



Hundred-year changes in the avifauna of the Valley of Mexico, Distrito Federal, Mexico

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Abstract

Species lists were compiled for the Valley of Mexico from the nineteenth century and from 1950-present. Of a total of 401 species, 228 were documented to be present in both time periods, 111 were detected only in recent observations, and 62 were detected only in the nineteenth century. Composition of species detected in one time period and not the other was similar (aquatic, montane, migratory); however a number of records for the nineteenth century indicate the presence of an aquatic avifauna associated with large lakes. Indeed, 14 species in this aquatic avifauna are otherwise absent or poorly represented in interior Mexico, suggesting that the Valley of Mexico was a unique natural area. Introduced exotic species were numerous in both time periods, with a surprising number of failed opportunities for establishment of populations.

Keywords: Faunal change, introductions, local extinctions, history of ornithology.

Resumen

Cambios de 100 años en la avifauna del Valle de México, Distrito Federal, México

Se compilaron listas de especies para el Valle de México tanto del siglo XIX como del presente. De un total de 401 especies, 228 se documentaron como presentes en ambos periodos, 111 fueron detectadas solamente por observaciones recientes y 62 fueron detectadas solamente en el siglo XIX. La composición de especies detectada en un periodo y no en el otro fue en general similar (especies montañas, acuáticas y migratorias); sin embargo, varios registros del siglo XIX indican la presencia de una avifauna acuática asociada a grandes lagos. De hecho, 14 especies en esta avifauna acuática están o ausentes o pobremente representados en el centro de México en la actualidad, sugiriendo que el Valle de México fue un área natural única. Las especies exóticas introducidas han sido numerosas en ambos periodos, con un número sorprendente de eventos fallidos de establecimiento de poblaciones.

Palabras clave: cambio de fauna, introducciones, extinciones locales, historia de la ornitología.

Résumé

Un siècle de changement de l'avifaune de la vallée de Mexico

Des listes d'oiseaux du 19^{ème} siècle et de 1950 jusqu'à nos jours ont été relevées. Sur les 401 espèces répertoriées 228 seulement ont été découvertes durant les deux périodes, 111 résultent d'observations actuelles et 62 sont exclusives au 19^{ème} siècle. La composition des espèces observées seulement au cours d'une période donnée restent identiques (aquatiques, de montagne et migratrices) cependant le nombre d'observations au cours du 19^{ème} siècle révèle la présence d'une avifaune aquatique associée aux grands lacs. Parmi elles, 14 espèces aquatiques sont actuellement rares ou en voie d'extinction dans le centre du Mexique, ce qui permet de penser que la vallée de Mexico était un site ornithologique naturel exceptionnel. Les espèces introduites sont nombreuses au cours de chaque période avec un surprenant nombre d'échecs dans l'établissement de populations viables.

Mots clés: changement faune, introductions, extinctions, histoire de l'ornithologie.

HUITZIL (2006) 7: 4-14

Change is a ubiquitous process in biology—environmental change on the longest (evolutionary) time scales has probably generated large portions of biological diversity via vicariant processes (Noonan 1988, Patton et al. 1990). On shorter (ecological) time scales, processes of change are rearranging species' distributions in response to, for instance, global climate change (King and Leemans 1990, Inouye et al. 2000, Walther et al. 2002) or human-induced land use changes (Chávez-León 1993, Klink et al. 1993, Bethke and Nudds 1995). Hence, understanding biological implications of these agents of change is an

important step towards a predictive understanding of patterns of biological diversity.

Because most events of change are longer-scale phenomena than the careers of individual investigators, tests and documentation of their effects are not straightforward. Indeed, examples for which old information (prior to change) is available are not common (Jehl and Johnson 1994). Although interpretation of patterns of change is usually complex, such investigations can reveal fascinating patterns of species turnover, invasion, sampling bias, and extinction (Goodman and



Gonzales 1989), and yet very few examples exist owing to the scarcity of adequate data sets.

The Valley of Mexico—roughly the present Mexico City metropolitan area—is a fascinating arena for such questions. An ecological jewel at the time of the Spanish Conquest, the region consisted of a series of interconnected lakes of varying salinity, surrounded by forested mountains. Moreover, because of its destiny to become the capital of Mexico, the Valley of Mexico counts with a rich history of faunal study. Mexico had an active, modern, and well-published group of systematists and biologists in the nineteenth century (Trabulse 1983) that left an excellent record of publications regarding the biota of the region (Peterson 1998). Since that period, the region has seen a number of environmental changes: sinking valley-bottom topography, creation of canyons by erosion, and migration of treeline higher in elevation as a result of urban warming, as well as dramatic changes in human populations and land use patterns have all characterized recent decades and centuries (Palma et al. 1999). Hence, sufficient information and interest exists to demand a before-and-after view of avifaunal composition.

The purpose of the present contribution is to present a preliminary analysis of avifaunal changes in the Valley of Mexico, in a region that has seen both drastic changes over the last century and sufficient early exploration to permit analysis. We draw comparisons of the known modern avifauna (Wilson and Ceballos-Lascurain 1993) with that of the latter half of the nineteenth century, based both on scientific publications of that time (most in Mexican scientific journals) and on a broad survey of specimen records (Peterson et al. 1998). These comparisons are particularly relevant given the massive modifications that have taken and are taking place in the region with rapidly expanding human populations.

Methods

This paper focuses on changes in avifaunas in the Distrito Federal in the Valley of Mexico. This region has the uncertain distinction of having been modified from a beautiful valley holding vast wetlands and other natural habitats to the largest metropolitan area in the world (Navarro and Benítez 1999). It was also an easy focus of early scientific collectors, so extensive specimen material and other documentation are available from the nineteenth century (Peterson et al. 1998).

The Atlas of Mexican Bird Distributions (Navarro et al. 2003, in prep.) is a centralized database summarizing known information on the distributions of the 1000+ species of birds occurring in Mexico. It summarizes the specimen holdings of 33 scientific collections (see acknowledgments), and includes more than 350,000 specimens from 36,000 unique localities (Peterson et al. 1998). Spanning years from 1814 to present, this database provides a unique resource for assessing avifaunal change. We omitted from consideration those specimens that were labeled as being taken from 'near Mexico City,' or the like, as such locality descriptors are known to be variable at best in their reliability (Dickerman 1965).

A seriously underappreciated body of scientific literature was produced by a little-known group of scientists in Mexico in the past century. Personages such as the Dugés brothers, Alfonso Herrera (father and son), Manuel María Villada, François Sumichrast, Rafael Montes de Oca, José María Velasco, and others formed a vibrant community of biologists. They described new species (e.g., *Amazilia tzacatl*, *Pharomachrus mocinno*, *Claravis pretiosa*, *Anas diazi*), developed studies of ecology and behavior, and contemplated mechanisms of evolution. Most of their work was published in the Mexican journal *La Naturaleza*, as well as the *Anales del Museo Nacional* (Sumichrast 1881, Villada 1873, 1897, Herrera 1890a, b, 1895). We surveyed all numbers of these journals for papers relevant to the birds of the Mexico City area. For recent information (i.e. the last two or three decades), a useful summary has been published (Wilson and Ceballos-Lascurain 1993), which was supplemented with recent specimen information. Other sources (e.g., Leopold 1965) were reviewed, but key information was often vague (e.g., *Anas platyrhynchos* occurred 'in the past' in the Valley of Mexico).

Information from these sources—the scientific literature and specimen data—was compared between prior to 1900 and after 1950. Species documented in one time period but not in the other were listed and analyzed in terms of ecological and distributional characteristics. We broadly classified species as aquatic (associated to wetlands), montane (associated to highlands), or migratory based on our own experience with Mexican birds.

Results and particular discussion

Of a total of 401 species, 228 were detected both in the nineteenth century and in recent decades, 111 were detected in recent decades but not in the nineteenth century, and 62 were detected in the nineteenth century and not since (see Appendix). Among species detected only recently, 6 represented species introduced and established in the region in the twentieth century (*Bubulcus ibis*, *Columba livia*, *Aratinga canicularis*, *Amazona oratrix*, *Sturnus vulgaris*, and *Passer domesticus*). Of the remaining recent-only species, 31 were aquatic species, 14 were montane species, and 32 were migratory species. The others 28 species represent montane and submontane native species of more open areas associated to human transformation of habitat (e. g. *Molothrus aeneus*, *Volatinia jacarina*), possibly coming from nearby dryer regions.

Sixty-two species were documented in the nineteenth century, but are not known from recent years. These species included 10 that are exotics, or probable introductions or released pets (*Aratinga nana*, *Ara militaris*, *Myadestes unicolor*, *Cyanerpes cyaneus*, *Amblycercus holosericeus*, *Padda oryzivora*, *Caryothraustes poliogaster*, *Cacicus melanicterus*, *Turdus grayi*, and *Serinus canarius*); several of these species were noted as escapees or introductions by the nineteenth century ornithologists. Another important component were 14 aquatic species attracted by the large lake system (e.g.,



Aramides cajanea, *Phalacrocorax pelagicus*, *Stercorarius parasiticus*, *Phalaropus tricolor*, *Grus canadensis*). Indeed, the records on this list that are most surprising (e.g., *Gavia stellata*, *Stercorarius parasiticus*) were specific subjects of papers documenting the unusual records. The avifauna also included a near-endemic species, *Quiscalus palustris*, which went extinct in the first decades of the twentieth century (Peterson 1998). Of the remaining XIX century-only species, 14 were aquatic, 5 montane, 14 migratory, and 3 more undefined. Finally, and most intriguing, a record of *Gymnogyps californianus*, now extirpated from Mexico, was carefully documented and distinguished from other vultures (Herrera 1890a).

Comparing the two lists of species detected in one time period but not in the other in greater detail, we tallied species as aquatic, montane, or migratory in their habits. No significant differences existed between the two lists in this respect (3 x 2 contingency test, $\chi^2 = 0.38$, $df = 2$, $P > 0.05$). This result suggests that the very different sampling regimes behind the two lists (primarily oriented around collecting in the nineteenth century, bird-watching in recent decades) did not end up sampling the avifauna in qualitatively different manners, and indeed that no detectable biases were present.

Particularly interesting is the perspective that such comparisons provided on the knowledge of species' geography. For four species, all aquatic, the Valley of Mexico in the nineteenth century provided possible new southernmost distributional records (*Gavia stellata* and *Podiceps auritus* both not previously known south of Sonora, *Phalacrocorax pelagicus* and *Aythya marila* both not previously known south of Sinaloa). For five other species, the Valley of Mexico in the nineteenth century provided the only known or one of very few occurrences inland from the coastal plains of Mexico (*Stercorarius parasiticus*, *Aramides cajanea*, *Aramus guarauna*, *Charadrius wilsonia*, and *Limosa fedoa*). Finally, for five additional species, the Valley of Mexico records are at the southern and/or interior margin of the species' known distribution (*Branta canadensis*, *Lophodytes cucullatus*, *Grus canadensis*, *Phalaropus tricolor*, and *Larus californicus*).

The presence of *Elanus leucurus* in the Valley of Mexico in the nineteenth century (described as accidental, in winter) suggests that its recent range expansions in the New World (Eisenmann 1971) were not the cause of its presence in the Valley of Mexico, and that individuals have occurred in the valley during at least 100 yr. *Turdus rufopalliatus* has also been suggested to represent a recent arrival in the Valley of Mexico (Howell and Webb 1995); lack of nineteenth-century records for that species does not permit us to refute this idea. Finally, a surprising number of species is seen as introduced in the Valley of Mexico; many of these introductions failed, and populations did not persist.

Species Accounts.—Ten species on the nineteenth-century-only list merit further comment. Although for several of these records, specimens are mentioned, most are likely to have been housed in the

Museo Nacional (Herrera 1895), most of which material has been lost (Barrera 1968).

Gavia stellata.—Villada (1883) mentioned a subadult male *Colymbus glacialis*, which is a name referable to this species, in the Museo Nacional. Villada provided a detailed description of the bird, including plumage coloration and measurements, and provided careful comparisons with other *Gavia* spp. (*G. immer* was also detected), particularly *G. pacifica*. This species was described as of accidental occurrence in the Valley of Mexico, and was found following a storm. At present, this species is known to winter irregularly south to northwestern Mexico only (AOU 1998), so this record represents a first record for central Mexico, and the southernmost record for the species.

Phalacrocorax pelagicus.—This species was listed as 'accidental' by Herrera (1890a). The record of this species was compared carefully by Herrera with the characteristics of other cormorant species; as such, it reflects his care in the identification—perhaps given the oddity of the record, this record could best be considered to be hypothetical. This summary of status is correct, as the species has not been otherwise recorded south of Sinaloa.

Gymnogyps californianus.—Herrera (1890a) described this species as very uncommon, saying that "I am inclined not to believe that it is resident in the Valley" (translation ours). He stated that the species had only been seen in winter, and carefully distinguished it from other vultures (*Cathartes* and *Coragyps*) that would be present. Although this record may best be described as difficult to believe, the description is convincing and little room exists for confusion. We present this record for further contemplation in view of more information that may eventually emerge.

Aramus guarauna.—Herrera (1890a) described this species as very uncommon, stating that he only knew of a few specimens collected at the Laguna de Texcoco, all in December. The species is unmistakable, and this record is the first in Mexico that is not from the coastal plains.

Stercorarius sp..—Villada (1883) mentioned 2 male specimens of *S. parasiticus*, one in adult plumage and one in subadult plumage. Indeed, the Museo Nacional listed two specimens, numbers 1414 and 1415, which are there identified as *S. pomarinus*; although the catalog did not provide any information that specifically ascribes them to the Valley of Mexico, it did mention their accidental occurrence in the Valley of Mexico (Herrera 1895). Herrera described it as accidental in the Valley of Mexico, and stated that the species was collected following a storm. He described the plumages and measurements of the two



specimens in careful detail, and distinguished these specimens as *S. parasiticus* on the basis of the very elongate and attenuated central rectrices (10 cm longer than rest of tail). This record would be the first inland record of the genus in central or southern Mexico, although inland records are well known from farther north (AOU 1998).

Nyctibius jamaicensis.—Herrera (1890b) listed this species as quite rare in the Valley of Mexico in winter in coniferous forests, where it was quite difficult to collect. Although this description (in particular the mention of coniferous forests) may seem suspect, Sumichrast (1881) provided additional detail: one bird was found near Mexico City in 1855 just after a big storm. Hence, although Herrera appears to have generalized overmuch, given the unmistakable nature of the species, and Sumichrast's detailed comment, this record represents a first record of this species for Mexico outside of the coastal plain.

Trogon melanocephalus.—Herrera (1890b) listed this species for the Valley of Mexico. Although seemingly an odd record that might better be discounted, Saussure (1875) provided additional detail, stating that although most trogons are restricted to the lowlands, only *T. mexicanus* and *T. melanocephalus* ascend to higher elevations. This record clearly lacks detail necessary for full acceptance, but is also certainly of interest, as it would represent the only known occurrence of the species from outside of the coastal plains.

Chloroceryle aenea.—Sumichrast (1881) mentioned *Ceryle cabanisi* from the Valley of Mexico, but without any details. This record would be the first inland record for the species in Mexico, although it does occur inland farther south in its distribution. Because no detail was provided for the record, we can only present the record for contemplation.

Dendroica carbonaria.—This record is of uncertain meaning. The species was described by Audubon, and most likely refers to immature *D. tigrina* (AOU 1998). Although the realization of the synonymous nature of this species was probably less universal at the time of the record, even *D. tigrina* would be most surprising in the Valley of Mexico, so the meaning of this record is uncertain.

Quiscalus palustris.—The Valley of Mexico is the type locality of this species, although the provenance of the type specimen has been disputed (Dickerman 1965). The evidence behind the Valley of Mexico records—which is excellent—has been treated elsewhere, with the conclusion that ample indications exist of the presence of this species in the Valley of Mexico, and that earlier concerns as to the provenance of the type were unfounded (Peterson 1998).

General discussion

Several complications make analyses of the sort attempted herein difficult. First and foremost is that of the nature of the information that we summarize. Unfortunately, the specimens on which many of the records reported in the older Mexican literature appear no longer to exist, which removes the possibility of rechecking identifications that could clear up some questions. La Naturaleza and other nineteenth century sources can of course be somewhat less explicit and clear than would be expected by modern standards, and older nomenclature can at times further complicate interpretations. Nonetheless, we feel that the information contained in these older sources offers an interesting perspective on questions that are otherwise difficult to ask.

A second consideration is that of nondetections—that is, in one time period or the other, failure to detect species causes apparent appearance or disappearance of species that have been present the entire time. In the present analysis, non-detections are probably of little importance in recent decades, but are of particular concern in the nineteenth-century list. Because we pieced together the latter list from specimens and mentions in the literature, gaps certainly exist: e.g., non-detection of *Aphelocoma californica*, which is known in the Distrito Federal from specimens as early as 1941 (Museum of Vertebrate Zoology 93460), and has doubtless been present all along. Other challenges, perhaps of lesser importance, but worthy of mention, include older names (e.g., *Colymbus glacialis*, *Asio accipitrinus*, *Myiarchus magister*, *Parus meridionalis*, etc.), and past taxonomic confusions (e.g., *Plegadis falcinellus* with *P. chihi*, *Rallus longirostris* with *R. elegans*). Each of these complications required careful inspection and consultation of taxonomic resources for correct resolution.

The differences between the two lists (recent decades only, nineteenth century only) are nevertheless quite intriguing. The nineteenth-century list holds several species not represented on the recent list. Two classes of species are worthy of detailed comment. First, aquatic species are clearly better represented, particularly species that would be found in association with large, open bodies of water (e.g., *Gavia* spp., *Stercorarius parasiticus*, *Phalacrocorax pelagicus*). The differences between the two lists as regards these 14 aquatic taxa can clearly be attributed to the draining of the large lakes of the Valley of Mexico, which began with a first drainage canal finished in 1605, and finished with the completion of the Gran Canal in 1875 (Ezcurra 1998, Navarro and Benítez 1999). Reduction of the extent of all of the lakes, destruction of associated marsh habitats, and complete elimination of several lakes all have contributed to these changes. However, other 28 species of aquatic birds are detected only in recent surveys. These include several species of the genera *Calidris* and *Charadrius*, therefore suggesting that identification aids for such difficult groups were scarce in the nineteenth century, and these taxa are now recorded due to improvements of its taxonomic knowledge.



Whereas the disappearance of aquatic species was perhaps expected at the outset of this analysis, the second component—exotic species—was less anticipated. Fully 10 nineteenth-century species either were noted as exotics that had escaped from captivity (e.g., *Serinus canarius*) or are most likely escapes (e.g., *Myadestes unicolor*, which is still a popular cage bird because of its fantastic song). This early introduction pressure in Mexico suggests that a considerable number of introductions have failed, perhaps because several were of tropical species (e.g., *Cyanerpes cyaneus*) not likely to survive in the Valley of Mexico's montane climate. The few introductions that have succeeded (e.g., Eurasian species, *Aratinga canicularis*, *Amazona oratrix*) have been of species that have some north-temperate or montane component to their native distributional areas.

This analysis—particularly the conclusions regarding the loss of an aquatic avifauna in the Valley of Mexico—re-emphasizes the dimensions of the loss of biotic richness associated with the dramatic growth of Mexico City. The Valley of Mexico was until relatively recently a unique aquatic ecosystem in central Mexico, and much of that biological richness has been lost. Replication of this type of study in other well-sampled regions would be most informative; particularly attractive candidates could include Chilpancingo and surroundings in Guerrero, the Cape region and surroundings of La Paz in Baja California Sur (Peterson et al. 1998).

Acknowledgments

We thank the numerous students and colleagues who have assisted in the assembly of the Atlas database, which was key to these analyses: Hesiquito Benítez, Octavio Rojas, Luis Antonio Sánchez, Erick

García, Alejandro Gordillo, and very especially Claudia Abad and Rosa Salazar. Thanks also to Armando Butanda for providing access to the Historical collection at the Library of the Instituto de Biología, UNAM. The following scientific collections kindly made data and specimens available to us for study and use in this study: American Museum of Natural History; Academy of Natural Sciences of Philadelphia; Bell Museum of Natural History; British Museum (Natural History); California Academy of Sciences; Carnegie Museum of Natural History; Canadian Museum of Nature; Denver Museum of Natural History; Delaware Museum of Natural History; Fort Hays State College; Field Museum of Natural History; Iowa State University; University of Kansas; Los Angeles County Museum of Natural History; Natuurhistorische Museum; Louisiana State University Museum of Zoology; Museum of Comparative Zoology, Harvard University; Moore Laboratory of Zoology, Occidental College; Museum Nationale d'Histoire Naturelle; Museum of Vertebrate Zoology, Berkeley; Museo de Zoología, Facultad de Ciencias, Universidad Nacional Autónoma de México; University of Nebraska; Royal Ontario Museum; San Diego Natural History Museum; Southwestern College; Texas Cooperative Wildlife Collections; University of Arizona; University of British Columbia Museum of Zoology; University of California Los Angeles; Universidad Michoacana de San Nicolás de Hidalgo; United States National Museum of Natural History; Western Foundation of Vertebrate Zoology; and Peabody Museum, Yale University. This study was funded by CONACyT (R-27961), CONABIO (V-009), SEMARNAT-CONACYT Sectorial Funds C01-0265, and PAPIIT-UNAM (IN-214200 and 233002).

Literature cited

- AOU (American Ornithologists' Union). 1998. Check-list of North American birds, 7th ed. American Ornithologists' Union, Washington, D.C., USA.
- Barrera, A. 1968. Las aves en el Museo de Historia Natural de la Ciudad de México. In Beltran, E. (Ed.), Las Aves en México: Homenaje a la Sección Mexicana del Comité Internacional para la Protección de las Aves. IMERNAR, México, D.F. Pp. 13-19.
- Bethke, R. W. and Nudds, T. D. 1995. Effects of climate change and land use on duck abundance in Canadian prairie-parklands. *Ecological Applications* 5: 588-600.
- Chávez-León, G. 1993. Land use and conservation status on Neotropical migrants in Michoacan, Mexico. Maine Agricultural and Forest Experiment Station. UNAM, U. Maine-USFWS/NBS 727: 139-149.
- Desfontaines, G. 1871. La ganga en México: Orden de las Zancudas. *La Naturaleza* 1^a. Serie, Núm. 2:154-158.
- Dickerman, R. W. 1965. The juvenal plumage and distribution of *Cassidix palustris* (Swainson). *Auk* 2: 268-270.
- Dugés, A. 1869. Catálogo de animales vertebrados observados en la República Mexicana. *La Naturaleza*, 1a. Ser. 1: 137-145.
- Eisenmann, E. 1971. Range expansion and population increase in North and Middle America of the White-tailed kite (*Elanus leucurus*). *American Birds* 25: 529-536.
- Ezcurra, E. 1998. De las chinampas a la megalópolis: El medio ambiente en la Cuenca de México. Fondo de Cultura Económica, Mexico City, Mexico.
- Goodman, S. M. and Gonzales, P. C. 1989. The birds of Mt. Isarog National Park, southern Luzon, Philippines, with particular reference to altitudinal distribution. *Fieldiana Zoology* 60: 1-39.
- Herrera, A. L. 1890a. Apuntes de Ornitología: La migración en el Valle de México. *La Naturaleza* 2nd Ser. 1: 165-189.



- Herrera, A. L. 1890b. Notas acerca de los vertebrados del Valle de México. *La Naturaleza* 2nd Ser. 1: 299-342.
- Herrera, A. L. 1895. Catálogo de la Colección de Aves del Museo Nacional. Museo Nacional, México, D.F., Mexico
- Howell, S. N. G. and Webb, S. 1995. *A Guide to the Birds of Mexico and Northern Central America*. Oxford University Press, Oxford, UK.
- Inouye, D. W., Barr, B., Armitage, K. B., and Inouye, B. D. 2000. Climate change is affecting altitudinal migrants and hibernating species. *Proceedings of the National Academy of Sciences USA* 97: 1630-1633.
- Jehl, J. R. J. and Johnson, N. K. editors. 1994. A century of avifaunal change in Western North America. *Studies in Avian Biology* 15. 348 pp.
- King, G. A. and Leemans, R. 1990. Effects of global climate change on global vegetation. *In* King, G. A., Winjun, J. K., Dixon, P. K., and Arnaut, L. Y. (Eds.), *Response and feedback of forest systems to global climate change*. Environmental Protection Agency, Corvallis, OR, USA.
- Klink, C. A., Moreira, A. G. and Solbrig, O. T. 1993. Ecological impacts of agricultural development in the Brazilian cerrados. *In* Young, M. D. and Solbrig, O. T. (Eds.), *The World's Savannas: Economic Driving Forces, Ecological Constraints and Policy Options for Sustainable Land Use*. Parthenon Publishing, Carnforth, U.K.
- Leopold, A. S. 1965. *Fauna Silvestre de México*. Instituto Mexicano de Recursos Naturales Renovables, México, D.F., Mexico
- Navarro, A. G. and Benítez, H. 1999. Biodiversidad de la Cuenca de México, pasado y presente. *Creación y Cultura* 2: 55-68.
- Navarro, A. G., Peterson, A. T., and Gordillo-Martínez, A. 2003. Museums working together: the atlas of the birds of Mexico. *In* Collar, N., Fisher, C., and Feare, C. (Eds.), *Why museums matter: avian archives in an age of extinction*. *Bulletin British Ornithologists' Club Supplement* 123A. Pp. 207-225.
- Noonan, G. R. 1988. Biogeography of North American and Mexican insects, and a critique of vicariance biogeography. *Systematic Zoology* 37: 366-384.
- Palma, M., Cram, S., Bocco, G. and Velázquez, A. 1999. Caracterización abiótica de la región de montaña del sur de la Cuenca de México. *In* Velázquez, A. and Romero, F. J. (Eds.), *Biodiversidad de la Región de Montaña del Sur de la Cuenca de México: Bases para el Ordenamiento Ecológico*. Universidad Autónoma Metropolitana, México, D.F., Mexico
- Patton, J. L., Myers, P., and Smith, M. F. 1990. Vicariant versus gradient models of diversification: The small mammal fauna of eastern Andean slopes of Peru. *In* Peters, G. and Hutterer, R. (Eds.), *Vertebrates in the Tropics*. Museum Alexander Koenig, Bonn, Germany. Pp. 355-371.
- Peterson, A. T. 1998. The distribution and type locality of the extinct Slender-billed Grackle, *Quiscalus palustris*. *Bulletin of the British Ornithologists' Club* 118: 119-121.
- Peterson, A. T., Navarro-Sigüenza, A. G. and Benítez-Díaz, H. 1998. The need for continued scientific collecting: A geographic analysis of Mexican bird specimens. *Ibis* 140: 288-294.
- Sánchez, J. and Villada, M. M. 1873. Palomas viajeras. Notas sobre las que últimamente han emigrado a México. *La Naturaleza* 1ª. Ser. 2:250-253.
- Saussure, H. D. 1875. Los curucús. *La Naturaleza* 1ª. Ser. 2: 14-16.
- Sumichrast, F. 1881. Enumeración de aves observadas en el territorio de la República Mexicana. *La Naturaleza* 1ª. Ser. 5: 227-250.
- Trabulse, E. 1983. *Historia de la Ciencia en México*. Fondo de Cultura Económica, México, D.F., Mexico.
- Villada, M. M. 1873. Troquilideos del Valle de México. *La Naturaleza* 1ª. Ser. 2:339-369.
- Villada, M. M. 1884. Aves de las regiones del Círculo Ártico en las lagunas del Valle de México. *La Naturaleza* 1ª. Ser. 6: 191-195.
- Villada, M. M. 1897. Los anátidos del Valle de México. *La Naturaleza* 2nd Ser. 2: 509-522.
- Walther, G.-R., Post, E., Convey, P., Menzel, A., Parmesan, C., Beebee, T. J. C., Fromentin, J.-M., Hoegh-Guldberg, O., and Bairlein, F. 2002. Ecological responses to recent climate change. *Nature* 416: 389-395.
- Wilson, R. G. and Ceballos-Lascuráin, H. 1993. *The birds of Mexico City*. BBC Printing and Graphics, Ltd., Burlington, Ontario, Canada.

Recibido: 17 de marzo del 2005; Revisión aceptada: 16 de enero del 2006.

Editor asociado: Thomas Dietsch



<i>R. limicola</i>	x		<i>Chlidonias niger</i>	x	
<i>Aramides cajanea</i>		x	<i>Rynchops niger</i>	x	x
<i>Porzana carolina</i>	x	x	Columbiformes		
<i>Porphyryla martinica</i>	x	x	Columbidae		
<i>Gallinula chloropus</i>	x	x	<i>Columba livia</i>	x	
<i>Fulica americana</i>	x	x	<i>Zenaida asiatica</i>	x	x
Aramidae			<i>Z. macroura</i>	x	x
<i>Aramus guarauna*</i>		x	<i>Columbina inca</i>	x	x
Gruidae			<i>C. passerina</i>	x	x
<i>Grus canadensis</i>		x	Psittaciformes		
Charadriiformes			Psittacidae		
Charadriidae			<i>Aratinga astec</i>		x
<i>Pluvialis squatarola</i>	x	x	<i>A. canicularis</i>	x	
<i>P. dominica</i>	x		<i>Ara militaris</i>		x
<i>Charadrius alexandrinus</i>	x		<i>A. macao</i>	x	x
<i>C. wilsonia</i>		x	<i>Amazona oratrix</i>	x	
<i>C. semipalmatus</i>	x		Cuculiformes		
<i>C. vociferus</i>	x	x	Cuculidae		
Recurvirostridae			<i>Coccyzus erythrophthalmus</i>	x	x
<i>Himantopus mexicanus</i>	x	x	<i>C. americanus</i>	x	x
<i>Recurvirostra americana</i>	x	x	<i>Geococcyx velox</i>	x	x
Jacanidae			<i>Crotophaga sulcirostris</i>	x	
<i>Jacana spinosa</i>	x		Stringiformes		
Scolopacidae			Tytonidae		
<i>Tringa melanoleuca</i>	x		<i>Tyto alba</i>	x	x
<i>T. flavipes</i>	x	x	Stringidae		
<i>T. solitaria</i>	x	x	<i>Otus flammeolus</i>	x	x
<i>Catoptrophorus semipalmatus</i>	x		<i>O. kennicottii</i>	x	
<i>Actitis macularia</i>	x		<i>O. trichopsis</i>	x	x
<i>Bartramia longicauda</i>	x	x	<i>Bubo virginianus</i>	x	x
<i>Numenius americanus</i>	x	x	<i>Glaucidium gnoma</i>	x	x
<i>Limosa haemastica</i>	x		<i>Micrathene whitneyi</i>	x	x
<i>L. fedoa</i>		x	<i>Athene cunicularia</i>		x
<i>Arenaria interpres</i>	x	x	<i>Strix varia</i>		x
<i>Calidris mauri</i>	x		<i>Asio otus</i>		x
<i>C. minutilla</i>	x	x	<i>A. flammeus</i>	x	x
<i>C. bairdii</i>	x		<i>Aegolius acadicus</i>	x	x
<i>C. melanotos</i>	x		Caprimulgiformes		
<i>C. himantopus</i>	x		Caprimulgidae		
<i>Limnodromus scolopaceus</i>	x		<i>Chordeiles acutipennis</i>	x	x
<i>Gallinago gallinago</i>	x	x	<i>C. minor</i>	x	
<i>Phalaropus tricolor</i>	x	x	<i>Nyctidromus albicollis</i>		x
<i>P. tricolor</i>	x	x	<i>Caprimulgus vociferus</i>	x	x
<i>P. lobatus</i>	x		Nyctibiidae		
<i>P. fulicaria</i>	x		<i>Nyctibius jamaicensis*</i>		x
Laridae			Apodiformes		
<i>Stercorarius parasiticus*</i>		x	Apodidae		
<i>Larus atricilla</i>	x	x	<i>Cypseloides niger</i>	x	
<i>L. pipixcan</i>	x		<i>Streptoprocne rutula</i>	x	
<i>L. delawarensis</i>	x		<i>S. semicollaris</i>	x	x
<i>L. californicus</i>		x	<i>Chaetura vauxi</i>	x	x
<i>Sterna maxima</i>	x		<i>Aeronautes saxatalis</i>	x	
<i>S. forsteri</i>	x		Trochilidae		



<i>Colibri thalassinus</i>	X	X	<i>E. hammondii</i>	X	X
<i>Chlororostilbon auriceps</i>		X	<i>E. wrightii</i>	X	X
<i>Cynanthus latirostris</i>	X	X	<i>E. oberholseri</i>	X	X
<i>Hylocharis leucotis</i>	X	X	<i>E. affinis</i>	X	X
<i>Amazilia beryllina</i>	X	X	<i>E. occidentalis</i>	X	X
<i>A. violiceps</i>	X	X	<i>E. fulvifrons</i>	X	X
<i>Lampornis amethystinus</i>		X	<i>Sayornis nigricans</i>	X	X
<i>L. clemenciae</i>	X	X	<i>S. phoebe</i>	X	
<i>Eugenes fulgens</i>	X	X	<i>S. saya</i>	X	X
<i>Tilmatura dupontii</i>		X	<i>Pyrocephalus rubinus</i>	X	X
<i>Calothorax lucifer</i>	X	X	<i>Myiarchus tuberculifer</i>	X	
<i>C. pulcher</i>		X	<i>M. cinerascens</i>	X	X
<i>Archilochus colubris</i>	X	X	<i>M. crinitus</i>	X	
<i>A. alexandri</i>		X	<i>M. tyrannulus</i>	X	X
<i>Calypte anna</i>		X	<i>Myiozetetes similis</i>		X
<i>Stellula calliope</i>		X	<i>Myiodynastes luteiventris</i>	X	
<i>Atthis heloisa</i>	X	X	<i>Tyrannus melancholicus</i>	X	
<i>Selasphorus platycercus</i>	X	X	<i>T. vociferans</i>	X	X
<i>S. rufus</i>	X	X	<i>T. verticalis</i>	X	
<i>S. sasin</i>	X		<i>T. tyrannus</i>	X	
Trogoniformes			<i>T. forficatus</i>	X	
Trogonidae			Laniidae		
<i>Trogon melanocephalus*</i>		X	<i>Lanius ludovicianus</i>	X	X
<i>T. mexicanus</i>	X	X	Vireonidae		
<i>T. ambiguus</i>		X	<i>Vireo griseus</i>	X	
Coraciiformes			<i>V. bellii</i>	X	
Alcedinidae			<i>V. plumbeus</i>		X
<i>Ceryle alcyon</i>	X	X	<i>V. solitarius</i>	X	X
<i>Chloroceryle americana</i>		X	<i>V. huttoni</i>	X	X
<i>C. aenea*</i>		X	<i>V. gilvus</i>	X	
Piciformes			Corvidae		
Picidae			<i>Cyanocitta stelleri</i>	X	X
<i>Melanerpes formicivorus</i>	X	X	<i>Cyanocorax yncas</i>	X	
<i>Sphyrapicus varius</i>	X	X	<i>Cyanocorax sp.</i>		X
<i>Picoides scalaris</i>	X	X	<i>Aphelocoma californica</i>	X	
<i>P. villosus</i>	X	X	<i>A. ultramarina</i>	X	
<i>P. stricklandi</i>	X	X	<i>Corvus corax</i>	X	X
<i>Colaptes auratus</i>	X	X	Alaudidae		
<i>Lepidocolaptes leucogaster</i>	X		<i>Eremophila alpestris</i>	X	X
Passeriformes			Hirundinidae		
Formicariidae			<i>Tachycineta bicolor</i>	X	X
<i>Grallaria guatemalensis</i>	X	X	<i>T. thalassina</i>	X	X
Tyrannidae			<i>Stelgidopteryx serripennis</i>	X	X
<i>Camptostoma imberbe</i>	X		<i>Riparia riparia</i>	X	
<i>Myiopagis viridicata</i>	X		<i>Petrochelidon pyrrhonota</i>	X	X
<i>Mitrephanes phaeocercus</i>	X	X	<i>Hirundo rustica</i>	X	X
<i>Contopus cooperi</i>	X	X	Paridae		
<i>C. pertinax</i>	X		<i>Poecile sclateri</i>	X	X
<i>C. sordidulus</i>	X	X	<i>Baeolophus wollweberi</i>		X
<i>Empidonax flaviventris</i>		X	Aegithalidae		
<i>E. alnorum</i>	X		<i>Psaltriparus minimus</i>	X	X
<i>E. albigularis</i>	X		Sittidae		
<i>E. minimus</i>	X		<i>Sitta carolinensis</i>	X	X



<i>S. pygmaea</i>	x	x	Peucedramidae		
Certhiidae			<i>Peucedramus taeniatus</i>	x	x
<i>Certhia americana</i>	x	x	Parulidae		
Troglodytidae			<i>Vermivora pinus</i>		x
<i>Campylorhynchus</i>			<i>V. peregrina</i>	x	
<i>megalopterus</i>	x	x	<i>V. celata</i>	x	x
<i>Salpinctes obsoletus</i>	x	x	<i>V. ruficapilla</i>	x	x
<i>Catherpes mexicanus</i>	x	x	<i>V. virginiae</i>	x	
<i>Thryomanes bewickii</i>	x	x	<i>V. crissalis</i>	x	
<i>Troglodytes aedon</i>	x	x	<i>Parula superciliosa</i>	x	x
<i>T. brunneicollis</i>	x	x	<i>P. americana</i>	x	
<i>Cistothorus platensis</i>	x		<i>Dendroica petechia</i>	x	x
<i>C. palustris</i>	x	x	<i>D. pensylvanica</i>	x	
Cinclidae			<i>D. magnolia</i>	x	
<i>Cinclus mexicanus</i>	x	x	<i>D. virens</i>	x	x
Regulidae			<i>D. fusca</i>	x	
<i>Regulus satrapa</i>	x	x	<i>D. graciae</i>	x	
<i>R. calendula</i>	x	x	<i>D. coronata</i>	x	x
Sylviidae			<i>D. nigrescens</i>	x	x
<i>Polioptila caerulea</i>	x	x	<i>D. townsendi</i>	x	x
<i>P. albiloris</i>	x		<i>D. occidentalis</i>	x	x
Turdidae			<i>D. carbonata*</i>		x
<i>Sialia sialis</i>	x	x	<i>D. auduboni</i>		x
<i>S. mexicana</i>	x	x	<i>Mniotilta varia</i>	x	x
<i>Myadestes occidentalis</i>	x	x	<i>Setophaga ruticilla</i>	x	
<i>M. unicolor</i>		x	<i>Protonotaria citrea</i>	x	
<i>Catharus aurantiirostris</i>	x	x	<i>Helmitheros vermivorus</i>	x	
<i>C. occidentalis</i>	x	x	<i>Seiurus aurocapillus</i>	x	
<i>C. frantzii</i>	x		<i>S. noveboracensis</i>	x	
<i>C. ustulatus</i>	x		<i>S. motacilla</i>	x	x
<i>C. guttatus</i>	x	x	<i>Oporornis philadelphia</i>	x	
<i>Hylocichla mustelina</i>		x	<i>O. tolmiei</i>	x	
<i>Turdus grayi</i>		x	<i>Geothlypis trichas</i>	x	x
<i>T. assimilis</i>	x	x	<i>G. nelsoni</i>	x	
<i>T. rufopalliatus</i>	x		<i>G. "trichas" melanops</i>		x
<i>T. migratorius</i>	x	x	<i>Wilsonia citrina</i>	x	
<i>Ridgwayia pinicola</i>	x	x	<i>W. pusilla</i>	x	x
Mimidae			<i>W. canadensis</i>	x	
<i>Mimus polyglottos</i>	x	x	<i>Cardellina rubrifrons</i>	x	
<i>Toxostoma longirostre</i>	x	x	<i>Ergaticus ruber</i>	x	x
<i>T. ocellatum</i>	x	x	<i>Myioborus pictus</i>	x	x
<i>T. curvirostre</i>	x	x	<i>M. miniatus</i>	x	x
<i>Melanotis caerulescens</i>	x	x	<i>Basileuterus rufifrons</i>	x	x
Sturnidae			<i>B. belli</i>	x	x
<i>Sturnus vulgaris</i>	x		<i>Icteria virens</i>	x	x
Motacillidae			Thraupidae		
<i>Anthus rubescens</i>	x	x	<i>Piranga flava</i>	x	x
<i>A. spragueii</i>	x	x	<i>P. rubra</i>	x	x
Bombycillidae			<i>P. ludoviciana</i>	x	x
<i>Bombycilla cedrorum</i>	x	x	<i>P. bidentata</i>	x	
Ptilonotidae			<i>Cyanerpes cyaneus</i>		x
<i>Ptilonotus cinereus</i>	x	x	Emberizidae		
<i>Phainopepla nitens</i>	x	x	<i>Volatinia jacarina</i>	x	



<i>Sporophila torqueola</i>	x	x	Icteridae		
<i>Diglossa baritula</i>	x	x	<i>Agelaius phoeniceus</i>	x	x
<i>Sicalis luteola</i>	x		<i>Sturnella magna</i>	x	x
<i>Atlapetes pileatus</i>	x	x	<i>Xanthocephalus</i>		
<i>Buarremon virenticeps</i>	x	x	<i>xanthocephalus</i>	x	x
<i>Melozone kieneri</i>	x		<i>Euphagus cyanocephalus</i>	x	x
<i>Pipilo chlorurus</i>	x	x	<i>Quiscalus mexicanus</i>	x	x
<i>P. maculatus</i>	x	x	<i>Q. palustris*</i>		x
<i>P. fuscus</i>	x	x	<i>Molothrus aeneus</i>	x	
<i>Aimophila mystacalis</i>	x		<i>M. ater</i>	x	x
<i>A. botterii</i>	x		<i>Icterus spurius</i>	x	x
<i>A. ruficeps</i>	x		<i>I. cucullatus</i>	x	
<i>Oriturus superciliosus</i>	x	x	<i>I. pustulatus</i>	x	
<i>Spizella passerina</i>	x	x	<i>I. graduacauda</i>	x	x
<i>S. pallida</i>	x	x	<i>I. gularis</i>	x	
<i>S. atrogularis</i>	x	x	<i>I. galbula</i>	x	
<i>Pooecetes gramineus</i>	x	x	<i>I. bullockii</i>		x
<i>Chondestes grammacus</i>	x	x	<i>I. abeillei</i>	x	x
<i>Passerculus sandwichensis</i>	x	x	<i>I. parisorum</i>	x	x
<i>Ammodramus bairdii</i>		x	<i>Amblycercus holosericeus</i>		x
<i>A. savannarum</i>	x		<i>Cacicus melanicterus</i>		x
<i>Melospiza melodia</i>	x	x	Fringillidae		
<i>M. lincolnii</i>	x	x	<i>Carpodacus cassinii</i>		x
<i>Zonotrichia leucophrys</i>		x	<i>C. mexicanus</i>	x	x
<i>Calcarius ornatus</i>		x	<i>Euphonia elegantissima</i>	x	x
<i>Xenospiza baileyi</i>	x		<i>Loxia curvirostra</i>	x	x
<i>Junco phaeonotus</i>	x	x	<i>Carduelis pinus</i>		x
Cardinalidae			<i>C. notata</i>	x	
<i>Caryothraustes poliogaster</i>		x	<i>C. psaltria</i>	x	x
<i>Cardinalis cardinalis</i>	x	x	<i>Serinus canarius</i>		x
<i>C. sinuatus</i>		x	<i>Coccothraustes abeillei</i>	x	
<i>Pheucticus ludovicianus</i>	x		<i>C. vespertinus</i>	x	x
<i>P. melanocephalus</i>	x	x	Passeridae		
<i>Guiraca caerulea</i>	x	x	<i>Passer domesticus</i>	x	
<i>Passerina cyanea</i>	x	x	Estrildidae		
<i>P. versicolor</i>	x	x	<i>Padda oryzivora</i>		x
<i>P. ciris</i>	x	x			