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Mammalian diversity in climatic domains for Tehuacán-Cuicatlán Biosphere Reserve, Mexico

Diversidad de mamíferos en los dominios climáticos de la Reserva de la Biosfera Tehuacán-Cuicatlán, México

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Abstract. The Tehuacán-Cuicatlán biosphere reserve (BRTC) is rich in mammalian diversity, but geographical distribution information is absent or insufficient for most species. Consequently, previous efforts to model the ecological niche and potential distribution of mammals have been hampered. The main purpose of this study was to examine the patterns of mammalian diversity in BRTC using a climatic domains classification. Biological datasets composed of geographically referenced localities commonly are raw input during analyses of geographical distributions of species, but in countries like Mexico datasets frequently are incomplete and biased. The recent availability of interpolators and geographic information systems make possible the enhancement of environmental datasets and open the possibility to use climatic parameters to explain biological patterns. In this study we generated a climatic domain classification for the Tehuacán-Cuicatlán valley and its surrounding areas of influence. With this approach, climatic domains were used as biodiversity surrogates, and we justified the overlapping of environmental data with the biological dataset (species, longitude, latitude, and elevation) to evaluate and complement the available mammal diversity information within BRTC.

Key words: biodiversity surrogate, geographic distribution, Mammalia.

Resumen. La reserva de la biosfera Tehuacán-Cuicatlán (BRTC) posee gran diversidad de mamíferos, pero la información sobre distribución geográfica es incompleta para la mayoría de las especies. Esto ha representado una dificultad en esfuerzos previos para modelar el nicho ecológico y la distribución potencial de mamíferos en la BRTC. Nuestro objetivo fue comparar los patrones de diversidad de mamíferos en la BRTC usando una clasificación de dominios climáticos. Las bases de datos biológicas compuestas de localidades georeferenciadas generalmente son usadas como datos crudos en análisis de distribución geográfica de especies, pero en países como México frecuentemente están incompletas y presentan sesgos de muestreo. La reciente disponibilidad de interpoladores y de sistemas de información geográfica permitió mejorar las bases de datos ambientales, lo que abrió la posibilidad de usar parámetros climáticos para explicar patrones biológicos. En este estudio generamos una clasificación de dominios climáticos del valle de Tehuacán-Cuicatlán y sus áreas de influencia. Con este enfoque, los dominios climáticos fueron usados como sustituto de biodiversidad, y justificamos la superposición de los parámetros climáticos con la base de datos biológica (especie, longitud, latitud y elevación) para evaluar y complementar la información disponible sobre la diversidad de mamíferos en la BRTC.

Palabras clave: sustituto de biodiversidad, distribución geográfica, Mammalia.

Introduction

The analyses of species distribution aimed to identify priority areas for biodiversity conservation rely mainly on datasets of point localities where specimens were collected. Nevertheless, raw data of geographical distributions of species are frequently incomplete, fragmented and biased (Reddy and Dávalos, 2003; Rondinini et al., 2006). When good range data are available for a species or group of

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species, it is common to use this information as surrogate of biodiversity patterns in other groups of species where information is absent or incomplete (Caro and O'Doherty, 1999; Pinto et al., 2008). Another choice has been to use the information contained in patterns at higher levels in the biological hierarchy, such as vegetation types and landscape features (Lindenmayer et al., 1991, Margules and Pressey, 2000). Moreover, with the use of geographic information systems and interpolators like ANUSPLIN (Hutchinson, 1991), trustworthy environmental data have been produced for areas where climatic information was missing, opening the possibility to use non-biological elements, such as climatic variables, to explain biological patterns (Téllez Valdés and Dávila Aranda, 2003). Several studies developed by Hutchinson (1991, 1995a, 1995b, 1997, 1998) and Hutchinson and Gessler (1994) enabled the 3-dimensional space interpolation of climatic data by incorporating a digital elevation model to generate raster surfaces of climatic variables and parameters for Australia. Using the software package ANUSPLIN, climatic surfaces of the minimum and maximum temperature and precipitation, and 19 specific bioclimatic parameters have recently been derived for Mexico and for the Tehuacán-Cuicatlán valley (Téllez Valdés and Dávila Aranda, 2003; Téllez Valdés et al., in press).

The Tehuacán-Cuicatlán biosphere reserve (BRTC) belongs to the floristic province of the Tehuacán-Cuicatlán valley, which is outstanding for its high plant diversity and endemism (Rzedowski, 1978; Dávila, 1997; Téllez Valdés and Dávila Aranda, 2003). Recently, some surveys and studies showed that the BRTC is rich in mammal species and endemisms compared to other protected natural areas in México (Botello et al., 2005, 2006a, 2006b; Ramírez Pulido and Martínez Vázquez, 2007). Nevertheless, studies of the diversity and distribution of mammals in the BRTC are limited in the number of localities and species investigated (Ramírez Pulido and Martínez Vázquez, 2007). Therefore, current knowledge regarding mammalian distribution patterns in the BRTC is fragmentary, particularly for Mexican endemic species (Ramírez Pulido and Martínez Vázquez, 2007). Thus, the bias and lack of information prevail for most mammal species in available biological datasets, and this shortcoming hampered our previous efforts to model the ecological niche and potential distribution of mammals within BRTC using BIOCLIM and GARP. Consequently, the main purpose of this study was to examine the patterns of mammalian diversity in BRTC using a climatic domains classification, since domains may be a good surrogate of biodiversity and may represent the reserve's high biological diversity and endemism rate, complex topography, and varied environmental conditions (Téllez Valdés and Dávila Aranda, 2003).

Materials and methods

Study area. The Tehuacán-Cuicatlán biosphere reserve is located in southeastern Puebla and northwestern Oaxaca, approximately at 96° 55´ to 97° 44´ longitude W and 17° 39´ to 18° 53´ latitude N. The reserve has an extension of about 5 000 km^2, but it belongs to a much larger unit, the floristic province of Tehuacán-Cuicatlán valley (Rzedowski, 1978) which covers about 10 000 km^2 and represents the southernmost semiarid area in Mexico and in North America. It is one of the most important arid regions in the world, due to its floristic richness and high endemism rate (Dávila , 1997; Dávila et al., 2002). Because the available biological dataset of mammalian distribution within BRTC was biased and incomplete for most species, we rather used the more complete and less biased dataset of mammalian diversity patterns for a region that included the Tehuacán-Cuicatlán valley and its surrounding areas of influence: the Balsas basin, the Mixteca region, the arid zone of the State of Veracruz, and part of the Sierra Madre del Sur mountain range.

We defined the climatic domains (geographic units with similar environments) through multivariate classification of a data set consisting of climatic estimates for points on a 1-km grid across our study area. Using ArcView 3.2 (Environmental Systems Research Institute [ESRI], Redlands, California, U.S.A.), we created a rectangular polygon with extreme coordinates 19.00º North, 17.00º South, -96.65º East, and -99.50º West. This polygon represented our study area and included the Tehuacán-Cuicatlán valley and its surrounding areas of influence: the Balsas basin, the Mixteca region, the arid zone of the State of Veracruz, and part of the Sierra Madre del Sur mountain range. The polygon included an area of approximately 90 000 km^2. We overlapped the environmental data with the biological dataset of point locations (species, longitude, latitude, and elevation) from mammalian species that fell in our study area.

Biological dataset. The Comisión Nacional para el Conocimiento y Uso de la Biodiversidad (CONABIO), México, provided a dataset of precisely georeferenced locations from the mammal species that fell in the study polygon with extreme coordinates 19.00º North, 17.00º South, -96.65º East, and -99.50º West. We also included in our dataset georeferenced locations from scats of the neotropical river otter, (*Lontra longicaudis*), observed by Francisco J. Botello (Instituto de Biología, Universidad Nacional Autónoma de México), and georeferenced locations of pictures of mammal species collected by camera traps during an ecological study of carnivore mammals in the BRTC (Botello, 2006). With this information, and according to the most recent publications (Villa Ramírez and Cervantes Reza, 2003; Ceballos and Oliva, 2005; Botello et al., 2005, 2006a, 2006b; Ramírez Pulido and Martínez Vázquez, 2007), we compiled a list of mammal species that have been collected, observed, or reported within the BRTC.

Climatic variables and climatic domains classification. We estimated 19 climate variables (Table 1) for points on a 1-km grid across our study area (approximately 90,000 grid points) from thin plate smoothing splines (Hutchinson, 1995a) using the ANUSPLIN version 4.3 (Hutchinson and Gessler, 1994; Hutchinson, 2004) fitted to meteorological station data. The description of the methodology used to choose and estimate the climate variables, and to classify the climatic domains has been described fully elsewhere (Téllez Valdés et al., in press). ANUSPLIN has been successfully used in interpolation exercises (New et al., 1999, 2002), has good performance in comparative tests of multiple interpolation techniques (Hartkamp et al., 1999; Jarvis and Stuart, 2001; Hijmans et al., 2005), and is computationally resourceful and easy to execute. Interpolation errors were slightly larger than 0.5 Celsius degrees for maximum and minimum temperatures, and between 8-13% for monthly mean precipitation (Téllez Valdés et al., in press), which are typical of denser data networks (Hutchinson, 1997).

Classification results were imported into desktop geographic information system ArcView 3.2 (ESRI, Redlands, California, U.S.A.) for inspection of 5-domains and 10-domains levels of classification, and for their comparison with digitalized maps of floristic and ecological regions, and vegetation types (Rzedowski, 1978). The climatic domains were overlapped with the biological database of geographic distribution of mammalian species in the Tehuacán-Cuicatlán valley and surrounding areas of influence.

Results

Mammalian dataset. We compiled 9 669 point locations of mammal species that fell in the study polygon with extreme coordinates 19.00º North, 17.00º South, -96.65º East, and -99.50º West. From these point locations, 2 882 were unique registries for 192 species, from which 2 258 point locations belonged to 92 of 98 mammal species that have been collected, observed or reported within the BRTC. We listed 98 mammals species that may inhabit the BRTC, according to the most recent publications (Villa Ramírez and Cervantes Reza, 2003; Ceballos and Oliva, 2005; Botello et al., 2005, 2006a, 2006b; Ramírez Pulido and Martínez Vázquez, 2007), and to Ramírez Pulido et al. (2005) taxonomic classification. The 98 species belonged to 8 orders, 20 families, and 64 genera of mammals (Table 2). We plotted the georeferenced locations of mammalian species in Tehuacán-Cuicatlán valley and surrounding areas of influence, as point locations (Figure 1).

We did not obtain georeferenced locations for the vole *Microtus oaxacensis*, the big small-eared shrew (*Cryptotis magna*), and 4 species of bats: Mexican big-eared bat (*Corynorhinus mexicanus*), western red bat (*Lasiurus blossevillii*), evening bat (*Nycticeius humeralis*), and little yellow bat (*Rhogeessa parvula*). For the Commissaris's long-tongued bat (*Glossophaga commissarisi*) we compiled just 1 point location. For 7 species we compiled 2 georeferenced locations, and for 19 species we obtained 3 to 9 locations.

Climatic Domain Classification. Noteworthily, at the 5-domains level of classification (Figure 1), domain 4 was made up of the Balsas basin, the Tehuacán Valley, and the Cuicatlán Valley. Two main braches for the 5-domains classification were evident (Figure 2). The first branch included the eastern part of the study area, which was the coastal plain of the Gulf of México, represented by domain 3, and differed in climate from the BRTC and surrounding areas of influence, represented by domains 1, 2, 4 and 5. The second branch showed 2 ramifications which separated domains 1 and 2 from domains 4 and 5, indicating that the Tehuacán-Cuicatlán valley and the Balsas basin had more similarity with the Sierra Madre del Sur mountain range, compared to the Sierra Madre Oriental, the Mexican Transversal Volcanic Belt, and the Sierra Norte de Oaxaca mountain range.

At the 10-domains level of classification (Figure 3), 2 main branches showed that climatic differences were evident and related mainly to precipitation and temperature rates (Table 3). The first branch was the group of domains 3, 4, and 6, determined mainly by higher precipitation rates and less extreme minimum temperature values in the Gulf of Mexico coastal plain (Figure 4), which differed in climate from the BRTC and surrounding areas of influence, and was made up of tropical rain forests in Veracruz (domain 4), montane forest in Oaxaca and Veracruz (domain 3), and evergreen tropical forest (domain 6). The second branch was characterized by temperate and arid environments in 3 ramifications: a) domains 2, 10 and 7, b) domains 8 and 9, and c) domains 1 and 5. The first ramification contained xeric vegetation such as desert rosette thicket and pine-oak forest in the Mexican Transverse Volcanic Belt (domain 2), oak and pine-oak forests in the Sierra Madre del Sur (domain 10), and oak forest in the Sierra Norte de Oaxaca (domain 7). The second ramification contained deciduous dry forest, pine forest, oak forest, and pine-oak forest in the Sierra Madre del Sur (domains 8 and 9). The third ramification contained deciduous dry forest in the Balsas basin, oak and pine-oak forests in the Sierra Madre del Sur and Mexican Transversal Volcanic Belt, and thicket in the Tehuacán-Cuicatlán valley. Notably again, the 10-domains classification identified climatic similarities between the Tehuacán-Cuicatlán valley and the Balsas basin.

Mammalian diversity in Climatic Domains of BRTC. Climate domains in the BRTC were characterized mainly by arid environments, with the addition of some temperate environments as well. At the 10-domains level of classification, just 7 of the 10 domains fell in the BRTC (Table 4), and domain 10, represented by oak and pine-oak forests, made up 44% of the reserve area. Domain 2 was oak and pine-oak forests, and domains 1 and 5 were represented by thicket in Tehuacán-Cuicatlán valley, and each of these domains covered over 15 % of BRTC total area (Figure 3). Domain 7 was represented by oak forest and covered less than 10 % of BRTC area, and domains 3 and 4 made up less than 1 % of the reserve´s BRTC and were composed of tropical rain and montane forests (Table 4).

From the total of 98 mammal species that we listed in the BRTC, georeferenced locations were documented only in 5 of the 7 domains in the reserve, and the number of species with point locations varied between 11 and 39 among these 5 domains (Table 4); domains 3 and 4 had no data and also were poorly represented in BRTC in terms of area.

The number of species with georeferenced locations increased substantially for every domain when we considered the full information in the study area polygon (Table 4) with extreme coordinates 19.00º North, 17.00º South, -96.65º East, and -99.50º West. For example, the number of species with georeferenced locations in domain 5 increased from 39 to 71. Data behaved similarly for domains 2, 1, and 10. For domains 3 and 4 that had zero georeferenced locations of mammal species within the BRTC, data increased to 53 and 10 species, respectively.

Discussion

Mammalian dataset. The georeferenced locations of mammalian species in the Tehuacán-Cuicatlán valley and surrounding areas of influence, plotted in Figure 1 as point locations, showed that the biological dataset was fragmented, biased, and incomplete. There were several places without georefenced locations, as well as some places with higher density of point locations. Although we listed 98 species, we obtained georeferenced locations for 92 of them. Also, there were 29 species with few or very few (1 to 9) point locations. For endemic and rare species with restricted distribution, the lack of information may be explained by the difficulty of collecting or observing specimens, as may be the cases of the vole *M. oaxacensis* and the big small-eared shrew (*C. magna*), both endemic to Oaxaca, and the chestnut-bellied shrew (*Sorex ventralis*), endemic to Mexico (Ramírez Pulido et al., 2005; Ramírez Pulido and Martínez Vázquez, 2007). The limited number of species and locations that have been studied within BRTC are other factors that may explain the absence of information regarding the geographic distribution of mammals (Ramírez Pulido and Martínez Vázquez, 2007). Nevertheless, the absence of georeferenced locations occurred also for 4 species of bats that show a wide distribution in México: Mexican big-eared bat (*C. mexicanus*), western red bat (*L. blossevillii*), evening bat (*N. humeralis*), and little yellow bat (*R. parvula*). Similarly, only 1 point location was obtained for the Commissaris's long-tongued bat (*G. commissarisi*), and 2 point locations were obtained for other mammal species without restricted distributions in México: the silky pocket mouse (*Perognathus flavus*), the tepezcuintle or lowland paca (*Cuniculus paca*), and 4 bats: black myotis (*Myotis nigricans*), Peale's free-tailed bat (*Nyctinomops aurispinosus*), big free-tailed bat (*Nyctinomops macrotis*), and big crested mastiff bat (*Promops centralis*).

Our list of mammal species within the BRTC is appointed to change in the near future, because recent studies suggest that some species might be extirpated from the BRTC, and other species may have not been documented yet (Botello et al., 2005, 2006a, 2006b; Ramírez Pulido and Martínez Vázquez, 2007). Ramírez Pulido and Martínez Vázquez (2007) mention that they found no evidence to support the assertion of the presence of jaguarundi (*Herpailurus yagouaroundi*), puma (*Puma concolor*), and jaguar (*Panthera onca)* within the BRTC, whereas for the tayra (*Eira barbara*) they reported that local people showed them some pelts but they found no further evidence. Recently, Botello et al. (2005, 2006a, 2006b) documented the first photographic registries of margay (*Leopardus wiedii*), bobcat (*Lynx rufus*), and tepezcuintle (*C. paca*) in the BRTC, as well as the first findings of scats of neotropical river otter (*Lontra longicaudis*). In addition, the American badger (*Taxidea taxus*) and pocket gophers (Order Rodentia, Family Geomyidae) are species acknowledged by local people to be present in the reserve, but not yet documented with georeferenced data.

Climatic Domains Classification. The climate patterns in our results revealed that at both the 5-domains and 10-domains levels of classification, although geographically separated from each other, the Tehuacán-Cuicatlán valley and the

Table 1. Bioclimatic parameters used for the generation of a climatic domains classification in a region that included the Tehuacán-Cuicatlán valley and its surrounding areas of influence; with extreme coordinates 19.00⁰ North, 17.00⁰ South, -99.50⁰ West and -96.65⁰ East

1. Annual mean temperature (°C)
2. Mean temperature diurnal range (°C)
3. Isothermality (°C)
4. Temperature seasonality (coefficient of variation in %).
5. Maximum temperature of warmest period (°C)
6. Minimum temperature of coldest period (°C)
7. Temperature annual range (°C)
8. Mean temperature of wettest quarter (°C)
9. Mean temperature of driest quarter (°C)
10. Mean temperature of warmest quarter (°C)
11. Mean temperature of coldest quarter (°C)
12. Annual precipitation (mm)
13. Precipitation of wettest period (mm)
14. Precipitation of the driest period (mm)
15. Precipitation seasonality (coefficient of variation in %)
16. Precipitation of wettest quarter (mm)
17. Precipitation of driest quarter (mm)
18. Precipitation of warmest quarter (mm)
19. Precipitation of coldest quarter (mm)

Table 2. Taxonomic diversity of mammalian species in Tehuacán-Cuicatlán biosphere reserve

Order[1]	*Family*[1]	*Number of Species*
Artiodactyla	Cervidae	1
	Tayassuidae	1
Carnivora	Canidae	2
	Felidae	5
	Mephitidae	3
	Mustelidae	2
	Procyonidae	3
Chiroptera	Emballonuridae	1
	Molossidae	4
	Mormoopidae	3
	Phyllostomidae	18
	Vespertilionidae	13

Table 2. Continues

Order[1]	*Family*[1]	*Number Of Species*
Cingulata	Dasypodidae	1
Didelphiomorpha	Didelphidae	3
Lagomorpha	Leporidae	3
Rodentia	Cuniculidae	1
	Heteromyidae	3
	Muridae	25
	Sciuridae	2
Soricomorpha	Soricidae	4

[1]Following the nomenclature classification proposed by Ramírez Pulido et al. (2005).

Table 3. Attributes obtained from 10 domains defined by numerical classification on the basis of climate estimates of approximately 90 000 points on a 1-km grid across Tehuacán-Cuicatlán valley and its surrounding areas of influence

ID	AMT °C	MTDR °C	ISO °C	TS %	MTWP °C	MTCP °C	TAR °C	MTWQ °C	MTDQ °C	MTWQ °C
1	18.4-23.9	12.7-17.2	0.60-0.76	0.42-0.77	28.9-35.6	7.1-13.6	19.5-25.0	19.0-24.6	16.1-23.2	20.3-26.3
2	12.7-20.5	12.7-18.0	0.65-0.74	0.47-0.70	22.5-32.1	2.3-8.9	19.3-25.5	13.2-21.4	10.8-18.2	14.4-22.7
3	15.1-22.2	9.8-14.0	0.58-0.68	0.52-0.74	23.5-33.0	6.8-12.9	16.0-22.2	15.8-23.5	13.7-21.2	16.8-24.6
4	21.5-25.4	10.4-13.9	0.57-0.64	0.70-0.81	30.6-35.7	11.4-16.5	17.9-22.2	22.8-26.9	19.5-24.4	23.8-27.9
5	22.2-28.7	13.1-17.7	0.58-0.71	0.48-0.86	33.9-40.8	9.8-16.6	20.3-27.6	22.7-28.5	19.6-29.4	24.8-31.5
6	19.0-25.3	9.8-12.3	0.57-0.63	0.65-0.79	26.7-34.7	10.7-16.4	16.0-19.6	20.4-26.9	17.8-23.2	21.0-27.8
7	3.4-18.2	6.8-14.1	0.62-0.76	0.20-0.64	8.20-28.1	-0.9-8.9	9.10-20.8	3.4-18.9	3.1-17.4	4.2-20.5
8	21.9-27.7	10.7-15.6	0.66-0.76	0.21-0.45	29.3-37.1	12.9-19.5	14.7-21.6	22.0-27.8	21.3-28.0	22.7-29.0
9	17.2-23.6	10.6-15.4	0.64-0.80	0.21-0.52	26.0-34.1	7.5-14.2	15.0-21.7	17.7-23.9	15.5-23.2	18.6-25.3
10	14.8-20.7	10.4-16.4	0.62-0.75	0.30-0.69	23.2-32.6	4.2-9.7	15.5.-24.2	14.8-21.3	13.4-19.0	16.7-23.2

ID	MTCQ °C	AP %	PWP mm	PDP mm	PS mm	PWQ mm	PDQ mm	PHQ mm	PCQ mm
1	16.1-22.0	313-1185	20-64	0-0	87-111	160-733	0-59	96-337	6-93
2	10.7-17.9	431-1350	23-69	0-0	80-104	227-791	0-58	146-400	11-61
3	12.9-19.2	1043-2829	53-141	0-11	79-93	594-1504	44-165	183-752	59-235
4	18.5-22.3	979-2697	49-142	0-10	80-100	546-1539	43-156	260-830	53-197
5	19.5-26.4	274-1177	18-64	0-0	90-113	155-730	0-46	86-293	4-62
6	16.2-22.1	2265-4057	107-208	0-16	79-95	1216-2196	126-247	648-1070	129-337
7	2.8-15.8	610-2801	29-123	0-0	77-97	307-1431	0-167	131-483	24-305
8	20.8-26.8	980-2079	56-132	0-0	100-121	629-1302	0-44	224-602	14-50
9	15.5-22.3	836-2082	44-119	0-0	95-113	501-1286	0-53	174-593	18-64
10	12.9-18.9	457-1413	29-73	0-0	85-102	236-850	0-50	113-440	12-106

ID = Domain number; AMT = Annual mean temperature; MTDR = Mean temperature diurnal range; ISO = Isothermality; TS = Temperature Seasonality; MTWP = Mean maximum temperature of warmest period; MTCP = Mean minimum temperature of coldest period; TAR = Temperature annual range; MTWQ = Mean temperature of wettest quarter; MTDQ = Mean temperature of driest quarter; MTWQ = Mean temperature of warmest quarter; MTCQ = Mean temperature of coldest quarter; AP= Annual Precipitation; PWP= Precipitation of wettest period; PDP= Precipitation of driest period; PS= Precipitation Seasonality; PWQ= Precipitation of wettest quarter; PDQ = Precipitation of driest quarter; PHQ= Precipitation of warmest quarter; PCQ= Precipitation of coldest quarter.

Table 4. Extension, number of mammalian species, and number of georreferenced locations within 10 domains defined by numerical classification on the basis of climate estimates of approximately 90 000 points on a 1-km grid across Tehuacán-Cuicatlán valley and its surrounding areas of influence, a polygon area with extreme coordinates19.00º North, 17.00º South, -96.65º East, and -99.50º West

ID	*Study area Km²*	*Study area % area*	*Total number of species in study area*	*Number of locations*	*Number of species collected, reported or observed for BRTC*	*Number of locations*
1	17023	18.89	132	580	82	474
2	7915	8.78	71	217	52	190
3	3226	3.58	91	217	53	129
4	3565	3.96	18	30	10	18
5	21144	23.47	102	830	71	754
6	1484	1.65	35	52	16	26
7	5225	5.80	80	305	56	205
8	4497	4.99	69	192	41	130
9	9078	10.08	56	111	41	87
10	16946	18.81	99	348	63	272

ID	*BRTC Km²*	*BRTC % area*	*Number of species collected, reported or observed for BRTC*	*Number of locations*
1	1105	18.32	29	51
2	927	15.37	24	32
3	23	0.38	0	0
4	3	0.05	0	0
5	954	15.82	39	136
6	-	-	-	-
7	393	6.52	11	21
8	-	-	-	-
9	-	-	-	-
10	2627	43.55	24	98

ID = Domain number; BRTC = Tehuacán-Cuicatlán biosphere reserve.

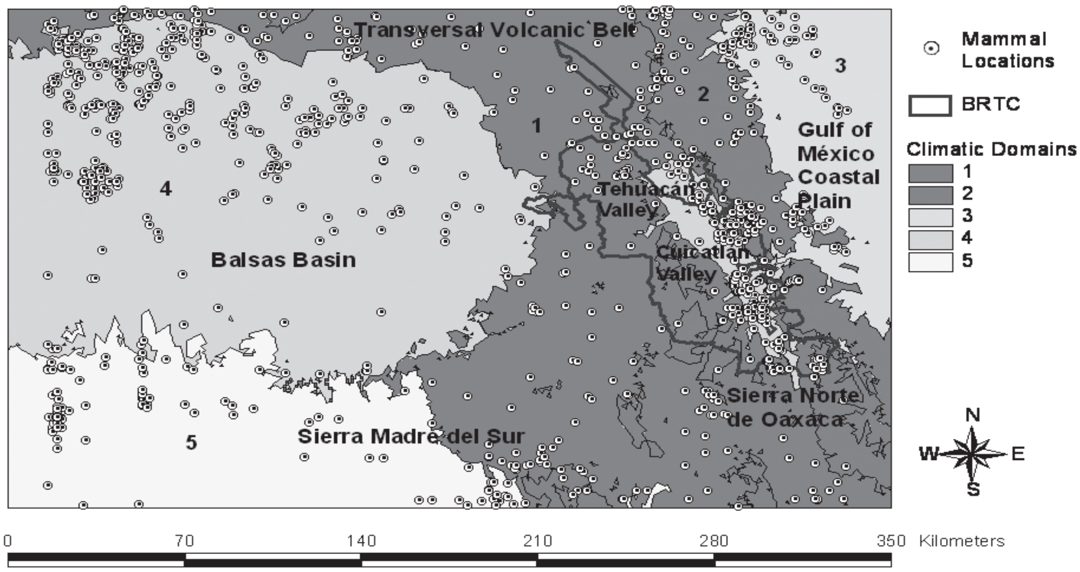

Figure 1. Geographic distribution of 5 domains defined by automatic classification of climatic data for approximately 90 000 points on a 1-km grid in the Tehuacán-Cuicatlán valley and surrounding areas of influence. Labels indicate the locations of topographic features. Points represent locations of species of mammals.

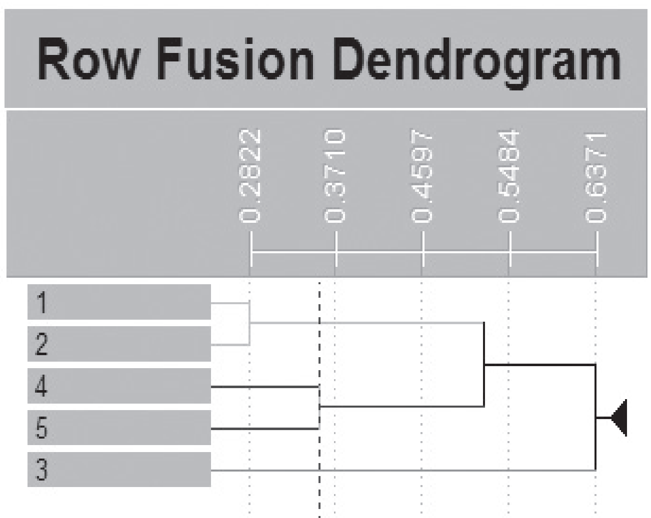

Figure 2. Dendrogram describing similarity (climatic distance) between 5 domains defined by automatic classification of climatic data for approximately 90 000 points on a 1-km grid across the Tehuacán-Cuicatlán Valley and surrounding areas of influence.

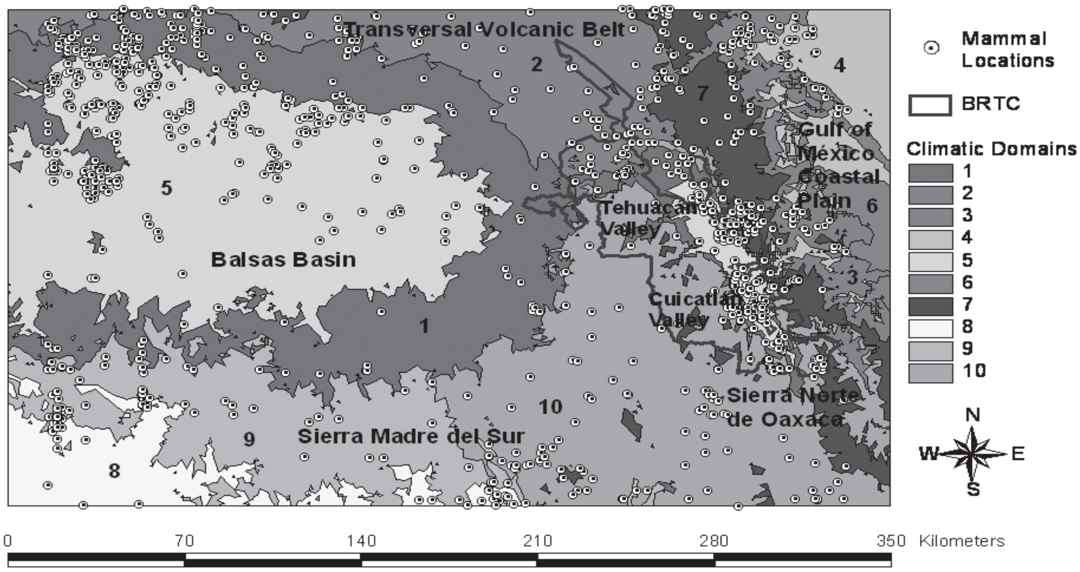

Figure 3. Geographic distribution of 10 domains defined by automatic classification of climatic data for approximately 90 000 points on a 1-km grid in the Tehuacán-Cuicatlán valley and surrounding areas of influence. Labels indicate the locations of topographic features. Points represent locations of species of mammals.

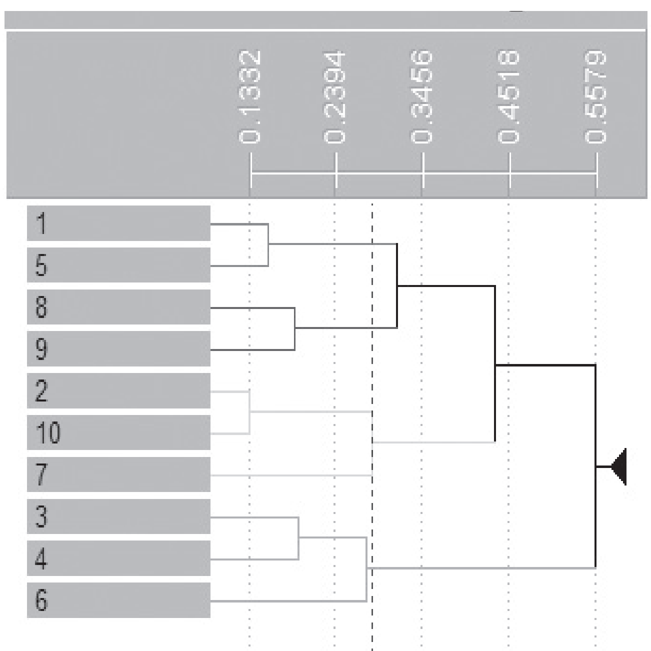

Figure 4. Dendrogram describing similarity (climatic distance) between 10 domains defined by automatic classification of climatic data for approximately 90 000 points on a 1-km grid across the Tehuacán-Cuicatlán valley and surrounding areas of influence.

Balsas basin share great similarity in climatic conditions. Their native flora, mainly in the warmest regions, shows a particular relationship (Miranda, 1948). Although the Tehuacán-Cuicatlán valley forms part of the hydrological region of the Papaloapan river, it probably belonged in the past to the Balsas basin (Rzedowski, 1978). Nevertheless, the floristic composition differs between Tehuacán-Cuicatlán valley and Balsas basin (Rzedowski, 1978), the best example perhaps being the genus *Bursera*. There are 48 species of *Bursera* in the Balsas basin compared to 12 species in the Tehuacán-Cuicatlán valley. Thus, the differences in floristic composition are manifested in the tropical deciduous forest being dominated by *Bursera* in the Balsas basin, while several Leguminosae genera dominate in the Tehuacán-Cuicatlán valley.

If we consider climate domains as a surrogate of biodiversity, the analysis of climate coverage protected by the limits of the BRTC (Téllez Valdés et al., in press), revealed marked variations across the reserve (Table 3). This fact increases the probability of including enough biological and environmental variation, which are the main elements that enable the occurrence of many of the ecological processes evolved in the area (Téllez Valdés et al., in press).

Mammal Diversity and Climatic Domains Analysis. It is interesting to point out that the environmental characteristics of the climatic domains in the Tehuacán-Cuicatlán valley were not unique and were shared with the Balsas basin. Thus, due to the insufficient information about the distribution of mammals inside the BRTC, climatic similarities between Tehuacán-Cuicatlán valley and Balsas basin justified the overlapping of environmental data with the biological dataset of point locations (species, longitude, latitude, and elevation) from mammalian species throughout the Tehuacán-Cuicatlán valley and its surrounding areas of influence. With this approach we implied that point locations of mammal species that fell within those climatic domains shared with the BRTC may be used to enhance conservation studies and analysis for the reserve. For example, one application may be to improve the modeling of the ecological niche and potential distribution of mammals within BRTC using BIOCLIM. Our previous efforts were severely hampered by bias and lack of information for most species, because we used only those point locations that fell within BRTC. Therefore, in subsequent analyses, we may enhance the modeling of the ecological niche and potential distribution of mammal species within the BRTC, with the more complete and less biased location data from the much wider geographic area of Tehuacán-Cuicatlán valley and its surrounding areas of influence.

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