ECOLOGICAL CHARACTERIZATION OF BAT SPECIES
DISTRIBUTIONS IN MICHOACAN, MEXICO
USING A GEOGRAPHIC INFORMATION SYSTEM

by

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CHAPTER I

INTRODUCTION

Understanding the factors contributing to biodiversity and zoogeographic patterns is crucial to the work of systematists, ecologists, and conservation biologists. The importance of these fields has grown, especially in the past decade, and is reflected in increased funding of such studies. These studies provide information not only for basic scientific understanding, but also for land and wildlife management planning for the area of interest. Despite recent increased successes of reductive works from experimental ecological and molecular evolutionary studies, macroscopic studies are needed to extrapolate such results to explain patterns and processes on larger scales (Brown, 1995).

Tropical regions contain much richer and more diverse faunas than other ecosystems (Wilson, 1985, 1988). Moreover, these regions face some of the most critical problems of species extinction and natural resource depletion (Ceballos and Navarro, 1991). For the rich tropical faunas to be protected adequately, surveys and species inventories for geographic areas in the tropics are research priorities in conservation biology (Soulé and Kohm, 1989).

Being in the transition zone between the Nearctic and Neotropical regions, Middle America has one of the richest and most distinct faunas of the world (Arita and Ortega, 1998). México is high in endemism at the species level (Ceballos and Navarro, 1991). For example, 149 (33% of all Mexican species) mammal species are endemic to the country. Central México exhibits the sharpest transition between the Nearctic and Neotropical biogeographic realms (Brown and Gibson, 1983). The transition is abrupt in some areas, and more gradual in others, creating a complex diversity of faunas. A major geological and topographic component of the region is the Trans-Mexican Neovolcanic Belt (TNB). The TNB is a mountain range in central México between 19° and 20° N latitude, and 96° and 105° E longitude (Fa and Morales, 1991). The range extends from southern Veracruz through Michoacán, Colima, and into southern Jalisco, reaching both the Pacific and Gulf coasts of México. The range forms a partial barrier between faunas

of the subtropics to the north and those of the more tropical regions to the south, with many species distributions terminating within it (Fa and Morales, 1991).

Factors such as climate, spatial heterogeneity, and environmental stability all affect the number and type of species found within a particular region. In fact, such abiotic factors are considered to be among the ultimate regulators of species distribution (Brown, 1995). The TNB has high spatial heterogeneity, resulting in high biodiversity, species interactions, and endemism.

The highest concentration in México of mammalian endemism (ca. 30 endemic species) is found in the TNB area, where drastic changes in elevation from coastal lowlands to higher mountain ranges create isolated habitat islands that produce high endemism. Most endemics occur in the central region of the belt, concentrated in the pine-oak forests of high elevations (mostly between 2,000 and 5,000 meters) (Fa and Morales, 1991, 1993).

The most species rich mammalian orders in the region are rodents and bats (Fa and Morales, 1993). Species diversity is strongly affected by habitats and vegetation (Fa and Morales, 1991). In the TNB, vegetation ranges from lowland tropical forests to high elevation grasslands. Cloud forests (with trees such as *Quercus*, *Clethra*, and *Liquidambar*) at higher elevations contain the highest mammalian species diversity, and tropical associations such as semideciduous forests (with *Bursera*, *Ceiba*, *Neobuxbaumia*, *Brosimum*, etc.) also exhibit high diversities (Fa and Morales, 1991).

Despite of the extremely rich mammalian fauna of México, knowledge of distributions, habitat preferences, and reproduction is poor for most species. This is true especially in the western portion of the TNB in the state of Michoacán on the southwest coast of México (Fig. 1.1). Michoacán extends from 17.93° N to 20.40° N latitude, and between 100.05° W and 103.75° W longitude. Bounded by the Pacific Ocean and the states of Colima, Jalisco, Guanajuato, Querétaro, México, and Guerrero, Michoacán covers an area of 59,864 km². The state contains extreme topographic variation (sea level to over 3800 m) and a high diversity of climatic regions and vegetation types (Sánchez-Hernández *et al.*, 1999).

Despite the recent attention that Michoacán has received from mammalogists, and despite its high mammalian diversity, it is one of the more poorly-known states in México (Sánchez-Hernández *et al.*, 1999). Although 26 protected areas (parks and reserves) exist in the TNB region, most are concentrated near the metropolitan area of México City. Protection of habitats is inadequate in western areas such as Michoacán (Fa and Morales, 1991). Fortunately, because of historical and physiographic reasons, the state of Michoacán has suffered less degradation than some of the eastern regions. Nevertheless, many species have become extinct or extirpated since the early 20th century, largely due to over-exploitation and habitat perturbation by humans (Ceballos and Navarro, 1991).

Our understanding of the current impact of human activities on Mexican species is incomplete. A comprehensive study of the Michoacán region's biodiversity is essential to the understanding and better management of the state's mammalian fauna. Knowledge gained from such studies also will be invaluable towards land usage management decisions. Planning for activities such as forestry and farming can utilize this information for their choice of locations and management. Furthermore, states adjacent to Michoacán with similar ecological conditions also may extrapolate the results to implement management strategies.

The focus of this study is on investigating the relationship between chiropteran species distribution and four fundamental environmental factors (climate, precipitation, soil, and vegetation) within Michoacán. Bats are an Order of mammals that is abundant, species rich, and biologically diverse. They are found virtually in all terrestrial biomes except tundra and polar regions (Nowak, 1999). Consequently, bats play various and important ecological roles in both tropical and temperate communities. They have, unfortunately, been largely neglected in conservation and environmental education programs (Marinho-Filho and Sazima, 1998). Due to their high richness and diversity, bats are ideal subjects by which species distribution and its interrelationship with the environment can be examined.

The distribution patterns of seventy-one bat species are evaluated in this study, utilizing a geographic information system (GIS), with respect to the four selected environmental factors. GIS is useful for such analyses in that it is capable of organizing and analyzing large sets and multiple layers of spatially related but distinct data (Witham and Kimball, 1996). GIS technology has wide applications in ecological modeling (e.g., Aspinall and Matthews, 1994; Kadmon and Heller, 1998; Liu *et al.*, 1995; Witham and Kimball, 1996), wildlife management and conservation (e.g., Bojórquez-Tapia *et al.*, 1995; Lewis, 1995; Ostro *et al.*, 1999), and pattern analysis (Sheeler-Gordon and Owen, 1999).

Correspondence analysis (CA) is used to analyze the bat species distribution's correlation to the components of the environmental factors. CA is a multidimensional graphical method of analysis that is suitable for categorical data (Greenacre, 1993). This technique and its modified forms have been extensively utilized for analyses in various sectors of quantitative science (e.g., Bojórquez-Tapia *et al.*, 1995; David *et al.*, 1974; Greenacre and Vrba, 1984; Melguen, 1974; Montaña and Greig-Smith, 1990).

The specific objectives of this study are:

1. to determine the relative importance of the four environmental factors, with respect to the distributions of bat species within Michoacán;
2. to determine the component within each factor that correlates most strongly with each species' distribution within Michoacán;
3. to construct a predictive map of bat species richness for the state of Michoacán.

These analyses are conducted based on each species' distribution individually, as well as those of the species grouped by families and by trophic category (guild). The species are evaluated by guilds because feeding habits likely affect the occurrence of bat species in an area.

The species richness map will provide valuable tools for conservation works in the state of Michoacán. Species-rich areas tend to support more uncommon species (Patterson, 1987), and are prone to generate conflicts between conservation and resource extraction (Bojórquez-Tapia *et al.*, 1995). Such areas should obtain the priority for

protection (Blockstein, 1990; Davis *et al.*, 1990). Predictive maps can help identify these priority areas for conservation.

Figure 1.1. Location of study area (red) in México.

CHAPTER II

MATERIALS AND METHODS

Species Data

A survey and inventory of small mammals in Michoacán was conducted by Dr. Robert D. Owen (Texas Tech University, TTU), Dr. Cornelio Sánchez-Hernández (Universidad Nacional Autónoma de México, UNAM), Dr. Maria de Lourdes Romero-Almaraz (Universidad Autónoma del Estado de Morelos, UAEM), Dr. Ricardo López-Wilchis (Universidad Autónoma Metropolitana-Iztapalapa, UAM-I), and M. en C. Arturo Núñez-Garduño (Universidad Michoacana de San Nicolás de Hidalgo, UMSNH). The project was designed to collect data to answer questions concerning systematics, ecology, and zoogeography of the mammalian and ectoparasite fauna of southwestern México. In addition, preliminary collection of material had been conducted beginning in 1975, mainly by Cornelio Sánchez-Hernández and his students. Intensive fieldwork for the project was carried out between 1992 and 1996, with the most intensive periods in 1994 and 1995. One month during each summer and one month during each winter of the two-year period were devoted to fieldwork, and several thousand mammalian specimens (mainly rodents, bats, and marsupials) were collected during this period.

Approximately 50 localities were sampled throughout the state to ensure that the collections are as representative as possible. Collecting methods for bats included mist nets, hand-nets, and hand. Specimens were processed as soon as possible (within the same day of capture). Each bat specimen was preserved in one of three ways: skin and partial skeleton, full skeleton, or in spirits (formalin, followed by ethanol). Information on each specimen including collecting locality, primary specimen identification, sex, reproductive status, and associated information concerning ectoparasites was recorded into a database system. Some of the later collections (934 out of 3,564) from the project also included coordinates of the collection sites, recorded with hand held global positioning system (GPS) receivers. This database has been updated periodically as final identifications were determined.

The portion of the database containing information for all chiropteran specimens from the field project was augmented with information from specimens in museum collections in the U.S. and México, provided by Drs. C. Sánchez-Hernández and M. de L. Romero-Almaraz. The combined data sets comprise a total of 3,564 bat specimens, representing 259 localities (Appendix A). To include all specimens in the analyses, collecting locality coordinates were estimated from maps of the state of Michoacán (1:250,000; Instituto Nacional de Estadística, Geografía e Informática, 1980) using the collection site information of those specimens. Both the GPS-recorded and estimated coordinates are recorded in the Latitude-Longitude coordinate system. Specimens that were only identified to the generic level, or bearing localities that could not be located, were excluded from the data set and the analyses. The resulting data set contains a total of 3,236 entries representing 71 species of bats.

A data set of species presence and absence in each collecting locality was constructed by selecting one specimen of each species found in every collection site. Each species collected at a site is represented by only one entry in this presence/absence set. This data set was used in the analysis to lessen the effect of sample size differences among species. An account of the specimens included in this data set is given in Appendix B.

Trophic Categorization

Each species was assigned to one of eight trophic categories (guilds): forest and clearing aerial insectivores, open-air insectivores, water bats (piscivores), gleaning insectivores/carnivores/omnivores, nectarivores, ground-story frugivores, canopy frugivores, and sanguinivores (Findley, 1993).

Environmental Data

Digitized maps of climate (Fig. 2.1), precipitation (Fig. 2.2), vegetation (Fig. 2.3), and soils (Fig. 2.4) of Michoacán, were provided by Lorinda Sheeler-Gordon. These maps were digitized from paper maps (1:500,000; Instituto Nacional de Estadística,

Geografia e Informatica, 1985) using a 486 Dell PC, running ARC/INFO Ver. 3.4.2b (ESRI, 1994), and a digitizing board (CalComp 9500, 36 x 48). Each environmental factor comprises different numbers of variables or components (see corresponding map of each factor for the categories). The maps were converted from the Universal Transverse Mercator (UTM) coordinate system to the Latitude-Longitude coordinate system using PC ARC/INFO Ver. 3.5.2 (ESRI, 1998).

The bat species data set was imported into the GIS to generate a point coverage of all the collecting localities (Fig. 2.5). This coverage was overlaid on the environmental factor maps by means of ArcView GIS Ver. 3.2 (ESRI, 1999), and each specimen was associated with the corresponding environmental component of each factor. Components of the climate factor initially included both temperature and humidity. These components were pooled to give categories that pertain only to temperature, given that humidity is already reflected in the precipitation factor. Temperature categories include “semi-cold” (mean annual temperature, MAT 8° – 14° C), “moderate” (MAT 14° – 18° C), “warm” (MAT 18° – 20° C), “semi-hot” (MAT 20° – 22° C), “hot” (MAT 22° – 26° C), and “very hot” (MAT 26° – 32° C). Gradients of precipitation were assigned to categories of “very low” (mean annual precipitation, MAP 400 – 600 mm), “low” (MAP 600 – 800 mm), “medium” (MAP 800 – 1200 mm), “high” (MAP 1200 – 1500 mm), and “very high” (MAP 1500 – 2000 mm). A raw categorical data matrix of the specimens and environmental variables was constructed.

Statistical Analyses

Correlations of the species distribution and the environmental variables were examined with correspondence analysis (CA). CA uses graphical display to obtain a summary description of a large data set comprising a large number of variables. Greenacre (1984, p. 54) describes correspondence analysis as: “a technique for displaying the rows and columns of a data matrix ... as points in dual low dimensional vector spaces.”

CA is similar in method to principal components analysis (PCA), but is particularly suitable for discrete data, whereas PCA is more suited to continuous data (Greenacre and Vrba, 1984; Lebart *et al.*, 1984). The graphical representation of data generated by CA allows visual examination of the correlations among the data points. Correspondence analysis is considered to be an exploratory analysis (Greenacre and Vrba, 1984; Lebart *et al.*, 1984) in that it detects possible patterns of associations and differences in the data, rather than evaluating specific hypotheses (Greenacre and Vrba, 1984).

The concept behind correspondence analysis is to determine the correlation of the data (the rows and columns of the matrix) in a multidimensional space as two clouds of points, and simplify the projection into a low (usually two) dimensional space, while conserving as much of the information as possible (Melguen, 1974). The configuration of the row and column points in the multidimensional space is based on the relative frequency (profile) of the data (in this case, species and environmental variables). The distance between two data points, known as the chi-square (χ^2) distance, is calculated based on the relative frequency of the data point. On the other hand, the chi-square (χ^2) statistic is a measure of the association between rows and columns of a table (SAS Institute, 1999). The inertia (referred to as “eigenvalue” by Lebart *et al.*, 1984) is calculated by dividing the χ^2 statistic by the grand total of the table (and hence is proportional to the χ^2 statistic).

Two other series of coefficients are useful for interpreting the axes: absolute contributions to principal inertia and squared correlations (squared cosines) (Lebart *et al.*, 1984). The absolute contribution of a variable is equal to the square of its coordinate multiplied by its frequency (Montaña and Greig-Smith, 1990), and indicates the proportion of variance explained by the variable in relation to each principle axis (Lebart *et al.*, 1984). The squared correlation is the squared cosine ($\cos^2$) of the angle between a variable’s vector and a principle axis. This value indicates the part of the variance of the variable explained by the principle axis (Lebart *et al.*, 1984).

An overall correspondence analysis was performed with the components of all four environmental factors as column data and the bat species presence and absence as row data. Inertia contributions from the environmental components (absolute contributions) were obtained. Mean contributions (i.e., total absolute contribution from all components of a factor divided by its number of components) instead of total absolute contributions were used as indicator of importance of the factors, as suggested by Montaña and Greig-Smith (1990). This was due to the fact that total absolute contributions are associated positively with the number of categories in a factor (Montaña and Greig-Smith, 1990). All contributions used (both total and mean) refer to the total from all principal axes (i.e., sum of contributions from all axes).

A cluster analysis using Ward's minimum-variance method (SAS Institute, 1999) was performed on the species coordinate output of the CA. In Ward's method, the distance between two clusters is the ANOVA sum of squares between the two clusters added over all variables. This method tends to join clusters with a small number of observations, and is biased toward producing clusters with roughly the same number of observations (SAS Institute, 1999). Doing so helped identify groups of species with similar environmental requirements. All statistical analyses were carried out using SAS Ver. 8 statistical software (SAS Institute, 1999). The SAS programs for the correspondence and cluster analyses are given in Appendix C.

Associations between each species and the environmental factors were determined from the ordination of the CA. The CA scatter plot superimposes the gradients formed by the environmental variables onto the plot of the species data points. By examining each species' relative position on the environmental gradients in the plot, its associated variables were determined. A species towards either extreme of a gradient was associated with the corresponding environmental variable. In situations where the position of the species data point was less distinct (such as between two environmental variables), the presence and absence data set was employed to facilitate interpretation of the graph. The "more common" variable(s) of a factor in a species was (were) determined

to be associated with the species. The same methodology was used to characterize the species for all three environmental factors (temperature, precipitation, and vegetation).

Species in each cluster established by Ward's cluster analysis were characterized by similar assignments (characterizations) of environmental variables. In essence, the position of each cluster on the environmental gradients was examined. The resulting matrix depicts the observed ecological and environmental associations of each species.

Species in Ward's cluster analysis result were coded with their trophic levels, enabling visual examination of clusterings of trophic groups.

Predictive Map

Grids of the state map were generated to construct the predictive map. A matrix of 1 km² grids was created using "GENERATE—GRID" command of PC ARC/INFO. This layer of grids was overlaid on the state map in ArcView to trim off the grids outlying the state border, using the query function. The grids layer also was overlaid on the environmental factor maps to characterize each grid. The resulting grid cover forms the shape of the state, with each grid containing the appropriate combination of variables of the four environmental factors.

A map of the distribution predicted by the CA result, was produced for each species. Grids that contain the exact combination of corresponding environmental variables for each species recorded in the environmental character matrix (Table 3.2) were queried in ArcView and saved as individual shape files. The predicted distribution range maps of the 71 bat species then were overlaid in ArcView to create a predicted chiropteran species richness map of Michoacán.

Figure 2.1. Climatic zones of Michoacán.

Figure 2.2. Precipitation levels of Michoacán.

Figure 2.3. Vegetation zones of Michoacán.

Figure 2.4. Soil types (FAO) of Michoacán.

Figure 2.5. Collecting localities in Michoacán.

CHAPTER III

RESULTS

The first axis (Dimension 1) of the CA ordination accounted for 41.3% of the total variation in the data (Table 3.1). Temperature, vegetation, and soil type formed gradients along Dimension 1 (Fig. 3.1). Species that scored low were associated with high temperature and tropical types of vegetation (e.g., tropical deciduous forest), and species with high scores were associated with moderate temperatures and temperate vegetation types (e.g., pine oak forest and scrubland). Dimension 1 also ordered species according to the latitudinal locations of their ranges.

The second axis (Dimension 2) explained 12.4% of the variation (Table 3.1). Precipitation formed a gradient along Dimension 2. Species correlated with high precipitation had low scores on Dimension 2 while those correlated with low precipitations scored high (Fig. 3.1).

The third (Dimension 3) and fourth (Dimension 4) axes accounted for 7.5% and 6.2% of the total variation (Table 3.1) respectively. The majority of the data clustered around the origin of Dimension 3 and Dimension 4. No discernible gradients among any of the environmental factors were present (Fig. 3.2).

A data point on the ordination plot that is proximate to the origin of the axes represents an item with low contribution to the variation of the data set (LeBart *et al.*, 1984). Consequently, a species that was near the origin had undifferentiated distribution throughout the whole state. Five species of the family Phyllostomidae (*Artibeus intermedius*, *A. jamaicensis*, *Desmodus rotundus*, *Glossophaga soricina*, and *Leptonycteris curasoae*) had homogeneous distributions accordingly. Several other species also had undifferentiated distributions for at least one of the three environmental factors. Furthermore, certain species, although not undifferentiated, were correlated with two or more variables for at least one environmental factor (Table 3.2).

Similarly, an environmental variable with close proximity to the origin carried no influence on species distributions. Semi-cold temperature and medium precipitation level

data points were located near the origin of Dimension 1 and Dimension 2 (Fig. 3.1). Very few species were associated with semi-cold climate conditions, and none were found to occur in regions of this temperature category (Table 3.2). Regions of medium precipitation, on the other hand, covered a majority portion of the state and were associated with most bat species. All but eleven species were depicted as having distributions in areas of medium precipitation levels (Table 3.2).

Relative Importance of Environmental Factors

Mean contributions (MC) of inertia indicated that the environmental factors, in descending order of importance in explaining species distributions, are: temperature (MC = 0.0484), vegetation (MC = 0.0396), precipitation (MC = 0.0329), and soil type (MC = 0.0283). In addition, using the presence and absence data set as an aid in interpreting the CA result, soil type characters were demonstrated to have high heterogeneity of association with the species distributions. Soil type was therefore excluded from the prediction model.

Correlations Between Species Distributions and Environmental Factors

The cluster analysis indicated two main clusters of species (Fig. 3.3). These clusters approximately represented the latitudinal distribution gradients of the species. Twenty-one species, 13 of which are from the family Vespertilionidae, belong to the northern cluster. The southern cluster included 50 species and represented all chiropteran families in the region.

On a more precise level, 12 groups of species with similar environmental requirements were identified. These groups were evaluated with respect to the ordination output of the CA (Fig. 3.1). Species-environment correlations were derived by examining relative positioning of each species data point with respect to all environmental factor data points. For example, in the characterization of precipitation associations of the species, the precipitation variables formed a gradient in which “very low” category scored positive in Dimension 2 and negative in Dimension 1 (i.e., top left corner of

graph), “low” category scored positive for both dimensions (top right corner), “medium” category scored positive for Dimension 1 and negative for Dimension 2 (bottom right corner) but was very close to the origin of the plot, and “high” category scored negative for both dimensions (bottom left corner) (Fig. 3.1). Consequently, species near the top left corner of the graph were associated with very low precipitation levels, those near the bottom left corner were associated with high precipitation levels, and so forth. Species near the bottom right corner and those near the origin of the dimensions (regardless of the quadrant they were in) were associated with medium precipitation. The presence and absence data set was used as an aid for the interpretation of the CA graphical output. With the exception of soil type, all environmental factors had rather consistent variable associations with each species based on examination of the data set.

Absolute distances between species points and environmental points were not considered in the analyses and interpretation because proximity of two points corresponding to two different sets of points in a CA ordination plot is, in most cases, meaningless (LeBart *et al.*, 1984).

Distribution Patterns by Families and Trophic Guilds

Bats in Michoacán belong to one of seven families: Emballonuridae, Molossidae, Mormoopidae, Natalidae, Noctilionidae, Phyllostomidae, and Vespertilionidae. Families Phyllostomidae and Vespertilionidae represent the majority (~65%) of the species. Neither the CA numerical output nor the cluster analysis revealed discernible grouping of species by families with respect to environmental variables. The CA graphical ordination, however, did indicate a latitudinal gradient among the families. In particular, species of the family Phyllostomidae had distributional ranges concentrated in the southern portion of the state, and species of the family Mormoopidae had exclusively southern distributions. Vespertilionid bats, on the other hand, were more commonly found in the northern region. Latitudinal patterns of the other families were less distinct (Fig. 3.4).

Distribution patterns by trophic guilds were similar to those of families in that no particular associations were detected between feeding guilds and environmental

variables. The feeding guilds appeared to fall loosely along the latitudinal gradient in the CA ordination (Fig. 3.5). Most species with ranges in the northern region of Michoacán were aerial insectivores. The southern region was generally occupied by frugivores (both canopy and ground story), open air insectivores, and gleaning insectivores/carnivores. Nectarivorous, piscivorous, and sanguinivorous bats were composed of too few species to discern patterns (Fig 3.5).

Predictive Maps

Appendix D includes the predicted distribution ranges of the 71 chiropteran species derived from the species-environmental factor correlation. When overlaid, these maps resulted in the species richness prediction map (Fig. 3.6) for the state's chiropteran fauna.

The total number of species of bats predicted to occur in any given grid ranged from six to forty. Regions of the state with the highest predicted richness included the southwestern and southeastern portions (Fig. 3.6). These areas generally contain tropical deciduous forest vegetation type and medium levels of precipitation.

Table 3.1. Correspondence analysis result: inertia and chi-square decomposition.

Dimension	Singular Value	Principal Inertia	Chi-Square	Percent	Cumulative Percent
1	0.579	0.336	1179.94	41.27	41.27
2	0.318	0.101	355.78	12.44	53.71
3	0.247	0.061	214.40	7.50	61.21
4	0.225	0.051	177.72	6.22	67.42
5	0.209	0.044	153.21	5.36	72.78
6	0.186	0.034	121.22	4.24	77.02
7	0.166	0.027	96.52	3.38	80.40
8	0.151	0.023	80.16	2.80	83.20
9	0.142	0.020	71.06	2.49	85.68
10	0.129	0.017	58.81	2.06	87.74
11	0.126	0.016	55.67	1.95	89.69
12	0.118	0.014	49.27	1.72	91.41
13	0.113	0.013	45.04	1.58	92.99
14	0.101	0.010	36.20	1.27	94.25
15	0.096	0.009	30.12	1.05	95.31
16	0.087	0.008	26.47	0.93	96.23
17	0.082	0.007	23.55	0.82	97.06
18	0.078	0.006	21.28	0.74	97.80
19	0.078	0.006	21.13	0.74	98.54
20	0.069	0.005	16.94	0.59	99.13
21	0.050	0.003	8.81	0.31	99.44
22	0.046	0.002	7.37	0.26	99.70
23	0.041	0.002	5.88	0.21	99.90
24	0.028	0.001	2.78	0.10	100.00
Total		0.813	2859.34	100.00	

Degrees of Freedom = 1890

Table 3.2. Predicted ecological requirements of bats in Michoacán based on the graphical result of the CA. The species are arranged by families. Variables represented by the vegetation abbreviations are: cul-land, cultivated land; irrig-ag, irrigated agriculture; pine-oak, pine oak forest; semi-dec, semi-deciduous forest; scrubland, scrubland; trop-dec, tropical deciduous forest. A cell that reads “all” indicates that the species has no specific requirements for that environmental factor.

Family/Species		Temperature	Precipitation	Vegetation
Emballonuridae				
<i>Balantiopteryx</i>	<i>plicata</i>	hot, very hot	all	trop-dec, irrig-ag
<i>Dididurus</i>	<i>albus</i>	hot	high	trop-dec
<i>Peropteryx</i>	<i>macrotis</i>	warm	medium	pine-oak
Molossidae				
<i>Eumops</i>	<i>glaucus</i>	hot	medium	trop-dec
<i>Eumops</i>	<i>underwoodii</i>	moderate	medium	pine-oak
<i>Molossus</i>	<i>aztecus</i>	hot	medium	semi-dec
<i>Molossus</i>	<i>molossus</i>	hot	medium	trop-dec
<i>Molossus</i>	<i>rufus</i>	hot	medium, high	trop-dec
<i>Molossus</i>	<i>sinaloae</i>	all	medium, low	trop-dec, pine-oak
<i>Nyctinomops</i>	<i>aurispinosus</i>	hot	medium	trop-dec
<i>Nyctinomops</i>	<i>femorasaccus</i>	hot, very hot	all	trop-dec
<i>Nyctinomops</i>	<i>laticaudatus</i>	very hot	very low	trop-dec
<i>Nyctinomops</i>	<i>macrotis</i>	moderate, semi-hot	low	pine-oak, trop-dec
<i>Promops</i>	<i>centralis</i>	hot	medium	trop-dec
<i>Tadarida</i>	<i>brasiliensis</i>	moderate, semi-hot	medium, low	pine-oak
Mormoopidae				
<i>Mormoops</i>	<i>megalophylla</i>	hot	medium, high	trop-dec, cul-land
<i>Pteronotus</i>	<i>davyi</i>	hot	medium	trop-dec, cul-land
<i>Pteronotus</i>	<i>pamellii</i>	all	all	trop-dec, cul-land
<i>Pteronotus</i>	<i>personatus</i>	hot, very hot	all	trop-dec
Natalidae				
<i>Natalus</i>	<i>stramineus</i>	hot	medium, high	trop-dec, semi-dec
Noctilionidae				
<i>Noctilio</i>	<i>leporinus</i>	hot	medium, high	trop-dec
Phyllostomidae				
<i>Anoura</i>	<i>geoffroyi</i>	moderate, warm	medium	pine-oak, cul-land
<i>Artibeus</i>	<i>hirsutus</i>	all	medium, low	trop-dec, irrig-ag, cul-land
<i>Artibeus</i>	<i>intermedius</i>	all	all	all
<i>Artibeus</i>	<i>jamaicensis</i>	all	all	all
<i>Artibeus</i>	<i>lituratus</i>	hot	medium, high	trop-dec, cul-land
<i>Carollia</i>	<i>subrufa</i>	hot	medium, high	trop-dec, semi-dec
<i>Centurio</i>	<i>senex</i>	hot	medium, high	trop-dec
<i>Chiroderma</i>	<i>salvini</i>	hot, warm	medium	cul-land
<i>Choeronycteris</i>	<i>mexicana</i>	moderate, semi-hot	medium	pine-oak, scrubland

Table 3.2. (Continued.)

Family/Species		Temperature	Precipitation	Vegetation
Phyllostomidae (Continued)				
<i>Dermanura</i>	<i>azteca</i>	moderate, warm	medium	pine-oak, cul-land
<i>Dermanura</i>	<i>phaeotis</i>	hot	medium, high	trop-dec, semi-dec
<i>Dermanura</i>	<i>tolteca</i>	<i>all</i>	medium, high	trop-dec, cul-land
<i>Desmodus</i>	<i>rotundus</i>	<i>all</i>	<i>all</i>	<i>all</i>
<i>Enchisthenes</i>	<i>hartii</i>	hot	medium, high	trop-dec, semi-dec
<i>Glossophaga</i>	<i>commissarisi</i>	hot, very hot	<i>all</i>	trop-dec
<i>Glossophaga</i>	<i>leachii</i>	hot, very hot	<i>all</i>	trop-dec
<i>Glossophaga</i>	<i>morenoi</i>	hot, very hot	<i>all</i>	trop-dec
<i>Glossophaga</i>	<i>sonicina</i>	<i>all</i>	<i>all</i>	<i>all</i>
<i>Leptonycteris</i>	<i>curasoae</i>	<i>all</i>	<i>all</i>	<i>all</i>
<i>Leptonycteris</i>	<i>nivalis</i>	moderate, warm	medium	cul-land, scrubland, pine-oak
<i>Macrotus</i>	<i>waterhousii</i>	hot, very hot	<i>all</i>	trop-dec, irrig-ag
<i>Micronycteris</i>	<i>megalotis</i>	hot, very hot	<i>all</i>	trop-dec
<i>Micronycteris</i>	<i>silvestris</i>	hot	high	semi-dec
<i>Musonycteris</i>	<i>harrisoni</i>	hot, very hot	<i>all</i>	trop-dec
<i>Stumira</i>	<i>lilium</i>	<i>all</i>	medium, high	trop-dec, cul-land
<i>Stumira</i>	<i>ludovici</i>	moderate, warm	medium	pine-oak
<i>Stumira</i>	<i>occidentalis</i>	hot	medium	trop-dec, semi-dec
<i>Uroderma</i>	<i>bilobatum</i>	hot	high	trop-dec
Vespertilionidae				
<i>Corynorhinus</i>	<i>mexicanus</i>	moderate	medium, high	pine-oak
<i>Corynorhinus</i>	<i>townsendii</i>	moderate, warm	medium	pine-oak
<i>Eptesicus</i>	<i>furinalis</i>	hot	high	semi-dec
<i>Eptesicus</i>	<i>fuscus</i>	moderate, warm	medium	pine-oak, cul-land
<i>Idionycteris</i>	<i>phylotis</i>	<i>all</i>	medium	cul-land
<i>Lasiurus</i>	<i>borealis</i>	<i>all</i>	medium	pine-oak, trop-dec
<i>Lasiurus</i>	<i>cinereus</i>	moderate	<i>all</i>	pine-oak
<i>Lasiurus</i>	<i>ega</i>	hot	medium, high	trop-dec
<i>Lasiurus</i>	<i>intermedius</i>	semi-hot	low	pine-oak
<i>Myotis</i>	<i>auriculus</i>	moderate	low	pine-oak
<i>Myotis</i>	<i>californicus</i>	moderate, semi-hot	medium, low	pine-oak
<i>Myotis</i>	<i>carteri</i>	hot	medium	trop-dec
<i>Myotis</i>	<i>fortidens</i>	hot	medium, high	trop-dec
<i>Myotis</i>	<i>jaliciensis</i>	moderate, warm	medium	pine-oak
<i>Myotis</i>	<i>leibii</i>	moderate	medium	pine-oak
<i>Myotis</i>	<i>lucifugus</i>	moderate, semi-hot	medium, low	pine-oak
<i>Myotis</i>	<i>nigricans</i>	moderate	low	pine-oak
<i>Myotis</i>	<i>velifer</i>	moderate, semi-hot	medium, low	pine-oak
<i>Myotis</i>	<i>yumanensis</i>	moderate, semi-hot	medium, low	pine-oak
<i>Rhogeessa</i>	<i>alleni</i>	very hot	very low	trop-dec
<i>Rhogeessa</i>	<i>mira</i>	very hot	very low	trop-dec
<i>Rhogeessa</i>	<i>parvula</i>	hot, very hot	<i>all</i>	trop-dec

Figure 3.1. Ordination plot of Dimension 1 and Dimension 2 of the CA. Orange data points represent species and blue data points represent environmental variables. Refer to Table 3.1 for full species names. The environmental variables are grouped and numbered as follows: 1 – climate, 2 – precipitation, 3 – vegetation, and 4 – soil type.

Figure 3.2. Ordination plot of Dimension 3 and Dimension 4 of the CA. Data point coloration and numbering same as Figure 3.1.

Figure 3.3. Cluster analysis of species Dimension 1 and Dimension 2 coordinates.

Figure 3.4. Ordination plot of Dimension 1 and Dimension 2 of the CA, with species grouped by families. Data point coloration same as Figure 3.1. The species data points' family numbering is as follows: 1 – Emballonuridae, 2 – Molossidae, 3 – Mormoopidae, 4 – Natalidae, 5 – Noctilionidae, 6 – Phyllostomidae, 7 – Vespertilionidae.

Figure 3.5. Ordination plot of Dimension 1 and Dimension 2 of the CA, with species grouped by feeding guilds. Data point coloration same as Figure 3.1. The species data points' feeding guild numbering is as follows: 1 – aerial insectivore, 2 – open air insectivore, 3 – gleaning insectivore/carnivore, 4 – nectarivore, 5 – canopy frugivore, 6 – ground story frugivore, 7 – piscivore, 8 – sanguinivore.

Figure 3.6. Predicted chiropteran species richness in the state of Michoacán.

CHAPTER IV

DISCUSSION

Correlations Between Species Distributions and Environmental Factors

Effect of temperature on species distributions has been documented for a wide variety of organisms, including birds (Rabinovich and Rapoport, 1975), parasites (Pozio *et al.*, 1998), macroinvertebrates (Lowe and Hauer, 1999), and microbes (Nishiguchi, 2000). Bojórquez-Tapia *et al.* (1995) reported mean annual temperature to have the highest contribution to variations in mammalian distributions in the Mexican states of Guerrero and Oaxaca. Temperature gradient in Michoacán corresponds to elevation (Fig. 2.1). Temperature categories in regions of low elevation of the state are mostly hot and very hot. Northern regions of Michoacán, which contains part of the Trans-Mexican Neovolcanic Belt, are characterized by semi-hot, warm, and moderate temperature categories. Similarly, the Sierra Coalcomán mountain range in southwestern Michoacán, which includes Cerro Laurel and Cerro la Bufo, is characterized by moderate to warm temperature.

Chiropteran species richness of Michoacán appears to be correlated positively with temperature. Although a quantitative measure of temperature was not used in the present study, results of the correspondence analysis demonstrated a strong relationship between temperature and bat species distributions in Michoacán. More species were associated with hot temperature than with warm or moderate conditions (Table 3.2). This correlation does not, however, apply to the very hot temperature category. Only 13 species were associated with this category (other than the species that were predicted to have homogeneous distributions). The relatively low number of species expected to occur in these regions may be a consequence of the association between this category and the very low precipitation category (see Fig. 3.1 and the discussion on precipitation).

Vegetation was the second most important factor in explaining chiropteran species distributions in Michoacán. Vegetation type within the state corresponds closely to temperature gradient and, in turn, to elevation. Tropical deciduous forest and semi-

deciduous forest occur mostly in low elevation regions of the state, where the temperatures generally range from hot to very hot. Pine oak forest and scrubland are found more commonly in areas of high elevation in Michoacán, where temperature categories include moderate, warm, and semi-hot.

Tropical deciduous forest and pine oak forest are the two most common vegetation types in Michoacán (Fig. 2.3), and each supports substantial numbers of bat species. However, other than the five Phyllostomid species with homogeneous predicted distributions, only three (*Idionycteris phyllotis*, *Molossus sinaloae*, and *Nyctinomops macrotis*) were associated with both of these vegetation categories (Table 3.2). Thus, it appears that vegetation type may be a good indicator of spatial segregation of bats.

Precipitation levels within the state also appear to correlate with elevation (see Fig. 2.2). It has been shown that in arid regions, primary productivity is correlated positively with precipitation (Pearson, 1965). Bat species of Michoacán, however, attained peak richness at medium precipitation levels, and all but 11 species were predicted to have distributions in regions of medium precipitation. Regions with the lowest precipitation (“very low” category) did not associate with very many species. On the other hand, the low abundance of species in areas of high precipitation may be the result of the positive correlation between precipitation and elevation. High elevation areas support fewer species than lowland counterparts (Graham, 1983; Nathan and Werner, 1999; Patterson *et al.*, 1998).

Other important factors contributing to mammalian species distributions described by Bojórquez-Tapia *et al.* (1995) included soil type, mean annual precipitation, and landform. In the present study, vegetation and precipitation level were considered better predictors of chiropteran species richness than was soil type. Soil types are heterogeneous within Michoacán (Fig. 2.4), and very little consistency of association was noted for the bat species. Consequently, although soil type formed a gradient along Dimension 1 of the CA output and seemed to correlate with vegetation type (Fig. 3.1), it was omitted as a factor in the bat species richness prediction model.

Elevation as an Environmental Factor

Elevation has been reported as an important factor affecting species distribution and richness (e.g. Bojórquez-Tapia *et al.*, 1995; Graham, 1983; Loiselle and Blake, 1991; Nathan and Werner, 1999; Patterson *et al.*, 1998; Zammuto and Millar, 1985). Given the extreme topographic variation within the state of Michoacán, elevation potentially would be a particularly useful predictor of species distribution patterns. Elevation was not included among the analyses of the present study because data regarding it were inconsistently available and, to an extent, unreliable. Roughly only 70% of the collections included elevational data, and these were determined by a variety of methods.

Nonetheless, effect of elevation on chiropteran species distributions in Michoacán is reflected indirectly through its associations with the selected environmental factors. Elevation's effect on temperature, precipitation, and vegetation patterns of the state influences the distribution and richness of its bat species.

Distribution Patterns by Families and Trophic Guilds

Three families (Vespertilionidae, Phyllostomidae, and Mormoopidae) exhibited an elevational pattern of distribution. However, other than the family Mormoopidae, no bats of any family occurred exclusively in high or low elevations. In addition, no distinct taxonomic patterns were detected in any of the groups identified by the cluster analysis, further indicating that family membership probably is not an important factor of chiropteran species distributions.

Distribution patterns of trophic guilds are not unlike those of families. Only general elevational gradients are discernible. The abundance of frugivorous bats in low elevation areas of Michoacán reflects vegetation type, which in the tropical deciduous and semi-deciduous forests includes a wider variety and greater abundance of fruiting trees, than do the pine-oak forests of high elevation. Nevertheless, the feeding guilds did not appear to correlate with vegetation types or temperature of the state directly.

Predicted Chiropteran Species Richness

The species richness map (Fig. 3.6) predicts that areas of low elevation in the state generally support a higher number of chiropteran species. One possible explanation for this prediction is the spatial heterogeneity hypothesis of species diversity gradients (Pianka, 1966). On the regional (macro-) scale, this hypothesis states that the tropics (corresponding to southern regions in Michoacán) contain more habitats, thereby supporting a more diverse fauna. On the local (micro-) scale, this hypothesis predicts that the tropics contain higher number of microhabitats. Such abundance of microhabitats facilitates a finer partitioning of each habitat among species and thus enables more species to co-exist (Davidowitz and Rosenzweig, 1998). In Michoacán, the southern half of the state contains both tropical habitats in low elevations and temperate habitats in regions of higher elevation. In its northern part, the state sustains only temperate habitats. This conforms to the macro-scale spatial heterogeneity hypothesis. Southern Michoacán may support more chiropteran species in part because it contains more habitat types of vegetation and temperature than the north.

Another hypothesis that may pertain is the climatic stability hypothesis (Pianka, 1966), which attributes high species richness of a region to its stable climates. This hypothesis states that the relative constancy of resources allows species to evolve more specializations and adaptations, and therefore more species can occupy the unit habitat space. Tropical regions have more consistent temperature and precipitation levels than the temperate (Pianka, 1966), hence sustaining more species. This can be discerned in the present study in that the hot temperature zones in southern Michoacán support higher numbers of bat species than do the temperate areas of comparable latitude (Fig. 3.6).

Conservation Implications

Bats are biologically diverse and ecologically important organisms. Because of their high richness and diversity, bats are good ecological indicators. Areas of the highest chiropteran species richness should receive conservation priorities because species-rich areas tend to support more uncommon species (Patterson, 1987). In order to minimize

conflicts between conservation and resource extraction, the species richness prediction map can be used to locate these species-rich areas and allot conservation priorities.

Analytical Tools

Correspondence analysis is a useful multivariate descriptive analytical method. It especially is favorable for categorical data such as vegetation and soil type, making it suitable for analyzing environmental factors in ecological studies. The descriptive nature of CA allows visual examination of two sets of data (in this case, species and environmental variables) in a joint display, and is a concise graphical summary of the nature of their correspondence (Greenacre and Vrba, 1984). The graphical plot of the analysis provides information on correlations not only between species and the environmental factors, but also within these two sets of data (i.e., among species and among the environmental components).

Correspondence analysis apparently is robust to differences in sample sizes among species. The species presence and absence data set was used in this study to avoid statistical effects of rare or abundant species. However, preliminary analyses (not reported here) were conducted using the original raw data prior to the construction of the presence and absence data set. The two-dimensional graphical output of CA was not substantially altered by the use of the presence and absence data compared to that of the raw data. Greenacre and Vrba (1984) reported a similar outcome with reweighted data of antelope frequencies on African wildlife areas.

The use of Geographic Information Systems has proven to be an important implement in analyzing species richness and distribution patterns. Coupled with the multivariate statistical method, the GIS was critically important to the pattern analysis of species distributions. The system was used to select and characterize each specimen ecologically, which was the core of this study. The GIS also provided insights in examining correlations among the environmental factors. Furthermore, the GIS was an integral process in the construction of the species richness prediction map.

CHAPTER V

CONCLUSIONS

Chiropteran species distributions of Michoacán mostly are influenced by the temperature gradients within the state. Among the temperature categories, hot temperature (MAT 22° – 26° C) supports the highest number of species. Vegetation type is the second most important factor in explaining species distributions of bats. Tropical deciduous forest sustains the greatest number of species, followed by pine oak forest. Species of bats appear to segregate between the two vegetation types. The third most important environmental factor affecting bat species distributions is precipitation level. Medium precipitation (MAP 800 – 1200 mm) category by far sustains the most species. Soil types of Michoacán are very heterogeneous and do not seem to correlate with bat species distributions in the region.

There were no discernible correlations between families or trophic guilds of bats and any of the environmental factors. The families and feeding guilds, however, did appear to conform generally to the latitudinal gradient within the state.

Elevation often is an important element in explaining many species distributions, especially in a topographically diverse region such as southwestern México. It was not included in this study because of insufficient data. Elevation should be considered in future studies of species distribution and richness of Michoacán.

Predicted distribution ranges for the bat species were mapped using the temperature, vegetation, and precipitation environmental factors associated with each species. A chiropteran species richness prediction map was constructed by overlaying all 71 species distribution maps. This map indicates that the southern portion of the state supports more species of bats. These regions generally contain hot temperatures and tropical vegetation types.

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APPENDIX A

GAZETTEER OF COLLECTING LOCALITIES

A gazetteer of collecting localities of all the specimens in the presence and absence data set used in this study is given. The localities are listed in alphabetical order. Grouped by latitude/longitude coordinates, some localities have slightly different descriptions, and only one is listed as the representative of the named locality. Descriptions of the localities include: location, reference, municipality (if available, in parenthesis), latitude/longitude coordinates. Each of these is separated by a semicolon.

1. Acuitzio del Canje; Huiramba; 19.484° N, 101.331° W
2. Acuitzio del Canje Huira; 2 Km SW; 19.478° N, 101.348° W
3. Aguililla; 20 Km N; 18.885° N, 102.769° W
4. Aguililla; 3 Km NW, 18.755° N, 102.766° W
5. Aguililla; 32 Km NW; 18.756° N, 102.810° W
6. Aguililla; 5 km NW; 18.772° N, 102.762° W
7. Angahuan; 2 Km SW; 19.530° N, 102.235° W
8. Angahuan; 25 Km SW; 19.527° N, 102.243° W
9. Apatzingán; 5 Km E; 19.056° N, 102.325° W
10. Apatzingán; Lago de Chandio, La Concha, 5 Km W; 19.094° N, 102.407° W
11. Apatzingán; Puertecillos, 5 Km NE; 19.076° N, 102.291° W
12. Apatzingán; 19.063° N, 102.327° W
13. Apatzingán; 19.090° N, 102.353° W
14. Aquila; 4 Km SE; 18.573° N, 103.472° W
15. Aquila; 6 Km NE (por carr) Los Tenamastes; 18.649° N, 103.512° W
16. Aquila; Cueva La Murcielaguera, 2 Km NE; 18.609° N, 103.486° W
17. Araro; Secundaria; (Zinapecuaro); 19.903° N, 100.832° W
18. Araro; (Zinapecuaro); 19.914° N, 100.828° W
19. Ario de Rosales; Casa de la familia Mares, calle Arteaga 56; 19.206° N, 101.708° W

20. Arroyo del Chivo; 20 Km N Infiernillo; 18.433° N, 101.948° W
21. Arumba; km 58 por carretera lado W; 19.621° N, 100.999° W
22. Aserradero Madeco Zicuirán; 18.932° N, 101.873° W
23. Atecuaro; (Morelia); 19.582° N, 101.194° W
24. Boca de Apiza; 18.683° N, 103.733° W
25. Boca de la Manzanilla; 18.063° N, 102.687° W
26. Briseñas; 20.271° N, 102.560° W
27. Caleta de Campos; 1 Km NW; 18.079° N, 102.764° W
28. Caleta de Campos; 2 Km N, 2 Km W; 18.087° N, 102.777° W
29. Caleta de Campos; 3 Km NE, 18.088° N, 102.724° W
30. Caleta de Campos; Los Hornos, 3 Km NNW; 18.099° N, 102.760° W
31. Caleta de Campos; Mina Caleta, 3 Km NE; 18.093° N, 102.730° W
32. Caleta de Campos; Puente Hornos, 1 Km NW; 18.078° N, 102.762° W
33. Caleta de Campos; 18.077° N, 102.750° W
34. Caleta de Campos; 18.079° N, 102.754° W
35. Capilla de SF de Jesus; Priv Constituyentes No 2; (Morelia); 19.700° N, 101.190° W
36. Capirio; 1.6 Km S; 18.851° N, 102.120° W
37. Carapán; 6 Km SE (Carr Carapán -Quiroga); 19.838° N, 101.986° W
38. Carapán; 19.853° N, 102.033° W
39. Cd Hidalgo; 1 Km S Las Grutas; 19.629° N, 100.502° W
40. Cd Hidalgo; 4.5 Km E; 19.689° N, 100.505° W
41. Cd Hidalgo; 5.5 Km W; 19.701° N, 100.616° W
42. Cd Hidalgo; Cerro el Ventero, 1 km NE Presa Pucuat; 19.628° N, 100.695° W
43. Cd Hidalgo; Cerro Recreativo, Presa Pucuat; 19.614° N, 100.698° W
44. Cd Hidalgo; Las Caleras, 5 Km (por carr), 1 Km S (terr); 19.637° N, 100.503° W
45. Cd Hidalgo; Las Grutas, 6.5 Km SE; 19.639° N, 100.502° W
46. Cd Hidalgo; 19.692° N, 100.555° W
47. Cenobio Moreno; 19.099° N, 102.500° W

48. Cerro Colorado; 2 Km W; (Benito Juárez); 19.321° N, 100.492° W
49. Cerro Colorado; (Benito Juárez); 19.318° N, 100.463° W
50. Cheran; 7.5 Km SW; 19.665° N, 102.010° W
51. Chorros del Varal; 10.25 Km SW; (Los Reyes); 19.520° N, 102.570° W
52. Chucondiran; 5.7 Km N; (Tiguindin); 19.787° N, 102.479° W
53. Coahuayana; Placita, 48 Km S; 18.530° N, 103.585° W
54. Coalcomán; 1 Km SE (por carr); 18.767° N, 103.152° W
55. Coalcomán; 10.16 Km NNE; 18.867° N, 103.138° W
56. Coalcomán; 11 Km NE; 18.866° N, 103.135° W
57. Coalcomán; 20 Km E (por carr); 18.745° N, 103.010° W
58. Coalcomán; 30 Km N 25 Km E; 18.992° N, 103.073° W
59. Coalcomán; 5 Km SE; 18.745° N, 103.127° W
60. Coalcomán; Río Cachán de las humedades; 18.247 ° N, 103.238° W
61. Coalcomán; 18.781° N, 103.156° W
62. Colola; 1 Km E; 18.296° N, 103.400° W
63. Colola; 1 Km S (por carr); 18.288° N, 103.404° W
64. Colola; 5 Km N; 18.340° N, 103.380° W
65. Colola; 18.303° N, 103.414° W
66. Corona; 3 Km W; (Peribán); 19.527° N, 102.226° W
67. Cueva de los murcielagos; Turitzio; 18.525° N, 100.935° W
68. Cueva del Burro; 0.75 Km SW Corona; (Peribán); 19.520° N, 102.453° W
69. Cueva del Potrero El Tor; 2.5 Km W Plan de Ayala; (Los Reyes); 19.541° N, 102.512° W
70. Cueva La Polvora; 1 Km NW Villa Victoria; 18.762° N, 103.376° W
71. Cueva Las Playitas; 1.7 Km SW Villa Victoria; 18.746° N, 103.382° W
72. Cuitzeo; 19.980° N, 101.145° W
73. Cumuato; 20.260° N, 102.595° W
74. Dos Aguas; 1 Km NE; 18.800° N, 102.935° W
75. Dos Aguas; 1 Km NNW; 18.818° N, 102.931° W

76. Dos Aguas; Chiqueritos, 1.8 Km N; 18.823° N, 102.926° W
77. Dos Aguas; 18.808° N, 102.929° W
78. Ejido El Aguaje; Km 29 Carr Zitácuaro -Huetamo; 19.286° N, 100.448° W
79. El Capirio; 20.2 Km SSW Nueva Italia; 18.864° N, 102.121° W
80. El Capiro; N Río Tepalcatepec; 18.853° N, 102.128° W
81. El Chorro; 1.5 Km N Maruata; 18.270° N, 103.345° W
82. El Guayabo; Mpio Angamacutiro, 34 Km; 19.008° N, 101.716° W
83. El Higueral; 8 Km N Arteaga; 18.384° N, 102.251° W
84. El Infiernillo; 1 Km NW; 18.308° N, 101.901° W
85. El Infiernillo; 18 Km N; 18.446° N, 101.903° W
86. El Infiernillo; 20 Km N; 18.464° N, 101.903° W
87. El Infiernillo; 7 Km N; 18.346° N, 101.903° W
88. El Infiernillo; Arroyo del Chivo, 30 Km N; (El Churumuco); 18.489° N, 101.977° W
89. El Infiernillo; El Atuto, 3 Km NE; 18.302° N, 101.880° W
90. El Jaguey; Nueva Italia; 18.984° N, 102.110° W
91. El Laurel; (Morelia); 19.528° N, 101.167° W
92. El Zapotal; 2 Km S; 18.670° N, 103.681° W
93. El Zapote; 2 Km N Maruata; 18.284° N, 103.345° W
94. Epitacio Huerto; 95 km S, 2 km E; 20.079° N, 100.319° W
95. Erongaricuario; 4 Km NW; (Pátzcuaro); 19.606° N, 101.743° W
96. Estero Río Chuta; 18.041° N, 102.560° W
97. EstPattBuvista_LaPiedad; 5 Km NW (por carr); 20.369° N, 102.121° W
98. Ex Hacienda de Guadalupe; 45 Km SW Tarimbaro; 19.798° N, 101.219° W
99. Filetera del Platanito; 47 Km SSE Nueva Italia; 18.634° N, 101.920° W
100. Granjas; SW Morelia; 19.582° N, 101.497° W
101. Hacienda la Bartolilla; 3 Km SW Zinapecuario; 19.853° N, 100.854° W
102. Huandacareo; 35 Km SE; 19.973° N, 101.251° W
103. Huandacareo; 35 Km SW; 19.973° N, 101.310° W

104. Huetamo; Arroyo Huetamo; 18.647° N, 100.899° W
105. Huetamo; costado del Hotel Real de la Loma; 18.625° N, 100.898° W
106. Infiernillo; 7 km N; 18.346° N, 101.901° W
107. Isla de Janitzio; Cueva Norte; (Pátzcuaro); 19.574° N, 101.652° W
108. Isla de Janitzio; (Pátzcuaro); 19.572° N, 101.652° W
109. Jacona; Cerro y Cueva de la Arena, 5 Km SW; 19.932° N, 102.336° W
110. La Huacana; 3 Km NW Carr La Huacana- Pátzcuaro; 18.988° N, 101.816° W
111. La Huacana; 5 Km N (por carr); 18.995° N, 101.801° W
112. La Huacana; 7 Km SW Carr La Huacana- Zicuirán; 18.931° N, 101.869° W
113. La Huacana; 8 Km N; 18.967° N, 101.816° W
114. La Huacana; Arroyo La Huacana; 18.963° N, 101.780° W
115. La Huacana; Calle Comonfort s/n, Huerta Familia Ceja; 18.962° N, 101.808° W
116. La Huacana; Ejido Eucheno, Arroyo San Antonio; 18.949° N, 101.763° W
117. La Huahua (Guagua?); Km 88 Carr Playa Azul-Tecomán; 18.179° N, 103.016° W
118. La Laguna; 2 Km SE Petembo; 19.115° N, 101.500° W
119. La Manzanilla; 500 m NE; 18.065° N, 102.686° W
120. La Manzanilla; Boca; 18.059° N, 102.689° W
121. La Palma; 3 Km E; 20.139° N, 102.726° W
122. La Placita; 40 Km NW Coalcomán; 18.532° N, 103.586° W
123. La Salada; 19.054° N, 101.609° W
124. La Yerbabuena; Turitzio; 18.523° N, 100.938° W
125. Lago Chapala; La Palma, SE; 20.147° N, 102.760° W
126. Lajas del Bosque; Minas de Tiamaro, 4 Km SE; 19.239° N, 100.467° W
127. Lajas del Bosque; Minas de Tiamaro, 4 Km SE; 19.229° N, 100.478° W
128. Lajas del Bosque; Rancho Buena Vista, 2 Km NE; 19.236° N, 100.459° W
129. Lajas del Bosque; Rancho Buena Vista, 3.5 Km NE; 19.235° N, 100.459° W
130. Las Grutas; 1 Km S Las Grutas; 19.626° N, 100.505° W
131. Las Grutas; 14 Km SE Ciudad Hidalgo; 19.592° N, 100.468° W
132. Las Minas; 2 Km W Tuxpán; 19.565° N, 100.485° W

133. Lázaro Cárdenas; Río Poyuta; 18.045° N, 102.533° W
134. Lázaro Cárdenas; 17.958° N, 102.199° W
135. Los Angeles; (Peribán); 19.547° N, 102.457° W
136. Los Azufres; 13 Km SW (por carr) CamTur, 2 Km N (por carr) S. Pedro; 19.731° N, 100.659° W
137. Los Capiros; Cueva del Salto, 15 Km NW; 18.326° N, 102.000° W
138. Los Cerritos; 2.75 Km NW; (Los Reyes); 19.640° N, 101.354° W
139. Los Coyotes; Km 258 Carr Uruapan-Playa Azul; 18.116° N, 102.287° W
140. Los Reyes; 5.5 Km NW; 19.615° N, 102.523° W
141. Los Reyes; 19.593° N, 102.477° W
142. Los Tenamastes; 6 km NW Aquila; 18.619° N, 103.504° W
143. Los Timones; Km 206 Carr Morelia- Zitácuaro; 19.667° N, 100.914° W
144. Maquilí; 5 Km NW (por carr); 18.598° N, 103.534° W
145. Maquilí; 18.579° N, 103.528° W
146. Maravatio; 0.5 km N, 15 km E; 19.893° N, 100.305° W
147. Maravatio; 2 Mi S; 19.866° N, 100.448° W
148. Maruata; Mpio Villa Jiminez, 2 Km N; 18.275° N, 103.345° W
149. Maruata; Río Las Campanas o Boca Maruata, 6 Km N; 18.320° N, 103.357° W
150. Maruata; 18.267° N, 103.347° W
151. Mina Catingan, Angangueo; 19.631° N, 100.794° W
152. Mojonera; 2.5 Km NE; 19.721° N, 101.814° W
153. Morelia; 3 Mi S, 28 Mi E; 19.653° N, 100.752° W
154. Morelia; Primaria 20 de Noviembre Sta Maria de Guido; 19.675° N, 101.192° W
155. Morelia; Santa Maria; 19.710° N, 101.164° W
156. Morelia; 19.686° N, 101.183° W
157. Morelia; 19.702° N, 101.183° W
158. Motín del Oro; 18.322° N, 103.467° W
159. Mpio Zamora; 19.980° N, 102.285° W
160. Negrrete; Hacienda El Molino; 19.365 N, 100.623° W

161. Nueva Italia; (El Jaguey); 19.023° N, 102.093° W
162. Nuevo San Juan (Conejos); 5 Mi SW Uruapan; 19.417° N, 102.130° W
163. Ojo de Agua; 4 Km N (por carr); 18.655° N, 103.668° W
164. Palos Marias; 18.814° N, 103.537° W
165. Paso de arrieros; 18.905° N, 103.415° W
166. Pátzcuaro; 5 Km Carr Pátzcuaro -Tacambaro; 19.473° N, 101.605° W
167. Pátzcuaro; 5.3 km N Zarzamora; 19.646° N, 101.736° W
168. Pátzcuaro; Huecorio; 19.538° N, 101.632° W
169. Pátzcuaro; Pátzcuaro; 19.515° N, 101.608° W
170. Pátzcuaro; 19.516° N, 101.621° W
171. Pedernales; 19.136° N, 101.471° W
172. Pichataro; 3 Km NW; 19.590° N, 101.832° W
173. Pichataro; 8.8 Km N; 19.655° N, 101.810° W
174. Placita; Mpio Cuahuayana, 40 Km NW; 18.532° N, 103.590° W
175. Playa Azul; 1 Km E; 17.980° N, 102.338° W
176. Playa Azul; 1 Km N; 17.991° N, 102.346° W
177. Playa Azul; 2 Km N (por carr); 18.000° N, 102.333° W
178. Playa Azul; 6 Km NW; 18.014° N, 102.399° W
179. Playa Azul; 6 Km NW (por carr); 18.025° N, 102.360° W
180. Playa Azul; 6 Km W (por carr); 17.997° N, 102.407° W
181. Playa Azul; Hotel de la Curva (alberca); 17.980° N, 102.353° W
182. Playa Maruata; 18.271° N, 103.329° W
183. Presa de Contzio (Cointzio); 100 m de la cortina; 19.631° N, 101.260° W
184. Presa Zicuirán; 1 Km S Cortina Presa; 18.913° N, 101.928° W
185. Presa Zicuirán; 500 m S Cortina de la Presa; 18.917° N, 101.928° W
186. Presa Zicuirán; 8 Km SW; 18.872° N, 101.987° W
187. Presa Zicuirán; 18.918° N, 101.928° W
188. Puente el Marques; 15 Km N Nueva Italia; 19.143° N, 102.052° W
189. Puente El Marques; 8.5 Km N Nueva Italia; 19.080° N, 102.066° W

190. Puente Río Nexpa; 56 Km W Caleta de Campos; 18.091° N, 102.791° W
191. Puerto Garnica; 19.665° N, 100.814° W
192. Punta San Telmo; 18.331° N, 103.464° W
193. Queréndaro; 19.795° N, 100.888° W
194. Quiroga; 5 Km NW (Carr a Zacapu); 19.677° N, 101.576° W
195. Rancho El Bonete; 8 Km SW La Huacana; (La Huacana); 18.959° N, 101.924° W
196. Rancho El Bonete; Lado NW Presa Zicuirán; 18.957° N, 101.910° W
197. Rancho El Gavillero; 2.5 Km WSW Rivapalacio; (San Lucas); 18.574° N, 100.784° W
198. Rancho El Marfil; 8 Km SE Coalcomán; 18.742° N, 103.093° W
199. Rancho El Reparito; Km 214 Carr Morelia-Playa Azul; 18.504° N, 102.001° W
200. Rancho El Reparito; Km 217 Carr Morelia-Playa Azul; 18.487° N, 102.024° W
201. Rancho El Reparito; Km 220 Carr Nueva Italia-Playa Azul; 18.471° N, 102.040° W
202. Rancho El Verde; 2 Km SW Coalcomán; 18.768° N, 103.183° W
203. Rancho El Verde; 2 Km W Coalcomán; 18.778° N, 103.182° W
204. Rancho Felipe Espinoza; 5 Km SE Coalcomán; 18.746° N, 103.121° W
205. Rcho El Reparito; km 218 Carr Nva Italia-Playa Azul; 18.478° N, 102.028° W
206. Río Chocla; 18.223° N, 103.185° W
207. Río Mexcalhuacan; 5.6 Km W Caleta de Campos; 18.064° N, 102.673° W
208. Río Mexcalhuacan; 18.060° N, 102.666° W
209. Río Nexpa; 5.6 Km W Caleta de Campos; 18.095° N, 102.791° W
210. Río Nexpa; Boca del río, 55 Km WNW Playa Azul; 18.087° N, 102.791° W
211. Río Nexpa; 18.090° N, 102.794° W
212. Río Ostula; 11 Km SE La Placita; (Aquila); 18.455° N, 103.533° W
213. Río Ostula; 11 Km SE La Placita; (Aquila); 18.497° N, 103.530° W
214. Río Ostula; 12 Km SE La Placita; (Aquila); 18.446° N, 103.528° W
215. Río Popoyuta; Poyuta; (Lázaro Cárdenas); 18.038° N, 102.545° W
216. Río Tupitina; Cueva Coyotes, 200 m NE; 18.154° N, 102.931° W
217. Sahuayo; 20.044° N, 102.721° W

218. San José Purúa; 19.516° N, 100.475° W
219. San Miguel Taimeo; 10 Km SW Zinapecuaro; 19.843° N, 100.797° W
220. San Miguel Taimeo; 2 Km E; (Zinapecuaro); 19.843° N, 100.777° W
221. San Telmo; Ojo de Agua; 18.629° N, 103.678° W
222. San Telmo; (Aquila); 18.624° N, 103.510° W
223. Santa Clara; 3 Km E; (Tocumbo); 19.638° N, 102.460° W
224. Santa Clara; 4.75 Km N; (Tocumbo); 19.715° N, 102.528° W
225. Santa Clara; 5 Km ENE; (Tocumbo); 19.658° N, 102.444° W
226. Santa Clara; 500 m E; (Tocumbo); 19.636° N, 102.233° W
227. Santa Clara; (Tocumbo); 19.638° N, 102.490° W
228. Tancítaro; 1 Km S; 19.324° N, 102.347° W
229. Tancítaro; 3 Km N; 19.368° N, 102.366° W
230. Tancítaro; Rancho La Barranca, 4Km S (por carr); 19.312° N, 102.330° W
231. Tancítaro; 19.338° N, 102.368° W
232. Tangancicuaro; Cueva de La Colmena, 3 Km NW; 19.910° N, 102.212° W
233. Tarecuato; 19.850° N, 102.475° W
234. Taretán; (Tzitzio); 19.427° N, 100.939° W
235. Tecario; 3 Km N; 19.260° N, 101.544° W
236. Tirio; SE Morelia (SW?); 19.553° N, 101.281° W
237. Tumbiscatio; 11 km S; 18.443° N, 102.383° W
238. Tuxpán; 2 Km W; 19.565° N, 100.483° W
239. Tuxpán; 4 Km NW Tuxpán; 19.593° N, 100.489° W
240. Tuxpán; Las Minas, 2 Km W; 19.634° N, 100.501° W
241. Tuxpán; 19.567° N, 100.462° W
242. Tuzantla; Puente y Río Tuzantla, 1 Km N Tuzanta; 19.222° N, 100.568° W
243. Ucareo; 3 Km N; (Zinapecuaro); 19.896° N, 100.671° W
244. Uruapan; Hda El Sabino, 25 Mi S; 19.385° N, 102.310° W
245. Uruapan; Parque nacional Uruapan; 19.418° N, 102.058° W
246. Villa Victoria; 0.5 Km SW; 18.754° N, 103.374° W

- 247. Villa Victoria; 8.4 Km WNW; 18.792° N, 103.423° W
- 248. Villa Victoria; El Salitre de Copala; 18.788° N, 103.408° W
- 249. Villa Victoria; La Listona, 8 km E de Villa Victoria; 18.744° N, 103.445° W
- 250. Villa Victoria; 18.758° N, 103.387° W
- 251. Zicuirán; 18.878° N, 101.968° W
- 252. Zitácuaro; 1 Km W; 19.430° N, 100.386° W
- 253. Zitácuaro; Puente de San Juan Viejo; 19.460° N, 100.344° W
- 254. 15 km N Nueva Italia; 19.180° N, 102.099° W
- 255. 20 km SSW Nueva Italia; 18.845° N, 102.019° W
- 256. 227 km WNW Platanitos; 18.637° N, 101.928° W
- 257. 45 km N, 4 W; Janitzio; (Pátzcuaro); 19.573° N, 101.652° W
- 258. 52.66 Km SSE Nueva Italia; 18.601° N, 101.865° W
- 259. Km 81 carr Ario de Rosales-La Huacana; 19.177° N, 101.724° W

APPENDIX B

SPECIMENS INCLUDED IN ANALYSES

A list of the specimens included in the analyses is given. Families, genera, and species follow those in Koopman (1993), except *Dermanura azteca*, *D. phaeotis*, and *D. tolteca*, following Owen (1987), and *Corynorhinus mexicana* and *C. townsendii*, following Bogdanowicz *et al.* (1998). The descriptions of the specimens are as follows: museum or collector acronym and catalog number, TK number (if available), and locality number representing the collecting locality (refer to Appendix A). The specimens are separated by semicolons. TK number is the uniform field catalog number utilized by field parties associated with the Museum of Texas Tech University. The museum and collector acronyms are as follows:

Museum acronyms:

FMNH – Field Museum of Natural History

IBUNAM – Instituto de Biología, Universidad Nacional Autónoma de México

KU and UK – Kansas University

UAMI – Universidad Autónoma Metropolitana, Unidad Iztapalapa.

UMSNH – Universidad Michoacana de San Nicolás de Hidalgo

USNM, WMNH, and NMNH – National Museum of Natural History

AMNH – American Museum of Natural History

Collector acronyms:

AERM – Alberto Enrique Rojas Martínez

ANG – Arturo Núñez-Garduño

BGM – Beatriz González Martínez

CAR – Carlos Álvarez Rivero

CBCT – Catalina B. Chávez Tapia

CLG – Celia López González

CSH – Cornelio Sánchez Hernández

DCV – Dolores Campos Villamil

DGR – David Garrido Ramírez

JAGE – José Antonio Guerrero Enríquez.

MLRA – María de Lourdes Romero Almaraz

RDO – Robert D. Owen

RHM – René Hinojosa Mercado

RLW – Ricardo López Wilchis

Emballonuridae

Balantiopteryx plicata

FMNH 52250, 13; IBUNAM 17124, 81; IBUNAM 8568, 85; IBUNAM 8570, 86; IBUNAM 17132, 214; IBUNAM 17115, 216; UMSNH 1846, 69; UMSNH 85, 188; UMSNH 193, 189; UMSNH 797, 196; UMSNH 670, 202; UMSNH 679, 251; USNM 126452, 123; ANG 796, 63; CAR 7, 127; CSH 4035, 65; CSH 2230, 201; JAGE 1, 104; MLRA 2425, 9; MLRA 2338, TK 45713, 10; MLRA 1523, 28; MLRA 1444, TK 45019, 84; MLRA 1973, 110; MLRA 2178, TK 45491, 113; MLRA 2015, 114; RLW 1109, TK 45973, 70; RLW 999, 258

Diclidurus albus

IBUNAM (DGR) 28502, TK 59, 34

Peropteryx macrotis

FMNH 51431, 231

Molossidae

Eumops glaucinus

UMSNH 274, 202

Eumops underwoodii

IBUNAM 15581, 108; IBUNAM 15667, 218

Molossus aztecus

RLW 1293, TK 46253, 248

Molossus molossus

IBUNAM 30129, 245; RLW 868, TK 45790, 4

Molossus rufus

IBUNAM 6043, 24; IBUNAM 6238, 53; IBUNAM 17383, 214; UMSNH 603, 192; UMSNH 180, 208; CSH 4078, 149; MLRA 1665, 175; RLW 869, TK 45791, 4; RLW 579, 222

Molossus sinaloae

IBUNAM 6053, 24; IBUNAM 7707, 26; IBUNAM 28871, 210; UMSNH 167, 79; UMSNH 2026, 156; UMSNH 2025, 157; UMSNH 165, 192; UMSNH 1347, 227; MLRA 2369, TK 45729, 10; MLRA 2927, 33; MLRA 2129, TK 45464, 242

Nyctinomops aurispinosus

UMSNH 74, 59

Nyctinomops femorosaccus

IBUNAM 6240, 53; IBUNAM 8598, 88

Nyctinomops laticaudatus

UMSNH 494, 245; UMSNH 823, 251

Nyctinomops macrotis

IBUNAM 6242, 53; IBUNAM 17386, 60; KU 38309, 121; UMSNH 1552, 155; UMSNH 1518, 35; UMSNH 1519, 156; UMSNH 1525, 157; UMSNH 722, 251

Promops centralis

UMSNH 14, 59

Tadarida brasiliensis

FMNH 11520, 125; FMNH 51420, 231; IBUNAM 7705, 73; IBUNAM 1613, 170; IBUNAM 2530, 217; IBUNAM 3751, 241; IBUNAM 7906, 257; KU 38287, 121; KU 63154, 147; UMSNH 451, 1; UMSNH 1659, 17; UMSNH 1564, 18; UMSNH 1706, 23; UMSNH 1692, 91; UMSNH 1513, 98; UMSNH 508, 108; UMSNH 1506, 154; UMSNH 1556, 156; UMSNH 1961, 157; UMSNH 519, 167; UMSNH 846, 168; UMSNH 404, 169; UMSNH 649, 173; USNM 125660, 141; MLRA 2852, 19; MLRA 2305, TK 45682, 38; MLRA 2630, 97; MLRA 2487, 101; MLRA 2769, TK 47863, 107; MLRA 2707, TK 47835, 132; MLRA 2266, TK 45645, 194; MLRA 1901, TK 45215, 238; MLRA 2851, TK 47924, 259; RLW 798, TK 45588, 45

Mormoopidae

Mormoops megalophylla

IBUNAM 17143, 214; UK 38216, 153; UMSNH 118, 59; BGM 36, 205; CSH 4002, 62; DCV 40, 15; MLRA 2065, TK 45393, 78; MLRA 2880, 127; MLRA 2044, TK 45372, 128; RLW 863, TK 45838, 43; RLW 776, TK 45569, 45; RLW 560, 149

Pteronotus davyi

IBUNAM 7692, 26; KU 39497, 237; BGM 33, 205; MLRA 2045, TK 45373, 128; MLRA 2939, 142; RHM 6, 105; RLW 553, 65

Pteronotus parnellii

IBUNAM 5976, 24; IBUNAM 30274, 27; IBUNAM 30145, 36; IBUNAM 6146, 53; IBUNAM 17141, 118; IBUNAM 17138, 132; UMSNH 1949, 46; UMSNH 906, 131; UMSNH 730, 195; UMSNH 774, 196; UMSNH 1719, 224; UMSNH 681, 251; AERM 335, 138; ANG 913, 44; BGM 32, 205; CAR 9, 127; CBCT 285, 60; CSH 2300, 16; CSH 4005, 62; CSH 2270, 145; DGR 36, 178; MLRA 2351, 10; MLRA 1513, TK 45065, 28; MLRA 1455, TK 45024, 84; MLRA 1984, TK 45324, 110; MLRA 2936, 116; MLRA 2051, TK 45378 128; MLRA 1737, TK 45125, 129; MLRA 1664, 175; MLRA 2120, TK 45453, 242; MLRA 1799, TK 45155, 253; RLW 820, 45; RLW 690, TK 45500, 49; RLW 545, 65; RLW 1112, TK 45976, 71; RLW 939, TK 45879, 75; RLW 1014, TK 45928, 124; RLW 568, 149; RLW 1193, 164; RLW 1310, TK 46266, 165; RLW 1163, 255; RLW 1153, 256

Pteronotus personatus

IBUNAM 8573, 86; IBUNAM 8572, 89; UMSNH 88, 192; CSH 2269, 145; MLRA 2929, 28; RHM 20, 104; RHM 12, 105

Natalidae

Natalus stramineus

IBUNAM 17371, 30; IBUNAM 17375, 214; UMSNH 573, 108; AERM 349, 31; CSH 2310, 14; CSH 2290, 16; CSH 4087, 149; DCV 20, 15; DGR 76, 29; MLRA 2930, 28; MLRA 2037, TK 45366, 126; MLRA 32, 127; RDO 964, 222; RLW 550, 64

Noctilionidae

Noctilio leporinus

IBUNAM 17137, 132; UMSNH 121, 192; UMSNH 69, 208; UMSNH 68, 209; UMSNH 330, 95; UMSNH 178, 189; MLRA 1659, TK 45114, 175

Phyllostomidae

Anoura geoffroyi

UMSNH 733, 22; UMSNH 283, 40; UMSNH 1267, 131; UMSNH 1565, 155; UMSNH 280, 157; UMSNH 783, 196; ANG 915, 252; DGR 11, 54; MLRA 2845, 39; MLRA 1797, TK 45153, 253; MLRA 2793, TK 47886, 259; RLW 791, 45; RLW 1117, TK 45981, 246

Artibeus hirsutus

IBUNAM 17214, 132; IBUNAM 17218, 212; UMSNH 78, 102; UMSNH 759, 196; WMNH 126450, 123; MLRA 2329, TK 45705, 10; MLRA 2193, TK 45770, 121; MLRA 1753, TK 45127, 127; MLRA 2128, TK 45463, 242; RLW 837, TK 45813, 45; RLW 694, 49; RLW 1023, 124

Artibeus intermedius

IBUNAM 8587, 20; IBUNAM 17281, 24; IBUNAM 17283, 81; IBUNAM 17287, 93; IBUNAM 17253, 176; IBUNAM 33919, 177; IBUNAM 17269, 212; IBUNAM 17270, 213; IBUNAM 17288, 214; IBUNAM 17252, 215; IBUNAM 17295, 221; UMSNH 1373, 51; UMSNH 1370, 66; UMSNH 336, 95; UMSNH 73, 102; UMSNH 605, 103; UMSNH 1289, 182; UMSNH 767, 185; UMSNH 766, 187; UMSNH 87, 192; UMSNH 760, 196; UMSNH 1288, 197; UMSNH 842, 198; UMSNH 195, 202; UMSNH 160, 208; UMSNH 1664, 234; AERM 330, 138; ANG 834, 21; ANG 832, 149; ANG 931, 242; BGM 1, 34; BGM 26, 205; CBCT 287, 60; CBCT 172, 92; CBCT 294, 211; CBCT 360, 15; CSH 2328, 14; CSH 4033, 65; CSH 2266, 145; CSH 2234, 201; DGR 79, 133; DGR 58, 178; JAGE 2, 104; MLRA 2374, 10; MLRA 2427, 11; MLRA 2382, TK 45736, 12; MLRA 2395, TK 45743, 47; MLRA 1438, TK 45013, 84; MLRA 2022, 115; MLRA 2048, TK 45375, 128; MLRA 1739, 129; MLRA 2711, TK 47839, 143; MLRA 2745, 171; MLRA 1661, 175; MLRA 1631, TK 45096, 180; MLRA 1801, TK 45157, 253; MLRA 2789, TK 47882, 259; RDO 963, 222; RHM 7, 105; RHM 60, 127; RLW 717, TK 45514, 49; RLW 1041, TK 45937, 55; RLW 638, 56; RLW 1113, TK 45977, 71; RLW 1008, 79; RLW 1126, 246

Artibeus jamaicensis

IBUNAM 17233, 212; IBUNAM 6025, 24; IBUNAM 17238, 34; IBUNAM 15700, 201; IBUNAM 17243, 214; IBUNAM 17234, 215; IBUNAM 17246, 221; UAMI 865, 3; UK 11375, 244; UMSNH 1375, 66; UMSNH 1377, 140; UMSNH 1279, 182; UMSNH 768, 184; UMSNH 758, 186; UMSNH 93, 192; UMSNH 691, 195; UMSNH 763, 196; UMSNH 127, 198; UMSNH 623, 204; UMSNH 132, 207; UMSNH 163, 208; UMSNH 139, 209; UMSNH 304, 219; UMSNH 1374, 226; UMSNH 1629, 234; UMSNH 786, 251; AERM 370, 32; ANG 353, 15; ANG 802, 65; ANG 840, 149; BGM 35, 205; CBCT 163, 92; CBCT 295, 211; CBCT 273, 222; CSH 2330, 14; CSH 2268, 145; DGR 45, 178; JAGE 4, 104; MLRA 2356, 10; MLRA 2381, TK 45735, 12; MLRA 2077, TK 45431, 78; MLRA 1418, TK 45418, 84; MLRA 2029, TK 45359, 114; MLRA 2046, TK 45374, 128; MLRA 1658, TK 45113, 175; MLRA 2103, 242; MLRA 2784, TK 47877, 259; RHM 13, 105; RLW 878, TK 45798, 4; RLW 720, TK 45516, 49; RLW 1038, 55; RLW 637, 56; RLW 1111, TK 45975, 70; RLW 1006, TK 45924, 79; RLW 1022, TK 45930, 124; RLW 1315, TK 46271, 165; RLW 1129, 246; RLW 1300, TK 46259, 249

Artibeus lituratus

UMSNH 15, 192; UMSNH 790, 198; AERM 328, 138; BGM 2, 34; CSH 2327, 14; CSH 2267, 145; DCV 30, 15; DGR 81, 133; DGR 30, 174; MLRA 2349, TK 45717,

10; MLRA 2379, TK 45733, 12; MLRA 2394, TK 45742, 47; MLRA 233, 116; MLRA 2137, TK 45468, 116; MLRA 1742, 129; MLRA 1629, TK 45095, 175; RLW 724, TK 45520, 49

Carollia subrufa

IBUNAM 6168, 53; IBUNAM 17199, 132; IBUNAM 17200, 148; ANG 331, 15; BGM 13, 34; BGM 24, 205; CSH 2319, 14; MLRA 1566, TK 45078, 28; MLRA 231, 116; MLRA 1650, TK 45106, 175

Centurio senex

IBUNAM 17346, 215; UMSNH 188, 192; BGM 38, 205; CSH 2317, 14

Chiroderma salvini

ANG 903, 44; RLW 747, TK 45540, 48

Choeronycteris mexicana

FMNH 44195, 193; IBUNAM 5735, 109; UMSNH 181, 219; MLRA 2472, TK 46324, 101; MLRA 1752, TK 45126, 127; RLW 888, TK 45844, 5;

Dermanura azteca

UMSNH 301, 50; UMSNH 1381, 51; UMSNH 1315, 131; UMSNH 791, 196; UMSNH 755, 243; ANG 908, 44; ANG 918, 252; MLRA 1895, TK 45209, 45; MLRA 2714, TK 47842, 143; MLRA 35, 240; MLRA 1798, TK 45154, 253; RLW 864, TK 45786, 4; RLW 889, TK 45845, 5; RLW 760, TK 45553, 48

Dermanura phaeotis

IBUNAM 6027, 24; IBUNAM 17330, 25; IBUNAM 17329, 34; IBUNAM 17340, 81; IBUNAM 17342, 93; IBUNAM 6226, 122; IBUNAM 17319, 212; IBUNAM 17343, 214; IBUNAM 17301, 215; IBUNAM 17344, 221; UMSNH 769, 185; UMSNH 161, 208; UMSNH 141, 209; AERM 372, 32; ANG 803, 65; ANG 823, 150; BGM 27, 205; CBCT 354, 15; CBCT 162, 92; CBCT 298, 211; CBCT 274, 222; CSH 2324, 14; CSH 4042, 62; DGR 44, 178; MLRA 2328, TK 45704, 10; MLRA 1563, TK 45076, 28; MLRA 2400, 47; MLRA 236, 116; RLW 866, TK 45788, 4; RLW 891, TK 45847, 5; RLW 772, TK 45565, 48; RLW 697, 49; RLW 567, 149; RLW 1314, TK 46270, 165

Dermanura tolteca

IBUNAM 17211, 221; IBUNAM 3749, 241; UMSNH 1, 192; CBCT 320, 15; CBCT 272, 222; CSH 2323, 14; CSH 4084, 149; MLRA 2395, TK 45743, 47; MLRA 1883, 78; MLRA 2035, TK 45365, 128; MLRA 2645, 228; MLRA 249, 230; MLRA 2131, 242; MLRA 2787, TK 47880, 259; RLW 873, 4; RLW 797, 45; RLW 759, TK 45552, 48; RLW 689, TK 45499, 49; RLW 618, TK 45227, 56

Desmodus rotundus

IBUNAM 6035, 24; IBUNAM 17356, 34; IBUNAM 877, 61; IBUNAM 8590, 86; IBUNAM 5740, 109; IBUNAM 17361, 118; IBUNAM 17347, 132; IBUNAM 8588, 137; IBUNAM 17365, 214; IBUNAM 5738, 232; IBUNAM 3750, 241; UK 11376, 244; UMSNH 18, 80; UMSNH 109, 83; UMSNH 1283, 90; UMSNH 903, 131; UMSNH 1735, 138; UMSNH 431, 172; UMSNH 1284, 182; UMSNH 698, 187; UMSNH 835, 192; UMSNH 697, 195; UMSNH 793, 196; UMSNH 1348, 223; USNM 126446, 123; CBCT 380, 15; CBCT 170, 92; CSH 2299, 16; CSH 4014, 63; CSH 4082, 149; CSH 2244, 201; DGR 50, 178; MLRA 1419, 84; MLRA 2181, TK 45494 113; MLRA 1902, 126; RLW 877, TK 45797, 4; RLW 838, TK 45814, 45; RLW 773, TK 45566, 48; RLW 736, TK 45529, 49; RLW 1108, TK 45972, 70; RLW 1114, TK 45978, 71; RLW 1123, 246; RLW 1304, TK 46261, 248

Enchisthenes hartii

CSH 2316, 14; RLW 1034, TK 45931, 55; RLW 1119, TK 45983, 246

Glossophaga commissarisi

UMSNH 106, 80; UMSNH 114, 189; UMSNH 756, 196; BGM 11, 34; BGM 20, 205; MLRA 1974, 110; MLRA 2028, TK 45358, 112; MLRA 2164, 113; MLRA 238, 116; MLRA 1568, 200; MLRA 1568, 200; RLW 752, TK 45545, 48

Glossophaga leachii

IBUNAM 17145, 132; IBUNAM 17149, 176; UMSNH 1274, 90; UMSNH 1274, 90; CBCT 160, 92; CBCT 268, 222; CSH 2335, 14; CSH 4064, 149; CSH 2308, 163; DCV 28, 15; DGR 83, 133; JAGE 17, 104; MLRA 2361, 10; MLRA 2377, TK 45731, 12; MLRA 1498, TK 45061, 28; MLRA 2388, TK 45738, 47; MLRA 1450, 84; MLRA 1988, TK 45327, 110; MLRA 2172, TK 45485, 113; MLRA 1567, 200; RHM 36, 127; RLW 865, TK 45787, 4

Glossophaga morenoi

IBUNAM 17175, 81; IBUNAM 5260, 82; IBUNAM 8577, 85; IBUNAM 8580, 86; IBUNAM 8583, 88; IBUNAM 17166, 119; IBUNAM 17161, 132; IBUNAM 15684, 201; UMSNH 1275, 161; UMSNH 694, 195; ANG 856, 222; BGM 37, 205; DGR 85, 133; JAGE 18, 104; MLRA 2367, TK 45727, 10; MLRA 1529, 28; MLRA 1415, TK 45415, 84; MLRA 1991, 110; MLRA 2162, 113; MLRA 2013, TK 45350, 115; MLRA 1584, 200; MLRA 2126, TK 45461, 242; RHM 30, 127; RLW 777, TK 45570, 45; RLW 752, TK 45545, 48; RLW 986, 99; RLW 1013, 45927 124

Glossophaga soricina

IBUNAM 5998, 24; IBUNAM 7963, 26; IBUNAM 17163, 30; IBUNAM 17155, 34; IBUNAM 15685, 86; IBUNAM 17165, 118; IBUNAM 17167, 119; IBUNAM 17148, 132; IBUNAM 17148, 132; IBUNAM 17685, 201; IBUNAM 17176, 214; IBUNAM 17178, 221; UK 11377, 244; UMSNH 1744, 68; UMSNH 1276, 90; UMSNH 328, 95; UMSNH 286, 108; UMSNH 539, 157; UMSNH 130, 192;

UMSNH 1278, 197; UMSNH 107, 208; UMSNH 282, 209; UMSNH 1640, 234; UMSNH 1277, 235; AERM 355, 31; ANG 900, 44; CBCT 281, 60; CBCT 159, 92; CBCT 263, 222; CBCT 85, 254; CSH 2309, 14; CSH 2301, 16; CSH 4001, 62; CSH 2305, 163; CSH 2305, 163; DGR 77, 29; DGR 9, 54; DGR 29, 174; DGR 42, 177; DGR 42, 177; JAGE 14, 104; MLRA 2364, 10; MLRA 2384, 12; MLRA 2931, 28; MLRA 2390, TK 45739, 47; MLRA 1885, TK 45199, 78; MLRA 1446, TK 45021, 84; MLRA 1975, 110; MLRA 2027, TK 45357, 112; MLRA 2935, 116; MLRA 2727, 118; MLRA 1867, TK 45188, 128; MLRA 2854, TK 47925, 130; MLRA 1604, 175; MLRA 2132, 242; RHM 9, 105; RLW 753, TK 45546, 48; RLW 576, 149; RLW 1313, TK 46269, 165; RLW 1145, TK 45998, 247; RLW 1292, TK 46252, 249; RLW ?, 250; SG 1842, 49;

Leptonycteris curasoae

FMNH 9922, 170; IBUNAM 6012, 24; IBUNAM 7695, 26; IBUNAM 17193, 34; IBUNAM 8585, 86; IBUNAM 17184, 132; IBUNAM 30071, 133; IBUNAM 30067, 138; IBUNAM 17180, 176; IBUNAM 28346, 179; IBUNAM 28346, 179; IBUNAM 30073, 205; IBUNAM 15911, 205; UMSNH 1390, 66; UMSNH 757, 158; UMSNH 120, 192; UMSNH 190, 208; ANG 824, 149; DGR 35, 177; MLRA 1572, 28; MLRA 1441, TK 45016, 84; MLRA 2138, TK 45469, 116; MLRA 1870, TK 45191, 128; MLRA 2743, 171; MLRA 1653, TK 45109, 175; RHM 35, 127; RLW 870, TK 45792, 4; RLW 1309, TK 46265, 165

Leptonycteris nivalis

UMSNH 395, 40; UMSNH 754, 41; UMSNH 311, 95; UMSNH 901, 131; USNM 52182, 193; ANG 901, 44; RLW 857, TK 45832, 43; RLW 824, TK 45801, 45

Macrotus waterhousii

IBUNAM 5992, 24; IBUNAM 30174, 201; UMSNH 752, 173; UMSNH 853, 184; UMSNH 893, 187; UMSNH 1272, 197; UMSNH 753, 243; USNM 126444, 123; MLRA 2391, TK 45740, 9; MLRA 2365, TK 45725, 10; MLRA 2066, TK 45394, 78; MLRA 1456, TK 45025, 84; MLRA 1881, 126; MLRA 36, 127; MLRA 2055, TK 45382, 128; MLRA 1559, 199; RHM 1, 242; RLW 1012, TK 45926, 67; RLW 1003, TK 45921, 79; RLW 1003, TK 45921, 79; RLW 1021, 124; RLW 1316, TK 46272, 165

Micronycteris megalotis

IBUNAM 2565, 61; IBUNAM 8575, 89; IBUNAM 15695, 201; CSH 2304, 144; MLRA 1442, TK 45017, 84; MLRA 1995, TK 45332, 110; MLRA 2446, 111; MLRA 2026, TK 45356, 112; MLRA 2174, TK 45487, 113; MLRA 2742, 118; MLRA 2159, 187; MLRA 1560, 199; MLRA 2792, TK 47885, 259; RLW 609, 58; RLW 990, 99; RLW 1294, TK 46254, 249

Micronycteris silvestris

RLW 1294, TK 46254, 249

Musonycteris harrisoni

IBUNAM 8586, 86; IBUNAM 17195, 118; IBUNAM 6160, 174; UMSNH 695, 187; UMSNH 693, 195; CSH 4000, 62; CSH 4049, 149; CSH 2220, 201; MLRA 1432, TK 45007, 84

Sturnira lilium

IBUNAM 6014, 24; IBUNAM 6176, 53; IBUNAM 33915, 54; IBUNAM 17205, 132; IBUNAM 33916, 178; IBUNAM 17208, 221; IBUNAM 22571, 241; IBUNAM 22571, 241; IBUNAM 22571, 241; UMSNH 155, 72; UMSNH 26, 80; UMSNH 1682, 100; UMSNH 734, 173; UMSNH 290, 198; UMSNH 95, 202; UMSNH 70, 203; UMSNH 856, 204; UMSNH 1715, 224; UMSNH 1386, 225; UMSNH 1641, 234; AERM 329, 138; ANG 326, 15; BGM 17, 205; CBCT 266, 222; CSH 2333, 14; CSH 2265, 145; CSH 4089, 149; DGR 86, 133; MLRA 2074, TK 45428, 78; MLRA 2933, 116; MLRA 1735, TK 45124, 129; MLRA 1667, 175; MLRA 1800, TK 45156, 253; RLW 867, TK 45789, 4; RLW 833, 45; RLW 769, TK 45562, 48; RLW 696, TK 45502, 49; RLW 1035, TK 45932, 55; RLW 615, TK 45225, 56

Sturnira ludovici

UAMI 10585, 8; UMSNH 185, 219; UMSNH 186, 220; ANG 919, 252; CLG 1189, 166; MLRA 2323, 37; MLRA 2302, TK 45679, 38; MLRA 2669, TK 47801, 228; MLRA 256, 230; MLRA 2790, TK 47883, 259; RLW 836, TK 45812, 45; RLW 668, TK 45261, 77; RLW 679, TK 45272, 229

Sturnira occidentalis

RLW 679, TK 45272, 229; BGM 31, 205; RLW 801, TK 45591, 45; RLW 1302, TK 46260, 249

Uroderma bilobatum

IBUNAM 17210, 132

Vespertilionidae

Corynorhinus mexicanus

UMSNH 320, 152; UMSNH 833, 157; DGR 22, 57; MLRA 2698, TK 47828, 151; MLRA 2032, TK 45362, 239; RLW 853, TK 45828, 42; RLW 917, TK 45870, 74; RLW 917, TK 45870, 74

Corynorhinus townsendii

IBUNAM 5786, 109; UMSNH 92, 219; UMSNH 3, 220; UMSNH 3, 220; MLRA 2898, 238; MLRA 2033, TK 45363, 239

Eptesicus furinalis

ANG 351, 15

Eptesicus fuscus

IBUNAM 5181, 7; UMSNH 198, 2; MLRA 1888, TK 45202, 78; MLRA 2701, TK 47829, 132; MLRA 2701, TK 47829, 132; RLW 676, TK 45269, 77

Idionycteris phyllotis

UMSNH 890, 131; UMSNH 1639, 234; JAGE 31, 127; MLRA 1896, TK 45210, 132; RLW 850, TK 45825, 42

Lasiurus borealis

IBUNAM 17380, 132; IBUNAM 5016, 162; UMSNH 1350, 52; UMSNH 724, 108; UMSNH 1770, 135; UMSNH 1770, 135; MLRA 1886, TK 45200, 78; MLRA 1886, TK 45200, 78; MLRA 1886, TK 45200, 78; RLW 940, TK 45880, 75; RLW 1005, TK 45923, 79

Lasiurus cinereus

UMSNH 1709, 155; UMSNH 1293, 191; ANG 921, 252; MLRA 1820, 136

Lasiurus ega

IBUNAM 17382, 132; UMSNH 116, 208; CBCT 303, 211; CSH 4003, 62; RLW 544, 65; RLW 544, 65

Lasiurus intermedius

IBUNAM 7704, 26

Myotis auriculus

UMSNH 117, 157

Myotis californicus

KU 11370, 170; KU 11370, 170; UMSNH 1683, 156; UMSNH 1691, 183; ANG 916, 252; MLRA 2627, TK 47773, 97; MLRA 2488, 101

Myotis carteri

MLRA 2488, 101

Myotis fortidens

IBUNAM 17378, 214; IBUNAM 17376, 215; IBUNAM 17376, 215; IBUNAM 17376, 215; CSH 4004, 62; CSH 4025, 65; MLRA 2017, TK 45353, 114; MLRA 2034, TK 45364, 128; MLRA 2127, TK 45462, 242

Myotis jaliciensis

MLRA 2127, TK 45462, 242; MLRA 3041, 107; MLRA 3041, 107

Myotis leIBUNAMii

UMSNH 327, 152

Myotis lucifugus

UMSNH 1711, 236; MLRA 2626, TK 47772, 97; MLRA 2480, TK 46332, 101

Myotis nigricans

UMSNH 1297, 157

Myotis velifer

FMNH 8458, 125; FMNH 51418, 231; IBUNAM 7446, 26; IBUNAM 7701, 73; KU 143780, 94; KU 38265, 121; KU 38265, 121; KU 143785, 146; KU 63153, 233; KU 143788, 257; UMSNH 232, 1; UMSNH 604, 50; UMSNH 246, 72; UMSNH 1686, 91; UMSNH 433, 95; UMSNH 1689, 98; UMSNH 801, 108; UMSNH 1299, 131; UMSNH 225, 155; UMSNH 242, 156; UMSNH 1685, 157; UMSNH 647, 168; UMSNH 569, 173; UMSNH 762, 186; UMSNH 728, 187; USNM 15145, 170; MLRA 2812, TK 47904, 19; MLRA 2621, TK 47767, 97; MLRA 2621, TK 47767, 97; MLRA 2772, TK 47866, 107; RLW 863, TK 45785, 6; RLW 852, TK 45827, 42; RLW 675, TK 45268, 77

Myotis yumanensis

IBUNAM 5162, 159; IBUNAM 7696, 73; USNM 21929, 160; USNM 52262, 170; MLRA 2478, TK 46330, 101

Rhogeessa alleni

IBUNAM 8597, 86; IBUNAM 8597, 86; MLRA 1454, TK 45023, 84

Rhogeessa mira

IBUNAM 8595, 86; KU 134588, 106; UMSNH 1294, 187; AERM 344, 138; MLRA 1439, TK 45014, 84

Rhogeessa parvula

IBUNAM 8592, 86; IBUNAM 9614, 87; AERM 343, 138; CSH 2336, 14; MLRA 1663, 175; RLW 614, TK 45224, 56

APPENDIX C

SAS PROGRAMS

SAS Program for Correspondence Analysis

```
DATA BATS;
  INFILE 'C:\George\MICHS\family_pa.prn' MISSOVER LRECL=223;
  INPUT MUS $1-7 COLL $9-15 CATNO 17-26 TK 28-33 SPPNO 36-38 GEN $41-
    56 GENSPP $60-64 TEMP $79-91 PREC $93-105 VEGE $107-119 SOIL
    $121-133 SEX $149 AGE $153-160 LAT 162-167 LONG 170-177 ELEV
    $187-198 DAY 202-203 MONTH $206-218 YEAR 220-223;
PROC CORRESP DATA = BATS OUT = RESULTS DIMENS = 4;
  TABLES GENSPP, TEMP PREC VEGE SOIL;
RUN;

%plotit (data=RESULTS, datatype=corresp, plotvars=Dim2 Dim1, href=0,
vref=0, ps = 150, gopts2= reset = goptions erase cback = white hsize =
6 in vsize = 7 in)
```

SAS Program for Cluster Analysis

```
DATA COOR;
  INFILE 'C:\GEORGE\SAS FILES\NoCF_COOR.PRN' MISSOVER LRECL=80;
  INPUT GENSPP$1-5 QUAL 13-24 MASS 27-38 INER 41-52 DIM1 54-66 DIM2
    68-80;
PROC CLUSTER DATA=COOR OUTTREE=TREE METHOD=ward;
  VAR DIM1 DIM2;
  ID GENSPP;
RUN;

goptions vsize=7.5in htext=1.5pct htitle=2.5pct;
  axis1 order=(0 to 1 by 0.1);
PROC TREE data=Tree out=New nclusters=5
  haxis=axis1 horizontal;
  HEIGHT _RSQ_;
  copy DIM1 DIM2 ;
  id GENSPP;
RUN;
```

APPENDIX D
PREDICTED CHIROPTERAN SPECIES DISTRIBUTIONS
IN MICHOACAN, MEXICO

The following maps depict the predicted distributional ranges of bats in Michoacán based on the correspondence analysis result. The recorded localities from where specimens of each species were collected are superimposed on the predicted ranges. The families are arranged alphabetically, as are the genera and species within each family.

Emballonuridae

Figure C.1. Predicted distributional range (shading), and recorded collecting localities (points) of *Balantiopteryx plicata* in Michoacán.

Figure C.2. Predicted distributional range (shading), and recorded collecting localities (points) of *Diclidurus albus* in Michoacán.

Figure C.3. Predicted distributional range (shading), and recorded collecting localities (points) of *Peropteryx macrotis* in Michoacán.

Molossidae

Figure C.4. Predicted distributional range (shading), and recorded collecting localities (points) of *Eumops glaucinus* in Michoacán.

Figure C.5. Predicted distributional range (shading), and recorded collecting localities (points) of *Eumops underwoodii* in Michoacán.

Figure C.6. Predicted distributional range (shading), and recorded collecting localities (points) of *Molossus aztecus* in Michoacán.

Figure C.7. Predicted distributional range (shading), and recorded collecting localities (points) of *Molossus molossus* in Michoacán.

Figure C.8. Predicted distributional range (shading), and recorded collecting localities (points) of *Molossus rufus* in Michoacán.

Figure C.9. Predicted distributional range (shading), and recorded collecting localities (points) of *Molossus sinaloae* in Michoacán.

Figure C.10. Predicted distributional range (shading), and recorded collecting localities (points) of *Nyctinomops aurispinosus* in Michoacán.

Figure C.11. Predicted distributional range (shading), and recorded collecting localities (points) of *Nyctinomops femorosaccus* in Michoacán.

Figure C.12. Predicted distributional range (shading), and recorded collecting localities (points) of *Nyctinomops laticaudatus* in Michoacán.

Figure C.13. Predicted distributional range (shading), and recorded collecting localities (points) of *Nyctinomops macrotis* in Michoacán.

Figure C.14. Predicted distributional range (shading), and recorded collecting localities (points) of *Promops centralis* in Michoacán.

Figure C.15. Predicted distributional range (shading), and recorded collecting localities (points) of *Tadarida brasiliensis* in Michoacán.

Momoopidae

Figure C.16. Predicted distributional range (shading), and recorded collecting localities (points) of *Mormoops megalophylla* in Michoacán.

Figure C.17. Predicted distributional range (shading), and recorded collecting localities (points) of *Pteronotus davyi* in Michoacán.

Figure C.18. Predicted distributional range (shading), and recorded collecting localities (points) of *Pteronotus parnellii* in Michoacán.

Figure C.19. Predicted distributional range (shading), and recorded collecting localities (points) of *Pteronotus personatus* in Michoacán.

Natalidae

Figure C.20. Predicted distributional range (shading), and recorded collecting localities (points) of *Natalus stramineus* in Michoacán.

Noctilionidae

Figure C.21. Predicted distributional range (shading), and recorded collecting localities (points) of *Noctilio leporinus* in Michoacán.

Phyllostomidae

Figure C.22. Predicted distributional range (shading), and recorded collecting localities (points) of *Anoura geoffroyi* in Michoacán.

Figure C.23. Predicted distributional range (shading), and recorded collecting localities (points) of *Artibeus hirsutus* in Michoacán.

Figure C.24. Predicted distributional range (shading), and recorded collecting localities (points) of *Artibeus intermedius* in Michoacán.

Figure C.25. Predicted distributional range (shading), and recorded collecting localities (points) of *Artibeus jamaicensis* in Michoacán.

Figure C.26. Predicted distributional range (shading), and recorded collecting localities (points) of *Artibeus lituratus* in Michoacán.

Figure C.27. Predicted distributional range (shading), and recorded collecting localities (points) of *Carollia subrufa* in Michoacán.

Figure C.28. Predicted distributional range (shading), and recorded collecting localities (points) of *Centurio senex* in Michoacán.

Figure C.29. Predicted distributional range (shading), and recorded collecting localities (points) of *Chiroderma salvini* in Michoacán.

Figure C.30. Predicted distributional range (shading), and recorded collecting localities (points) of *Choeronycteris mexicana* in Michoacán.

Figure C.31. Predicted distributional range (shading), and recorded collecting localities (points) of *Dermanura azteca* in Michoacán.

Figure C.32. Predicted distributional range (shading), and recorded collecting localities (points) of *Dermanura phaeotis* in Michoacán.

Figure C.33. Predicted distributional range (shading), and recorded collecting localities (points) of *Dermanura tolteca* in Michoacán.

Figure C.34. Predicted distributional range (shading), and recorded collecting localities (points) of *Desmodus rotundus* in Michoacán.

Figure C.35. Predicted distributional range (shading), and recorded collecting localities (points) of *Enchisthenes hartii* in Michoacán.

Figure C.36. Predicted distributional range (shading), and recorded collecting localities (points) of *Glossophaga commissarisi* in Michoacán.

Figure C.37. Predicted distributional range (shading), and recorded collecting localities (points) of *Glossophaga leachii* in Michoacán.

Figure C.38. Predicted distributional range (shading), and recorded collecting localities (points) of *Glossophaga morenoi* in Michoacán.

Figure C.39. Predicted distributional range (shading), and recorded collecting localities (points) of *Glossophaga soricina* in Michoacán.

Figure C.40. Predicted distributional range (shading), and recorded collecting localities (points) of *Leptonycteris curasoae* in Michoacán.

Figure C.41. Predicted distributional range (shading), and recorded collecting localities (points) of *Leptonycteris nivalis* in Michoacán.

Figure C.42. Predicted distributional range (shading), and recorded collecting localities (points) of *Macrotus waterhousii* in Michoacán.

Figure C.43. Predicted distributional range (shading), and recorded collecting localities (points) of *Micronycteris megalotis* in Michoacán.

Figure C.44. Predicted distributional range (shading), and recorded collecting localities (points) of *Micronycteris silvestris* in Michoacán.

Figure C.45. Predicted distributional range (shading), and recorded collecting localities (points) of *Musonycteris harrisoni* in Michoacán.

Figure C.46. Predicted distributional range (shading), and recorded collecting localities (points) of *Sturnira lilium* in Michoacán.

Figure C.47. Predicted distributional range (shading), and recorded collecting localities (points) of *Sturnira ludovici* in Michoacán.

Figure C.48. Predicted distributional range (shading), and recorded collecting localities (points) of *Sturnira occidentalis* in Michoacán.

Figure C.49. Predicted distributional range (shading), and recorded collecting localities (points) of *Uroderma bilobatum* in Michoacán.

Vespertilionidae

Figure C.50. Predicted distributional range (shading), and recorded collecting localities (points) of *Corynorhinus mexicanus* in Michoacán.

Figure C.51. Predicted distributional range (shading), and recorded collecting localities (points) of *Corynorhinus townsendii* in Michoacán.

Figure C.52. Predicted distributional range (shading), and recorded collecting localities (points) of *Eptesicus furinalis* in Michoacán.

Figure C.53. Predicted distributional range (shading), and recorded collecting localities (points) of *Eptesicus fuscus* in Michoacán.

Figure C.54. Predicted distributional range (shading), and recorded collecting localities (points) of *Idionycteris phyllotis* in Michoacán.

Figure C.55. Predicted distributional range (shading), and recorded collecting localities (points) of *Lasiurus borealis* in Michoacán.

Figure C.56. Predicted distributional range (shading), and recorded collecting localities (points) of *Lasiurus cinereus* in Michoacán.

Figure C.57. Predicted distributional range (shading), and recorded collecting localities (points) of *Lasiurus ega* in Michoacán.

Figure C.58. Predicted distributional range (shading), and recorded collecting localities (points) of *Lasiurus intermedius* in Michoacán.

Figure C.59. Predicted distributional range (shading), and recorded collecting localities (points) of *Myotis auriculus* in Michoacán.

Figure C.60. Predicted distributional range (shading), and recorded collecting localities (points) of *Myotis californicus* in Michoacán.

Figure C.61. Predicted distributional range (shading), and recorded collecting localities (points) of *Myotis carteri* in Michoacán.

Figure C.62. Predicted distributional range (shading), and recorded collecting localities (points) of *Myotis fortidens* in Michoacán.

Figure C.63. Predicted distributional range (shading), and recorded collecting localities (points) of *Myotis jalisciensis* in Michoacán.

Figure C.64. Predicted distributional range (shading), and recorded collecting localities (points) of *Myotis leibii* in Michoacán.

Figure C.65. Predicted distributional range (shading), and recorded collecting localities (points) of *Myotis lucifugus* in Michoacán.

Figure C.66. Predicted distributional range (shading), and recorded collecting localities (points) of *Myotis nigricans* in Michoacán.

Figure C.67. Predicted distributional range (shading), and recorded collecting localities (points) of *Myotis velifer* in Michoacán.

Figure C.68. Predicted distributional range (shading), and recorded collecting localities (points) of *Myotis yumanensis* in Michoacán.

Figure C.69. Predicted distributional range (shading), and recorded collecting localities (points) of *Rhogeessa alleni* in Michoacán.

Figure C.70. Predicted distributional range (shading), and recorded collecting localities (points) of *Rhogeessa mira* in Michoacán.

Figure C.71. Predicted distributional range (shading), and recorded collecting localities (points) of *Rhogeessa parvula* in Michoacán.

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