 – Atotonilco (N); 16 – San Marcos (LP). Nuevo León: 17 – Cueva San Josecito (LP). Puebla: 18 – Puebla? (N). San Luis Potosí: 19 – El Cedral (LP); 20 – La Presita (LP); 21 – Laguna de la Media Luna (LP). Sonora: 22 – Golfo de Santa Clara (MP); 23 – Arizpe (LP); 24 – Rancho La Brisca (LP). 25 –Terapa (N); Veracruz: 26 – Barranca Seca (LP). Yucatán: 27 – Oxkintok (LP); 28 – Cueva Lara (LP); 29 – Cueva Spukil (LP). N= Bird remains present but not studied yet; EP= Early Pleistocene; MP= Middle Pleistocene; LP=Late Pleistocene; H=Early Holocene.

Table I

Summary of Pleistocene bird records from particular states of México. The most important of them are shadowed. nd=fossil bird not identified so far

| State | Number of localities | Number of taxa recorded |
|---|---|---|
| Aguascalientes | 1 | nd |
| Baja California | 1 | 2 |
| Chihuahua | 2 | 19 |
| Estado de México | 7 | 47 |
| Hidalgo | 1 | 1 |
| Jalisco | 4 | 33 |
| Nuevo León | 1 | 63 |
| Puebla | 1 | nd |
| San Luis Potosí | 3 | 30 |
| Sonora | 4 | 9 |
| Veracruz | 1 | 2 |
| Yucatán | 3 | 21 |
| Total | 29 | 227 |

Most of these localities have been dated either through stratigraphic correlation or by faunal association and only four by radiometric $^{14}C$ methods. In San Josecito Cave, during the 1990 excavations fossil bird data from the original strata were obtained, ranging in dates between 27,000 to 11,000 y.B.P., as well as from a deposit below, dating to between 45, 000 to 27,000 y.B.P. (STEADMAN et al. 1994). Some strata from El Cedral have been dated, obtaining a wide range of dates between 40,000 years to 2,000 y.B.P., but a layer with evidence of human presence was dated in 33,000 y.B.P (LOLENZO & MIRAMBELL 1981). From the State of México in Tlapacoya dates ranging from 33,000 to 22,000 y.B.P., including some layers around 7,200 y.B.P. were obtained (BRODKORB & PHILLIPS 1986) and Tocuila was dated to 11,188 y. B.P (MORETT et al. 1998).

The North American Land Mammals Age chronologies (NALMA) constitute the most common method for making comparisons between faunal sites in North American vertebrate palaeontology. However, most of the bird sites do not refer to this chronology. Only the Terapa locality has been tentatively assigned to the Irvingtonian (MEAD et al. 2001) and Tocuila is assigned to the Rancholabrean (MORETT et al. 1998).

In the near future, it will be desirable to relate the sites to the NALMA framework as a method for helping with any future correlations with other faunal remains identified from the Americas. Although some sites from the Late Pleistocene have been assigned to a Rancholabrean age, not all of those have a positive identification of *Bison*, and for this reason further analyses are necessary in order to make a confident age assignment for all of the sites.

Only five sites could provide information concerning paleoclimatic stages. Isla Guadalupe and Rancho La Brisca have been assigned as Sangamonian. Two more as Wisconsinan: Barranca Seca and Arizpe. Finally, Jocotepec is mentioned as Late Sangamonian-Wisconsinan. A future task will be to improve the chronological and climatic frameworks in many Mexican localities.

A particular research line in Late Pleistocene localities is studying sites inhabited, or presumed to have been inhabitated by early Americans, as can be seen in El Cedral; Tlapacoya, Tepexpan, Chimalhuacán and Tocuila. However, there is no evidence for the cultural use of birds on these sites.

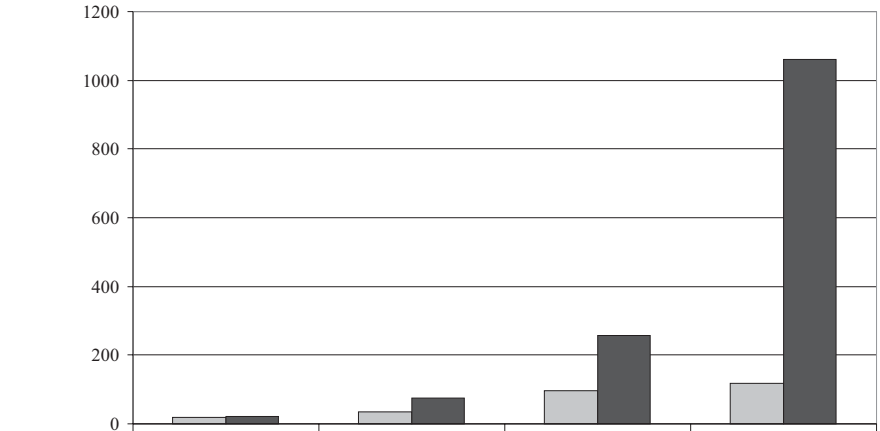
Golfo de Santa Clara is a locality assigned to the Middle Pleistocene (SHAW 1981), where as Epazoyucan, is a Late Pleistocene locality (CASTILLO-CERÓN et al 1997) and, Oxkintok most probably is Late Pleistocene (COPE 1896). However, their taxa were not identified to a specific level and are not included in Table II.

Five other localities appear in the literature, but their bird remains have not yet been studied. Four of those have been assigned to the Pleistocene, these are: Cedazo, in State of Aguascalientes (MOOSER 1958), Atotonilco, in the State of Jalisco (HOWARD 1968), Miñaca, in the State of Chihuahua (LINDSAY 1984), and one more only referred to as Puebla (ALVAREZ 1977). Finally, Zumpango, State of México is an Early Holocene locality in the same situation (MALDONADO-KOERDELL 1947). In the near future, it will be necessary to study that material.

## Taxonomic representation

The Mexican Pleistocene bird record comprises 227 taxa belonging to 19 orders, 38 families, 98 genera, and 118 species or with tentative identifications to that level (Table I and Table II). In comparison with the recent taxa recorded in México (after HOWELL & WEBB 1995), the fossil data represent 86.4% of the currently known orders, 51.4% of known families, 38.2% of known genera, and 11.1% of known species (Fig. 2). Though important by themselves, these figures are far lower than the corresponding percentages available for other vertebrate groups, such as mammals and reptiles.

The species list, including tentative identifications (Table II), supports the occurrence of two extirpated taxa: Greater Flamingo *Phoenicopterus ruber*, with a current minimal range of distribution in Mexico, and Purplish Jay *Cyanocorax cyanomelas*. The latter is significant because remains of that species were identified in a Yucatán locality (FISHER 1953), and their present distribution is ranged from Bolivia to Paraguay and north of Argentina (RIDGELY & TUDOR 1989).




| | order | family | genera | species |
|---|---|---|---|---|
| Pleistocene | 18 | 36 | 97 | 118 |
| Recent | 22 | 74 | 256 | 1060 |

Fig. 2. Comparison between records of Pleistocene and Recent bird taxa in México.

Table II

Fossil birds at species level or near identification. + = extinct taxon; (e) = extirpated taxon; (cf.) = tentative identification in particular locality. Chronology: E = Early Pleistocene; L = Late Pleistocene; (H) = Early Holocene; (**) = Indicated as Pleistocene-Holocene locality. Habitat: A = Aquatic; T = Terrestrial

| Taxa | Chronology | Habitat | Localities | References |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |
| *Podylimbus podiceps* (LINNAEUS, 1758) | L | A | C. Jiménez (**), C. San Josecito, Jocotepec, Tepexpan | ALVAREZ (1977); MESSING (1986); STEADMAN et al. (1994); WETMORE (1949) |
| *Podiceps nigricollis* BREHM, 1831 | L | A | C. Jiménez (**), El Cedral (**), Jocotepec, Tlapacoya (cf.) | ALVAREZ (1977); BRODKORB & PHILLIPS (1986); CORONA-M. (unpubl.); MESSING (1986) |
| *Podiceps parvus* SCHUFELDT, 1913 + | L | A | Chimalhuacán, Tlapacoya | BRODKORB & PHILLIPS (1973; 1986) |
| *Aechmophorus occidentalis* (LAWRENCE, 1858) | L | A | Chimalhuacán, Jocotepec | ALVAREZ (1977); BRODKORB & PHILLLIPS, (1973) |
| *Plyolymbus baryosteus* MURRAY, 1967 + | E | A | Chapala | HOWARD (1969) |
| *Puffinus* cf. *ophistomelas* COUES, 1864 | L | A | Isla Guadalupe | HUBBS & JEHL (1976) |
| *Pelecanus erythrorhynchos* GMELIN, 1789 | L | A | San Marcos, Tlapacoya | BRODKORB & PHILLIPS (1986); HOWARD (1969) |
| *Phalacrocorax brasilianus* (GMELIN, 1789) | E | A | Chapala | HOWARD (1969) |

Table II cont.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| *Phalacrocorax auritus* (LESSON, 1831) | L | A | Tepexpan, Tlapacoya | BRODKORB & PHILLIPS (1986); CORONA-M. & POLACO (2000) |
| *Phalacrocorax goletensis* HOWARD, 1965 + | L | A | Jocotepec | ALVAREZ (1977) |
| *Phalacrocorax chapalensis* ALVAREZ, 1977 + | L | A | Jocotepec | ALVAREZ (1977) |
| *Anhinga anhinga* (LINNAEUS, 1766) | L | A | Jocotepec | ALVAREZ (1977) |
| *Teratornis merriami* L. MILLER, 1909 + | L | T | C. San Josecito | STEADMAN et al. (1994) |
| *Ardea herodias* LINNAEUS, 1758 | L | A | San Marcos | HOWARD (1969) |
| *Ardea alba* LINNAEUS, 1758 | L | A | Tlapacoya | BRODKORB & PHILLIPS (1986) |
| *Egretta thula* (MOLINA, 1782) | L | A | Tlapacoya | BRODKORB & PHILLIPS (1986) |
| *Nycticorax nycticorax* (LINNAEUS, 1758) | L | A | C. San Josecito, Tlapacoya | BRODKORB & PHILLIPS (1986); STEADMAN et al. (1994) |
| *Mycteria wetmorei* (HOWARD, 1935) + | L | A | San Marcos | HOWARD (1969) |
| *Breagyps clarki* (L. MILLER, 1910) + | L | T | Tequixquiac | HOWARD (1969) |
| *Coragyps atratus* (BECHSTEIN, 1793) | L | T | C. Jiménez (**), C. San Josecito | MESSING (1986); STEADMAN et al. (1994) |
| *Cathartes aura* (LINNAEUS, 1758) | L | T | El Cedral (**), La Presita | CORONA-M. (unpubl.); CORONA-M. & POLACO (1999) |
| *Gymnogyps californianus* (SHAW, 1798) | L | T | C. Jiménez (**), C. San Josecito | MESSING (1986), STEADMAN et al. (1994) |
| *Phoenicopterus copei* (SCHUFELDT, 1891) + | L | A | Chimalhuacán | BRODKORB & PHILLIPS (1973) |
| *Phoenicopterus ruber* LINNAEUS, 1758 (e) | E, L | A | Chapala, Tepexpan (cf.), Tocuila (cf.) (**) | CORONA-M. & ARROYO--CABRALES (1997); CORONA-M. & POLACO (2000); HOWARD (1969) |
| *Dendrocygna bicolor* (VIEILLOT, 1816) | L | A | El Cedral (**) | CORONA-M. (unpubl.) |
| *Chen coerulescens* LINNAEUS, 1758 | L | A | San Marcos | HOWARD (1969) |
| *Branta canadensis* (LINNAEUS, 1758) | L | A | Tlapacoya | BRODKORB & PHILLIPS (1986) |
| *Aix* cf. *A. sponsa* (LINNAEUS, 1758) | L | A | C. San Josecito | STEADMAN et al. (1994) |
| *Anas strepera* LINNAEUS, 1758 | L | A | Tocuila (**) | CORONA-M. & ARROYO-CABRALES (1997) |

Table II cont.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| *Anas platyrhynchos* LINNAEUS, 1758 | L | A | El Cedral (**) | CORONA-M. (unpubl.) |
| *Anas cyanoptera* VIEILLOT, 1816 | L | A | El Cedral (**), Tequixquiac, Tocuila (**) | CORONA-M. (unpubl., 1997); HOWARD (1969) |
| *Anas clypeata* LINNAEUS, 1758 | L | A | El Cedral (**) | CORONA-M. (unpubl.) |
| *Anas acuta* LINNAEUS, 1758 | L | A | C. Jiménez (**); El Cedral (**), San Marcos, Tequixquiac | CORONA-M. (unpubl.); HOWARD (1969); MESSING (1986) |
| *Anas* cf. *crecca* LINNAEUS, 1758 | L | A | C. Jiménez (**); Rancho La Brisca | MESSING (1986); VAN DEVENDER et al. (1985) |
| *Aythia valisineria* (WILSON, 1814) | L | A | El Cedral (**) | CORONA-M. (unpubl.) |
| *Aythia americana* (EYTON, 1838) | L | A | Jocotepec; Tequixquiac | ALVAREZ (1977); HOWARD (1969) |
| *Aythia collaris* (DONOVAN, 1809) | L | A | Tequixquiac; El Cedral (**) | CORONA-M. (Unpubl.); HOWARD (1969) |
| *Aythia marila* (LINNAEUS, 1761) | L | A | Jocotepec | ALVAREZ (1977) |
| *Aythia affinis* (EYTON, 1838) | L | A | Chimalhuacán; San Marcos | BRODKORB & PHILLIPS (1973); HOWARD (1969) |
| *?Bucephala albeola* (LINNAEUS, 1758) | L | A | C. Jiménez (**) | MESSING (1986) |
| *Oxyura jamaicensis* (GMELIN, 1789) | L | A | C. San Josecito (cf.); El Cedral (**) | CORONA-M. (unpubl.); STEADMAN et al. (1994) |
| *Oxyura zapatanima* ALVAREZ, 1977 + | L | A | Jocotepec | ALVAREZ (1977) |
| *Wetmoregyps daggetti* (L. MILLER, 1915) + | L | T | C. San Josecito | STEADMAN et al. (1994) |
| *Neophrontops americanus* L. MILLER, 1916 + | L | T | C. San Josecito | STEADMAN et al. (1994) |
| *Neogyps errans* L. MILLER, 1916 + | L | T | C. San Josecito | STEADMAN et al. (1994) |
| *Elanus leucurus* (VIEILLOT, 1818) | L | T | C. San Josecito | STEADMAN et al. (1994) |
| *Circus cyaneus* (LINNAEUS, 1766) | L | T | C. San Josecito | STEADMAN et al. (1994) |
| *Accipiter? bicolor* (VIEILLOT, 1817) | L | T | C. Spukil | FISHER (1953) |
| *Asturina nitida* (LATHAM, 1790) | L | T | C. San Josecito | STEADMAN et al. (1994) |
| *Buteogallus fragilis* (L. MILLER, 1911) + | L | T | San Marcos | HOWARD (1969) |

Table II cont.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| *Parabuteo unicinctus* (TEMMINCK, 1824) | L | T | C. San Josecito | STEADMAN et al. (1994) |
| *Buteo jamaicensis* (GMELIN, 1788) | L | T | C. San Josecito; El Cedral (**) | CORONA-M. (unpubl.); STEADMAN et al. (1994) |
| *Buteo* cf. *B. regalis* (GRAY, 1844) | L | T | C. San Josecito | STEADMAN et al. (1994) |
| *Aquila chrysäetos* (LINNAEUS, 1758) | L | T | C. San Josecito, Tequixquiac | HOWARD (1969); STEADMAN et al. (1994) |
| *Spizaetus grinelli* (L. MILLER, 1911) + | L | T | C. San Josecito, Tequixquiac | HOWARD (1969); STEADMAN et al. (1994) |
| *Polyborus plancus* (MILLER, 1777) | L | T | C. San Josecito, Tequixquiac | HOWARD (1969); STEADMAN et al. (1994) |
| *Falco sparverius* LINNAEUS, 1758 | L | T | C. Jiménez (**), C. San Josecito | MESSING (1986); STEADMAN et al. (1994) |
| *Falco mexicanus* SCHLEGEL, 1851 | L | T | C. San Josecito, Tlapacoya | BRODKORB & PHILLIPS (1986); STEADMAN et al. (1994) |
| *Ortalis vetula* (WAGLER, 1830) | L | T | C. Lara, C. Spukil | FISHER (1953) |
| *Meleagris gallopavo* LINNAEUS, 1758 | L | T | Arizpe, Laguna de la Media Luna (cf.), Rancho La Brisca | CRACRAFT (1968); HERNÁNDEZ-JUNQUERA (1977); VAN DEVENDER et al. (1985) |
| *Meleagris ocellata* CUVIER, 1820 | L | T | C. Spukil | FISHER (1953) |
| *Meleagris crassipes* L. MILLER, 1940 + | L | T | C. San Josecito | STEADMAN et al. (1994) |
| *Dendrortyx macroura* (JARDINE & SELBY, 1828) | L | T | La Presita | CORONA-M. & POLACO (1999) |
| *?Dendrortyx leucophrys* (GOULD, 1844) | L | T | C. Spukil | FISHER (1953) |
| *?Oreortyx pictus* (DOUGLAS, 1829) | L | T | C. Jiménez (**) | MESSING (1986) |
| *Colinus nigrogularis* (GOULD, 1843) | L | T | C. Lara, C. Spukil | FISHER (1953) |
| *Odontophorus? guttatus* (GOULD, 1838) | L | T | C. Spukil | FISHER (1953) |
| *Cyrtonyx montezumae* (VIGORS, 1830) | L | T | C. San Josecito | STEADMAN et al. (1994) |
| *Rallus* (*R. elegans/ longirostris*) | L | A | C. San Josecito | STEADMAN et al. (1994) |
| *Rallus limicola* VIEILLOT, 1819 | L | A | C. San Josecito | STEADMAN et al. (1994) |
| *Fulica americana* GMELIN, 1789 | L | A | C. Jiménez, C. San Josecito, Chimalhuacán | BRODKORB & PHILLIPS (1973); MESSING (1986); STEADMAN et al. (1994 |

Table II cont.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| *Grus canadensis?* (LINNAEUS, 1758) | H | A | Lago de Texcoco | MARTÍN DEL CAMPO (1944) |
| *Burhinus* cf. *bistriatus* (WAGLER, 1829) | L | A | C. San Josecito | STEADMAN et al. (1994) |
| *Charadrius vociferus* LINNAEUS, 1758 | L | A | C. Jiménez (**) | MESSING (1986) |
| *Recurvirostra americana* GMELIN, 1789 | L | A | Chimalhuacán | BRODKORB & PHILLIPS (1973) |
| *Tringa melanoleuca* (GMELIN, 1789) | L | A | El Cedral (**) | CORONA-M. (unpubl.) |
| *Numenius* cf. *N. americanus* BECHSTEIN, 1812 | L | A | C. San Josecito | STEADMAN et al. (1994) |
| *Calidris fusicollis* (VIEILLOT, 1819) | L | A | Jocotepec | ALVAREZ (1977) |
| *Gallinago gallinago* (LINNAEUS, 1758) | L | A | El Cedral (**) | CORONA-M. (unpubl.) |
| *Scolopax minor* GMELIN, 1789 | L | A | C. San Josecito | STEADMAN et al. (1994) |
| *Synthliboramphus* cf. *S. hypoleuca* (XÁNTUS DE VESEY, 1860) | L | A | Isla Guadalupe | HUBBS & JEHL (1976) |
| *Columba flavirostris* WAGLER, 1831 | L | T | C. Spukil | FISHER (1953) |
| *Columba fasciata* SAY, 1823 | L | T | Barranca Seca, C. San Josecito | BRODKORB (1962); STEADMAN et al. (1994) |
| *Zenaida macroura* (LINNAEUS, 1758) | L | T | Barranca Seca, C. San Josecito | BRODKORB (1962); STEADMAN et al. (1994) |
| *Columbina talpacoti* (TEMMINCK, 1811) | L | T | C. Spukil | FISHER (1953) |
| *Leptotila verreauxi* (BONAPARTE, 1855) | L | T | C. Spukil | FISHER (1953) |
| *Rhynchopsitta pachyrhyncha* (SWAINSON, 1827) | L | T | C. San Josecito | STEADMAN et al. (1994) |
| *Rhynchopsitta terrisi* (MOORE, 1947) | L | T | C. San Josecito | STEADMAN et al. (1994) |
| *Rhynchopsitta phillipsi* + REA, 1997 | L | T | C. San Josecito | REA (1997) |
| *Geococcyx californianus* (LESSON, 1829) | L | T | C. San Josecito, C. Jiménez (**), El Cedral (**) | CORONA-M. (unpubl.); MESSING (1986); STEADMAN et al. (1994) |
| *Tyto alba* (SCOPOLI, 1760) | L | T | C. San Josecito, Tlapacoya | BRODKORB & PHILLIPS (1986); STEADMAN et al. (1994) |
| *Otus flammeolus* (KAUP, 1853) | L | T | C. San Josecito | STEADMAN et al. (1994) |

Table II cont.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| *Otus asio/ kennicotti* | L | T | C. San Josecito | STEADMAN et al. (1994) |
| *Otus trichopsis* (WAGLER, 1832) | L | T | C. San Josecito | STEADMAN et al. (1994) |
| *Bubo virginianus* (GMELIN, 1788) | L | T | C. Jiménez (**), C. San Josecito | MESSING (1986); STEADMAN et al. (1994) |
| *Glaucidium gnoma?* WAGLER, 1832 | L | T | C. San Josecito | STEADMAN et al. (1994) |
| *Michratene* cf. *M. whitneyi* (COOPER, 1861) | L | T | C. San Josecito | STEADMAN et al. (1994) |
| *Athene cunicularia* (MOLINA, 1782) | L | T | C. Spukil, C. Jiménez (**) | FISHER (1953); MESSING (1986) |
| *Ciccaba virgata* (CASSIN, 1849) | L | T | C. San Josecito | STEADMAN et al. (1994) |
| *Strix brea* HOWARD, 1933 + | L | T | Rancho La Brisca | VAN DEVENDER et al. (1985) |
| *Strix occidentalis* (XANTUS DE VESEY, 1860) | L | T | C. San Josecito | STEADMAN et al. (1994) |
| *Asio otus* (LINNAEUS, 1758) | L | T | C. San Josecito | STEADMAN et al. (1994) |
| *Asio flammeus* PANTOPPIDAN, 1763 | L | T | C. San Josecito, C. Spukil | FISHER (1953); STEADMAN et al. (1994) |
| *Aegolius acadicus* (GMELIN, 1788) | L | T | C. San Josecito | STEADMAN et al. (1994) |
| *Chordeiles minor* (FORSTER, 1771) | L | T | C. Jiménez (**) | MESSING (1986) |
| *Phalaenoptilus nutallii* (AUDUBON, 1844) | L | T | C. San Josecito | STEADMAN et al. (1994) |
| *Colaptes auratus* (LINNAEUS, 1758) | L | T | C. San Josecito | STEADMAN et al. (1994) |
| *Cyanocorax cyanomelas* VIELLOT, 1818 (e) | L | T | C. Spukil | FISHER (1953) |
| *Aphelocoma coerulescens* (BOSC, 1795) | L | T | C. San Josecito | STEADMAN et al. (1994) |
| *Aphelocoma ultramarina* (BONAPARTE, 1825) | L | T | El Cedral (**) | CORONA-M. (unpubl.) |
| *Gymnorhinus cyanocephalus* WIED, 1841 | L | T | C. San Josecito | STEADMAN et al. (1994) |
| *Corvus corax* LINNAEUS, 1758 | L | T | C. Jimenez (**), C. San Josecito, Tlapacoya | BRODKORB & PHILLIPS (1986); MESSING (1986); STEADMAN et al. (1994) |
| *Hirundo pyrrhonota* (VIEILLOT, 1817) | L | T | C. San Josecito | STEADMAN et al. (1994) |
| *Turdus migratorius* LINNAEUS, 1766 | L | T | C. San Josecito | STEADMAN et al. (1994) |

Table II cont.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| *Toxostoma* cf. *T. ocellatum* (SCLATER, 1862) | L | T | Tequixquiac | STORER (1954) |
| *Toxostoma* cf. *T. curvirostre* (SWAINSON, 1827) | L | T | El Cedral (**) | CORONA-M. (unpubl.) |
| *Agelaius phoeniceus* (LINNAEUS, 1766) | L | T | C. Spukil, Rancho La Brisca | FISHER (1953), VAN DEVENDER et al. (1985) |
| *Eupahgus cyanocephalus* (WAGLER, 1829) | L | T | El Cedral (**) | CORONA-M. (unpubl.) |

The number of extinct species reaches 17, ten of them recovered from San Josecito Cave. It is remarkable that among the extinct birds the number of predators and scavengers is similar to that formed by terrestrial and aquatic taxa. In the former, there are eight taxa: *Teratornis merriami, Breagyps clarki, Wetmoregyps daggetti, Neophrontops americanus, Neogyps errans, Buteogallus fragilis*, *Spizaetus grinelli* and *Strix brea*. The second group is composed of: *Plyolymbus baryosteus*, *Podiceps parvus*, *Phalacrocorax goletensis*, *Ph. chapalensis*, *Mycteria wetmorei*, *Phoenicopterus copei*, *Oxyura zapatanima*, *Meleagris crassipes*, *Rhynchopsitta phillipsi*. This situation contrasts with that of the extinct birds in the North American Pleistocene, since in this case most of the extinct taxa were predators and scavengers (STEADMAN & MARTIN 1984). This difference could be due to an under representation in the Mexican fossil record or, more plausibly to a climatically induced extinction event in Central America during the last interglacial period that affected birds there in a different way to that recorded in North America.

Aquatic bird taxa represent 43% of the recorded fossil bird species in México, but only two of them were marine, while terrestrial birds represents 57% pertaining to habitats such as woodland, forest, shrub or grasslands.

The diversity of identified taxa is another noteworthy aspect: Anseriformes, Falconiformes, Strigiformes and Passeriformes, in that ranking order, incorporate the highest number of identified species and represent 50% of the total taxa. However, in relation to habits, predators and scavengers, i.e. eagles, falcons, vultures, and owls, are the most diverse group; followed by swimmers (grebes, ducks, and relatives), and wading birds. This could be biased due to the type of localities, since most assemblages come from caves and others from aquatic environments.

Some identified taxa at the supraespecific level could represent other extinct or extirpated birds. Among them are two storks, genus *Mycteria* and genus *Ciconia*, an owl, genus *Bubo* and one flamingo. However, further studies are necessary to clarify their taxonomical status.

## Regions and sites of particular relevance

Among the Pleistocene localities the most remarkable ones are those from San Josecito, El Cedral, and the various sites located in the regions of Chapala-Zacoalco and the Basin of México (Fig. 1 and Table II).

1. San Josecito Cave includes a diverse and abundant fauna of reptiles, mammals, and birds. The research started in the 1940's. In the 1990's a combined team from INAH (México) and Texas Tech University (USA) re-studied this site (ARROYO-CABRALES & JOHNSON 1995).

The bird remains identified from this cave shows a great diversity of animals, particularly raptors and scavengers, both extinct and living forms, along with several remains from other groups such as fowls and ducks, most probably preyed upon by the raptors. The most important aspect of this bird assemblage is the presence of taxa new to science, along with the study of the paleoenvironmental changes due to the glacial periods.

2. El Cedral was excavated between 1977 and 1981. The bone assemblage was originated as a natural deposit since it is a former spring water body. The main findings included a great diversity of fossil animals. The hypothesis points to the use of the site by humans for resting and hunting.

The unidentified avifaunal remains were housed at the Paleozoology Laboratory of INAH. In recent years 16 extant species along with one extirpated taxon were identified. Most of the taxa belong to aquatic and wading birds very similar to recent species. However, unlike mammal bones, a detailed taphonomical analysis did not reveal any cultural marks or other signs of hunting or consumption (CORONA-M unpubl.).

3. In the Chapala-Zacoalco region, there are three localities close to each other (Chapala, Atotonilco and San Marcos), which are part of the same lake system and the site of Jocotepec, a former portion of the lake. All of those localities were discovered due to the progressive drying of the lake in recent years because the nearby big city of Guadalajara has grown, and the shores of the lake have been occupied. From the three first localities, a great amount of mammal and bird bones have been recovered, mainly by the inhabitants of the area, which were donated to local scientists or public museums. Most of these materials remain unidentified. Researchers from Los Angeles County Museum recovered some materials that are presently housed in their collections. In any case, the contextual information is either very limited or does not exist, making it difficult to date the deposits. However, the one exception is Jocotepec, which due to a controlled excavation and mammal associations has been assigned to Late Sangamonian –Wisconsinan age, and it is a clear Late Pleistocene locality (ALVAREZ 1977). In the cases of Chapala and San Marcos, HOWARD (1969) postulated relative dates of Late Pliocene-Early Pleistocene and Late Pleistocene, respectively.

Most of the birds identified in those localities are aquatic, mainly swimmers and waders. The most remarkable taxa include two species of flamingo, one of them an extinct, unnamed species, the other similar to the recent species *Phoenicopterus ruber*, now extirpated from this particular region. Extinct species include cormorants (*Phalacrocorax chapalensis* and *P. goletensis*), a duck (*Oxyura zapatanima*), one grebe (*Plyolymbus baryosteus*), and one stork (*Mycteria wetmorei*).

4. The Basin of México houses the largest number of paleontological localities in the country. This situation is a by-product of many sites being discovered by chance and later studied, while others are the result of intensive public and private construction works due to the ever-expanding development of México City.

All of the sites in the Basin of México are located on the paleoshores of the ancient lake system. The localities of Tlapacoya, Tepexpan, Chimalhuacán and Tocuila have evidence of early settlements and culturally modified bones, mainly mammoths and other mammals, but not birds. Tequixquiac is important in that a large amount of bones of extinct fauna were recovered. Zumpango and the site named in literature as Lago de Texcoco, is really located in San Juan de Aragón at the east of México City, and both were important because they were the only purposely known Early Holocene localities. All of the remaining localities can be considered of Late Pleistocene age.

The identified birds represent mainly aquatic groups: loons, grebes, pelicans, ducks, geese, and cranes, all of them similar to recent forms. Extirpated species include the Double-crested Cormorant *Phalacrocorax auritus*, flamingos similar to recent forms, the Sandhill Crane *Grus canadensis*, identified by sub-fossil eggs, and Golden Eagle *Aquila chrysaetos*. This species assemblage does not inhabit central México at present. Flamingos and bicrested cormorants are found at the coasts. The Sandhill Crane and Golden Eagle are common inhabitants to the north of the Basin, but crane does not currently breed in the country (HOWELL & WEBB 1995). Remarkable there is also the list of extinct taxa in the area, which includes a grebe (*Podiceps parvus*), an additional species of flamingo (*Phoenicopterus copei*), one vulture (*Breagyps clarki*) and an eagle (*Spizaetus grinelli*).

## IV. CONCLUSIONS

From the data thus far compiled it is clear that most avian fossils in México have been found either by chance during public works or associated with megafauna in paleontological and archaeological excavations, but not through systematic and specific research. Still, the Pleistocene bird record perhaps lies third in the relative importance of fossil vertebrates in Mexico, though far lower in significance than the record of mammals and reptiles. This record also represents almost 10% of the living species of birds presently inhabiting the country.

The localities and regions discussed exhibit a great diversity of fossil birds recorded. This situation contrasts with the lack of complementary data from the localities, i.e. stratigraphic data, radiometric dating; and with the scarcity of publications during the last one hundred years, due to a lack of paleornithological workers in Mexican institutions.

Many questions arise from this discussion of Pleistocene birds, such as the phylogenetic relationships of extant and extinct taxa, such as the flamingos, the causes of local extinctions and the changes recorded in the geographical distribution of certain birds. Likewise, the influence of climatic factors on these biogeographical phenomena, and whether the early inhabitants made use of birds as food, tool or in any other way, as has been documented in other cultural areas of North and South America. Surely those will be questions of great relevance for the future of this field of research.

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