

Amphibians and reptiles of Yécora, Sonora and the Madrean Tropical Zone of the Sierra Madre Occidental in northwestern Mexico

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ABSTRACT: The Municipio de Yécora is located in the Madrean Tropical Zone of the Sierra Madre Occidental in eastern Sonora, Mexico. The herpetofauna of the region is very diverse with 93 species in 59 genera and 27 families known from the Río Yaqui to the Chihuahua border. This includes 20 species of amphibians and 73 species of reptiles. Thirty-six species in the Yécora area fauna have protection in NOM-059-SEMARNAT-2010 law. There are no non-native species in the fauna. The Yécora area herpetofauna is representative of the Madrean Tropical Zone and serves as a baseline to evaluate faunas of the Madrean Archipelago in northeastern Sonora and southeastern Arizona, USA as well as those to the south along the axis of the range.

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INTRODUCTION

Sierra Madre Occidental

The Sierra Madre Occidental extends up western Mexico from Zacatecas and Jalisco north to Chihuahua and Sonora (Rzedowski 1978). The Continental Divide follows the Sierra Madre northward to the Sierra Huachinera on the Chihuahua-Sonora border, and then through the isolated Sierra Pulpito and Sierra San Luis in Sonora and the Animas Mountains in southwestern New Mexico, USA. González-Elizondo *et al.* (2012) defined the floristic divisions of the Sierra Madre Occidental. The Madrean Tropical Zone is on the western crest of the Sierra above tropical vegetation on the Pacific slopes.

The Madrean Archipelago is the region of isolated Sky Island mountain ranges between the northern Sierra Madre Occidental and the Mogollon Rim of central Arizona (Lowe 1992; McLaughlin 1995; Warshall 1995). Floras of the Sky Islands are comprised of species from both the Madrean Tropical and Northern Madrean zones (González-Elizondo *et al.* 2012).

Warshall (1995) recognized 40 Sky Island mountain ranges with crowns of oak woodland and pine-oak forest in the Madrean Archipelago based on the Brown and Lowe (1982) vegetation map. A more recent GIS-based analysis at Sky Island Alliance identified 55 Sky Islands and Sky Island complexes of ranges connected by oak woodland corridors in the Madrean Archipelago, 23 in Arizona and New Mexico and 32 in Sonora and Chihuahua (Deyo *et al.* 2013; Van Devender *et al.* 2013a).

In this paper, we discuss the Madrean Tropical herpetofauna centered on the Municipio de Yécora in the Sierra Madre Occidental of eastern Sonora in terms of regional floristic and biogeographic contexts.

MATERIALS AND METHODS

Study Area

Mexico federal highway 16 (MEX 16, Figure 1) provides a dramatic 177 km long elevational transect and environmental gradient through the study area from lowland tropical vegetation to highland montane forests (Búrquez-M. *et al.* 1992).

The study area (Figure 2) encompasses a region of eastern Sonora that is 5,294 km². The Municipio de Yécora, Sonora, with an area of 3,300 km² comprises most of the study area. It is almost entirely in the drainage of the Río Yaqui (CONAGUA 2010); only the southeastern edge of Mesa del Campanero is in the Río Mayo watershed. Elevation in the Municipio (Figure 3) ranges from 480 m along Arroyo Tepoca near Curea to 2,150 m on Mesa del Campanero (Figure 4), an increase of 1,770 m in a horizontal distance of 27 km (by air). Our herpetofaunal transect along MEX 16 began at 190 m elevation at the MEX 16 crossing of the Río Yaqui near Tónichi in the Municipio de Soyopa (28°33'7.55" N, 109°36'56.01" W), passes through part of the Municipio de Ónavas, and then through the Municipio de Yécora to the Chihuahua border (28°25'51.23" N, 108°30'45.89" W). It is 104 km by air from Tónichi to the Chihuahua border. It also includes the area north on SON 20 (a state highway) from near San Nicolás (28°25'54.28" N, 109°11'42.34" W) to the Cajón de Onapa reservoir near Güisamopa (28°41'16.03" N, 109° 8'23.31" W) in the Municipio de Sahuaripa, and south on SON 12 (a state highway) from near San Nicolás (28°25'26.65" N, 109°11'11.26" W) through Curea to just southeast of Nuri (28°6'38.04" N, 109°19'17.59" W) into the Municipio de Rosario de Tesopaco.



FIGURE 1. View of MEX 16 from Mesa del Campanero near Rancho la Cruz (1,947 m). Photo by EFE, September 2009

Vegetation zonation

There are important vegetational changes that coincide with elevation that are most easily seen along MEX 16 from Tepoca to the Chihuahua border (Figure 5). The transition between the New World Tropics and the North Temperate Zone is at about 29° N in east-central Sonora. Foothills thornscrub (FTS, *matorral espinoso*) is a very important biotic community in Sonora that is transitional between Sonoran desertscrub and tropical deciduous forest (TDF, *selva baja caducifolia*, Figures 6 and 7) in southern Sonora and oak woodland in eastern Sonora (Van Devender et al. 2013b). In the Municipio de Yécora, thornscrub occurs in a limited area at 460-550 m elevation in a rain-shadow valley at Curea, but is widespread in lower areas in the Municipios de Ónavas and Soyopa. In the Municipio de Yécora, tropical deciduous forest is found in a broad band at 500-1,160 m elevation.

In the Yécora area, oak woodland (*bosque de encino*) is present at 1,050-1,700 m elevation. At 1,220-2,240 m, it often occurs in a mosaic with pine-oak forest (*bosque de pino-encino*). Mixed-conifer forest (*bosque de coníferas mixtas*) with Durango fir/*pinabete duranguense* (*Abies durangensis*) in Barranca El Salto on the west side of Mesa del Campanero at 1,900-2,100 m is the only example of that vegetation type in Sonora.

Grassland (*pastizal*) occurs in high valleys at 1,200-1,700 m, often in a mosaic with oak woodland or pine-oak forest. Grassland also occurs in the Yécora Valley.

Another unusual habitat in the Municipio de Yécora consists of the gossans, hydrothermally altered volcanic areas with bright red or yellow acidic soils (pH as low as 4). Islands of open pine-oak forest or oak woodland are surrounded by tropical deciduous forest (Goldberg 1982).

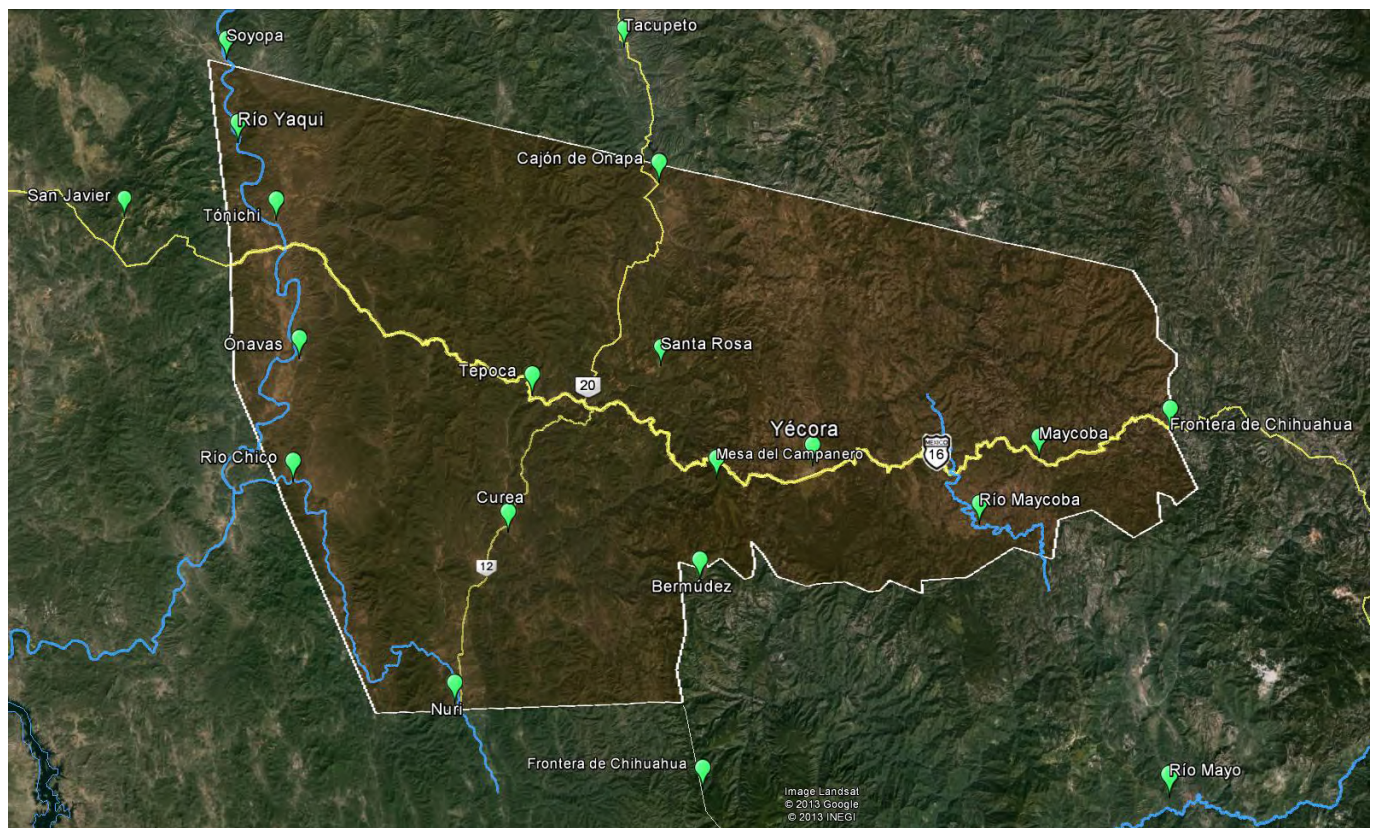


FIGURE 2. Map of MEX 16 study area.



FIGURE 3. Elevational profile of MEX 16 within the study area, from west-to-east. Y-axis = elevation. X-axis = distance. Lower color gradient depicts biotic communities: TS (thornscrub), TDF (tropical deciduous forest), OW (oak woodland), POF (pine-oak forest), GL (grassland). Black vertical lines represent points of interest; places names are shown on either side of line.



FIGURE 4. MEX 16 ascending the western slope of Mesa del Campanero. Photo by EFE, September 2009

Climate

Climate data for the area are collected and made available by Comisión Nacional del Agua (CONAGUA) from the years 1951-2010 (CONAGUA 2014).

In general, the climate grades west-to-east with elevation from seasonally dry tropical lowlands (Figure 7) to cool-temperate highlands. The western region from Tónichi to San Nicolás is tropical in character with dry winters and oppressively hot and humid summers that bring monsoon-like thunderstorms – their number and intensity increasing to the east with elevation. Semi-succulent tropical trees (*Plumeria rubra*, *Jatropha cordata*) grow to substantial heights here where frosts are uncommon. Tónichi, near the western edge of the transect, represents the driest and hottest locality with 612 mm mean annual precipitation and a mean annual temperature



FIGURE 5. Photographs of select biotic communities along the MEX 16 transect. From top left-to-right: thornscrub near Curea, photo by TRV April 2000; tropical deciduous forest near San Nicolas, Photo by EFE, July 2007; oak woodland west of Maycoba, Photo by EFE, July 2005; pine-oak forest near Rancho el Horquetudo, photo by EFE, August 2008

of 25.5° C . At San Nicolás, near the center of the transect, mean annual precipitation increases by 29.7% to 870 mm and mean average temperature decreases to 20.5° C.

To the east, from the stunning western escarpment of Mesa del Campanero nearing Yécora, the climate becomes temperate. Winters can be cold with sub-freezing temperatures and occasional snow. Summer conditions are wet and cool. Although climate data for Mesa del Campanero are unavailable, it likely represents one of the wettest regions in Sonora primarily due to its elevation and its geographic position above and between Neotropical Sonora and the SMO cordillera. Climate data for Yécora (9.7 km by air east of Mesa del Campanero and 584 m lower in elevation) is temperate with a mean average temperature of 14.3° C and mean annual precipitation of 893.7 mm.

Maycoba (1534 m), 47.8 km east of Yécora represents the single CONAGUA data point for the remaining eastern portions of the transect. The elevation in this region varies from a low point of 1,229 m at ca. 26 km east of Yécora to a highpoint 1,690 m ca. 13 km west of the Chihuahua border (Figure 3). This remote, mesic area is temperate with complex topography that seems to facilitate summer thunderstorm development. Mean average temperature for Maycoba is 14.8° C and mean annual precipitation is 929.4 mm. Sonora's only sphagnum moss bog occurs in this region at Ciénega de Camilo ca. 10 km east of Maycoba (Van Devender *et al.* 2003).

Methods

Amphibians and reptiles were encountered during field searches and driving roads at night. Many areas were visited at different times of the day and in different seasons, but most of the effort was in the summer rainy season in July-September. We acquired herpetofauna records from twenty-five institutions and supplemented these records with data available from online sources such as VertNet (<http://vertnet.org/index.php>) and scientific publications, particularly Enderson *et al.* (2009; 2010). The collections of the University of Arizona Museum of Natural History (UAZ) contain historical records from the Yecora



FIGURE 6. Tropical deciduous forest near Tepopa. Photo by EFE, July 2007



FIGURE 7. Dry and wet seasons in tropical deciduous forest along the MEX 16 transect. On the left, a predominately leafless forest in early July 2005. On the right, a lush a canopy in late September 2005. Photos by EFE.

area resulting from several researchers, including Darryl R. Frost, Stephen F. Hale, Peter A. Holm, Charles H. Lowe, Brent E. Martin, Julia V. Salmon, and Cecil R. Schwalbe. Most historical records and our new observations and images are also available in the MABA database (<http://www.madrealn.org/symbfauna/collections/index.php>). Photographic vouchers of selected taxa were deposited into UAZ. Due to permit restrictions, animals were photographed but not collected. Research in Mexico and photographic voucher acquisition were under SEMARNAT permit 05169/07.

Nomenclature follows Liner and Casas-Andreu (2008) and Enderson *et al.* (2010) with the exception of *Procinura aemula* where we prefer the name *Sonora aemula* (Cox *et al.* 2012).

RESULTS

A total of 93 species of amphibians (20 species) and reptiles (73 species) in 59 genera and 27 families are known in the Yécora study area (Table 1). The reptiles include turtles (6 species), lizards (25 species), and snakes (42 species). The most diverse families are Colubridae (34 species) and Phrynosomatidae (14 species). Bufonidae, Hylidae, and Viperidae have five species each. The genera with the greatest diversity are *Sceloporus* (8 species) and *Crotalus* (5 species). *Coluber*, *Incilius*, *Kinosternon*, and *Phrynosoma* have three species each. None of the species observed in these areas are non-native.

DISCUSSION

Fauna Analyses

The diversity of amphibians and reptiles in the study area is greatest in tropical deciduous forest with 63 species. Fewer species occur in foothills thornscrub (52 species) at lower elevations and in oak woodland (49 species) and pine-oak forest (42 species) at higher elevations. The 69 species in tropical vegetation (FTS, TDF) is only slightly higher than in montane vegetation (OW, POF, 60 species).

There is considerable species turnover along the MEX 16 elevational gradient with only 11 species (11.8% of the fauna) recorded in all vegetation types. These are widespread generalists in the southwestern United States, the Madreal Archipelago, or the Neotropics. Pine-oak forest has the lowest species diversity with only 11 spp (11.8% of the fauna) found in this vegetation. The lower percentage of Madreal POF herpetofauna within the study area may perhaps correlate with the lower maximum elevation of Sonora POF compared to that of Chihuahua, or may represent a climatic effect related to the Continental Divide. Several species known from Chihuahua in Madreal POF near the Sonora border are absent from the study area, including *Barisia levicolis*, *Crotalus pricei*, *Conopsis nasus*, *Kinosternon hirtipes*, *Phrynosoma hernandesi*, *Plestiodon brevirostris*, *Spea multiplicata*, and *Thamnophis sirtalis*.

Surprisingly, no species were limited to oak woodland. Our herpetofaunal observations and analysis of historical records indicate that oak woodland is a transitional environment where species of divergent biogeographic origin interdigitate. Of the 49 species known from oak woodland, 19 have tropical affinity and 17 have Madreal affinity. Notable among the tropical species recorded from oak woodland are *Eleutherodactylus interorbitalis*

previously reported only from near Mazatlán, Sinaloa (Enderson and Bezy 2007e), *Heloderma horridum*, and *Micrurus distans* (Van Devender and Enderson 2007).

Although tropical deciduous forest has the highest species diversity, only 5.4% of the fauna (five species) was encountered only there. These are mostly Neotropical species, with the exception of *Phrynosoma ditmarsii*, a rare, Sonoran endemic horned lizard. Six species (6.4%) found only in foothills thornscrub are widespread in the arid and semiarid regions of the southwestern United States and adjacent northern Mexico.

Enderson *et al.* (2009) estimated that 26% (n=48) of Sonora's herpetofauna can be biogeographically classified as tropical. The representative tropical herpetofauna of the MEX 16 study area consists of 31 species (64.7% of Sonora's total tropical herpetofauna). These figures are surprisingly high considering the northern latitude of the MEX 16 transect and its position near the northern extent of TDF. Nonetheless, eleven tropical species reach their northern latitudinal limits within the MEX 16 transect (Table 2) and of the seventeen tropical species not known from the MEX 16 transect, three are recorded within 18 km of the study area (*Agkistrodon bilineatus*, *Anaxyrus kelloggi*, and *Urosaurus bicarinatus*). Another two species are regionally endemic aquatic turtles (*Kinosternon alamosae* and *Trachemys nebulosa*), and three (*Lithobates forreri*, *Thamnophis validus*, and *Tlachyha smithii*) are typically associated with coastal thornscrub, which lies well outside the study area. The remaining six species absent from the MEX 16 herpetofauna are exclusively tropical forms, known in Sonora only from the most extensive, and mature area of TDF in the state and possibly the world near Álamos (Van Devender *et al.* 2000). These include the diurnal snakes *Drymobius margaritiferus* and *Mastigodryas clifftoni*. Also missing are the amphibians *Craugastor occidentalis*, *Incilius marmoreus*, *Hypopachus variolosus*, *Lithobates pustulosus*, *Rhinella marina*, and the beautiful semi-aquatic turtle *Rhinoclemmys pulcherimma*. This exceptional diversity indicates the importance of the tropical herpetofauna within the Madreal Tropical Zone.

Biogeography

In general, the oak woodland and pine-oak forests have a very similar appearance throughout the Madreal Archipelago and in the Madreal Tropical Sierra Madre Occidental, reflecting widespread species of trees and shrubs. Reina-G. and Van Devender (2005) compared the floras of the Yécora area and the Huachuca Mountains, one of the most diverse Sky Island ranges in Arizona (Bowers and McLaughlin 1996). But only 40% or less of the Sky Island floras actually occur in the mainland Sierra Madre Occidental due to the increase in temperate and desert plants in the north. The Yécora flora is about 30% richer than any Sky Island.

The Madreal Archipelago is a convergence zone for five biotic provinces (Van Devender *et al.* 2013a): the cold temperate Rocky Mountains and Colorado Plateau to the north, the grasslands and Chihuahuan desertscrub to the east, Sonoran desertscrub to the west, and New World tropical vegetation and tropical temperate forests from the Sierra Madre Occidental to the south. On the western versant of North America, the transition between the New

TABLE 1. A checklist of amphibians and reptiles of the Yécora area and Madrean Tropical Zone of Sonora, México. NOM-059 SEMARNAT (2010) status. A = Amenazada (threatened), Pr = Protegida (special protection).

TAXON	NOM
AMPHIBIA	
CAUDATA	
Ambystomatidae	
<i>Ambystoma rosaceum</i> Taylor, 1941	Pr
Plethodontidae	
<i>Pseudoeurycea bellii</i> (Gray, 1850)	A
ANURA	
Bufonidae	
<i>Anaxyrus mexicanus</i> (Brocchi, 1879)	
<i>Anaxyrus punctatus</i> (Baird & Girard, 1852)	
<i>Incilius alvarius</i> (Girard in Baird, 1859)	
<i>Incilius mazatlanensis</i> (Taylor, 1940)	
<i>Incilius mcoyi</i> Santos-Barrera and Flores-Villela, 2011	
Craugastoridae	
<i>Craugastor augusti</i> (Dugès in Brocchi, 1879)	
<i>Craugastor tarahumaraensis</i> (Taylor, 1940)	Pr
Eleutherodactylidae	
<i>Eleutherodactylus [Syrrhophus] interorbitalis</i> (Langebartel & Shannon, 1956)	Pr
Hylidae	
<i>Hyla arenicolor</i> Cope, 1866	
<i>Hyla wrightorum</i> Taylor, 1939	
<i>Pachymedusa dacnicolor</i> (Cope, 1864)	
<i>Smilisca baudinii</i> (Duméril & Bibron, 1841)	
<i>Smilisca fodiens</i> (Boulenger, 1882)	
Leptodactylidae	
<i>Leptodactylus melanonotus</i> (Hallowell, 1861)	
Microhylidae	
<i>Gastrophryne mazatlanensis</i> (Taylor, 1943)	Pr
Pelobatidae	
<i>Scaphiopus couchii</i> Baird, 1854	
Ranidae	
<i>Lithobates magnaocularis</i> (Frost & Bagnara, 1974)	
<i>Lithobates tarahumarae</i> (Boulenger, 1917)	
REPTILIA	
TESTUDINES	
Emydidae	
<i>Terrapene nelsoni</i> Stejneger, 1925	Pr
<i>Trachemys yaquia</i> Legler & Webb, 1979	Pr
Kinosternidae	
<i>Kinosternon arizonense</i> Gilmore, 1922	
<i>Kinosternon integrum</i> LeConte, 1854	Pr
<i>Kinosternon sonoriense</i> LeConte, 1854	
Testudinidae	
<i>Gopherus [agassizi] morafkai</i> Murphy, Berry, Edwards, Leviton, Lathrop & Riedle, 2011	A
SQUAMATA	
Anguidae	
<i>Elgaria kingii</i> Gray, 1838	Pr
Crotaphytidae	
<i>Crotaphytus nebrius</i> Axtell & Montanucci, 1977	
Eublepharidae	
<i>Coleonyx fasciatus</i> (Boulenger, 1885)	
Gekkonidae	
<i>Phyllodactylus homolepidurus</i> Smith, 1935	
Helodermatidae	
<i>Heloderma horridum</i> (Wiegmann, 1829)	A
Iguanidae	
<i>Ctenosaura macrolopha</i> Smith, 1972	
Phrynosomatidae	
<i>Callisaurus draconoides</i> Blainville, 1835	A
<i>Holbrookia elegans</i> Bocourt, 1874	
<i>Phrynosoma ditmarsii</i> Stejneger, 1906	
<i>Phrynosoma orbiculare</i> (Linnaeus 1789)	A
<i>Phrynosoma solare</i> Gray, 1845	
<i>Sceloporus albiventris</i> Smith, 1939	
<i>Sceloporus clarkii</i> Baird & Girard, 1852	
<i>Sceloporus jarrovi</i> Cope in Yarrow, 1875	
<i>Sceloporus lemosespinali</i> Lara-Gongora, 2004	Pr
<i>Sceloporus nelsoni</i> Cochran, 1923	
<i>Sceloporus poinsettii</i> Baird & Girard, 1852	
<i>Sceloporus slevini</i> Smith, 1937	
<i>Sceloporus virgatus</i> Smith, 1938	
<i>Urosaurus ornatus</i> (Baird & Girard, 1852)	
Polychrotidae	
<i>Anolis nebulosus</i> (Wiegmann, 1834)	
Scincidae	
<i>Plestiodon callicephalus</i> (Bocourt, 1879)	
<i>Plestiodon parviauriculatus</i> (Taylor, 1933)	Pr
Teiidae	
<i>Aspidozelis costata</i> (Cope, 1878)	Pr
<i>Aspidozelis tigris</i> (Baird & Girard, 1852)	
Boidae	
<i>Boa constrictor</i> Linnaeus, 1758	
Colubridae	
<i>Chilomeniscus stramineus</i> Cope, 1861	Pr
<i>Coluber bilineatus</i> (Jan, 1863)	
<i>Coluber flagellum</i> Shaw, 1802	A
<i>Coluber mentovarius</i> (Duméril, Bibron & Duméril 1854)	A
<i>Diadophis punctatus</i> (Linnaeus, 1766)	
<i>Drymarchon melanurus</i> (Duméril, Bibron & Duméril, 1854)	
<i>Geophis dugesii</i> Bocourt, 1883	
<i>Gyalopion canum</i> Cope, 1860	
<i>Gyalopion quadrangulare</i> (Günther, 1893)	
<i>Hypsiglena chlorophaea</i> Cope, 1860	
<i>Imantodes gemmistratus</i> Cope, 1861	Pr
<i>Lampropeltis getula</i> (Linnaeus, 1766)	A
<i>Lampropeltis pyromelana</i> (Cope, 1867)	A
<i>Lampropeltis triangulum</i> (Lacépède, 1789)	A
<i>Leptodeira splendida</i> Günther, 1895	
<i>Leptophis diplotropis</i> (Günther, 1872)	A
<i>Oxybelis aeneus</i> (Wagler, 1824)	
<i>Pituophis catenifer</i> (Blainville, 1835)	
<i>Pituophis deppei</i> (Duméril 1853)	
<i>Pseudoficimia frontalis</i> (Cope, 1864)	
<i>Rhinocheilus lecontei</i> Baird & Girard, 1853	
<i>Salvadora hexalepis</i> (Cope, 1866)	
<i>Senticolis triaspis</i> (Cope, 1866)	
<i>Sonora [Procinura] aemula</i> (Cope, 1897)	Pr
<i>Storeria storerioides</i> (Cope, 1865)	
<i>Sympholis lippensis</i> Cope, 1862	
<i>Tantilla wilcoxi</i> Stejneger, 1902	
<i>Thamnophis cyrtopsis</i> (Kennicott, 1860)	A
<i>Thamnophis eques</i> (Reuss, 1834)	A
<i>Thamnophis melanogaster</i> Peters, 1864	A
<i>Thamnophis rufipunctatus</i> (Cope, 1875)	
<i>Trimorphodon lambda</i> (Duméril, Bibron & Duméril 1854)	
<i>Trimorphodon tau</i> Cope, 1870	
<i>Tropidodipsas repleta</i> Smith, Lemos-Espinal, Hartman & Chiszar, 2005	
Elapidae	
<i>Micruroides euryxanthus</i> (Kennicott, 1860)	A
<i>Micrurus distans</i> (Kennicott, 1860)	Pr
Viperidae	
<i>Crotalus atrox</i> Baird & Girard, 1853	Pr
<i>Crotalus basiliscus</i> (Cope, 1864)	Pr
<i>Crotalus lepidus</i> (Kennicott, 1861)	Pr
<i>Crotalus molossus</i> Baird & Girard, 1853	Pr
<i>Crotalus willardi</i> Meek, 1905	Pr

World tropics and the northern temperate zone is at about 29°N in east-central Sonora. Tropical deciduous forest is (or was formerly) widespread along the Pacific coast from Costa Rica northwest to the Sierra San Javier (28°35' N), 80 km west-northwest of Yécora on the west side of the Río Yaqui (Van Devender *et al.* 2010). The northern limits of thornscrub are at about 30°30' N in the Ríos Bavispe and Sonora valleys, but a significant number of thornscrub plants occur in southern Arizona in desert grassland or oak woodland.

In contrast, the main influences in the Yécora area are the Neotropics and the Sierra Madre. In the Yécora area herpetofauna, 30 and 27 species respectively have affinities to these biotic provinces, for a total of 63.3% of the fauna. Species with distributions in the greater Madrean Archipelago comprise 16.7% of the fauna. Some 20.0% of the herpetofauna are widely distributed the southwestern United States and adjacent northern Mexico.

None of the Yécora transect amphibians and reptiles have northern cold temperate affinities. The absence of species from other biotic provinces is more than offset by increasing diversity to the south in both lowland and montane biotic communities. This is primarily related to warmer winter temperatures and reduced frequencies of hard freezes.

Endemism

Three regionally endemic taxa are known from the study area. One species, the snail-eating snake *Tropidodipsas repleta* (Figure 8), was described from a single specimen collected west of Mesa del Campanero (Smith *et al.* 2005) and represents the northern-most member of a genus otherwise associated with the tropics. It has since been discovered near Chinipas, Chihuahua (Lemos and Smith 2007), but subsequent observations from the Yécora area are few. Little is known of this species. However, it is conjectured to be a close relative of *T. annulifera*, which occurs in northern Sinaloa (Smith *et al.* 2005).

The elusive horned lizard, *Phrynosoma ditmarsii* (Figure 9) is reported from the study area (Perrill 1983). The type specimen was collected from an unknown locality in NE Sonora during the Lumholtz expedition of 1890-1891 (Stejneger 1906). Its subsequent rediscovery is documented in Lowe and Howard (1971) and Roth (1997). In the years since its rediscovery, *P. ditmarsii* has been confirmed from six isolated localities; all but two are within the Sonoran realm of the Madrean Archipelago, typically at the lower reaches of oak woodland in east-central Sonora. One of the exceptions is the MEX 16 record from Rancho la Mula in the Municipio de Ónavas as reported by Perrill (1983). The locality represents the southernmost distributional record for the species and the only record from TDF. Its occurrence here is puzzling and may suggest a geographic and ecological distribution of greater significance than currently known.

Perhaps the most remarkable taxon in the region is the rare and beautiful lungless salamander subspecies, *Pseudoeurycea belli sierraoccidentalis* (Figure 10). Its extraordinary discovery southwest of Yécora in 1964 extended the species geographic range by ca. 880 km north of the nearest reported locality in Nayarit (Lowe *et al.* 1968). A rare and secretive taxon, it is presently known

from two localities, one in the Yécora region and the other near Ocampo, Chihuahua, ca. 58 km by air southeast of Yécora in the SMO (Van Devender *et al.* 1989). Our field searches and experience in the region (Bezy *et al.* 2004) support the notion of rarity. Described primarily on the basis of color pattern, *P. b. sierraoccidentalis* from the Yécora region are large, black-to-charcoal gray and differ from *P. b. belli* by having dorsal spots that are considerably fewer in number and in color intensity (Parra-Olea *et al.* 2005). *Pseudoeurycea belli* is a wide-ranging species found throughout southern and central Mexico in generally mesic upland environments that are in or adjacent to the Sierra Madre, where it is apparently persists in secondary growth forest, plantations, and urban gardens (Parra-Olea *et al.* 2005). Although we have not studied the question, our qualitative observations suggest that habitat destruction, temporal adaptations to the considerably drier and colder climate regime of the northern SMO, and possibly climate change may contribute to the rarity of *P. belli* in the Yécora region. At our one *P. belli* locality, harvesting of old growth



FIGURE 8. *Tropidodipsas repleta* from MEX 16. Photo by Brandon La Forest, 2011



FIGURE 9. *Phrynosoma ditmarsii*, east of Baviacora, Sonora. Photo by EFE

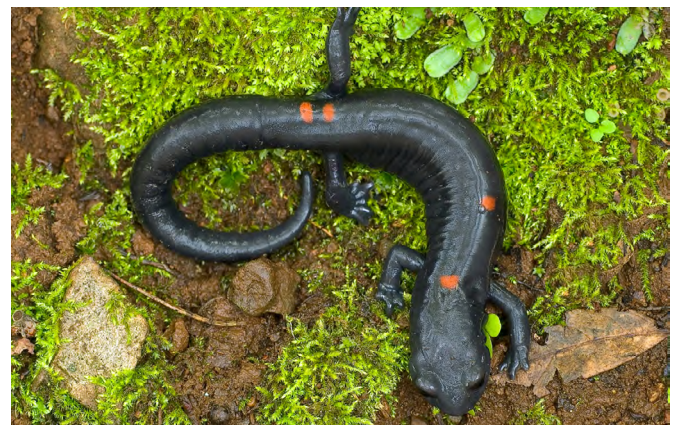


FIGURE 10. *Pseudoeurycea belli sierraoccidentalis* from the MEX 16 study area. Photo by EFE, August 2004.

and secondary growth forest is an on-going practice. The effects of logging in the Yécora region have not been studied, however, evidence from other species suggests that it may have a negative impact on plethodontid species (e.g., Petranksa *et al.* 1994).

Herpetofaunal Comparisons

The largest area of Madrean Tropical forests is in the northwestern Sierra Madre Occidental from the vicinity of Yécora to the Huachinera area in eastern Sonora. The herpetofauna for the state of Sonora has 189 species, including 37 amphibians and 152 reptiles (Enderson *et al.* 2009; Palacio-Baéz and Enderson 2012). The herpetofauna of the MEX 16 transect with 93 species is very diverse and represents 49.2% of the state herpetofauna within an area that occupies roughly 2.8% of the state. This paper serves both to characterize the herpetofauna of the Madrean Tropical floristic division of the Sierra Madre Occidental, and as a baseline to evaluate the Madrean contribution to Sky Island faunas from the Madrean Archipelago (Reina-G. and Van Devender 2005; Van Devender *et al.* 2013 a, b). The only previous regional herpetofaunal study from the northern Sierra Madre was for the Yépomera-Madera area in Chihuahua (Van Devender and Lowe 1977).

The Yécora regional herpetofauna is much richer than that of individual ranges in the Madrean Archipelago in Sonora. Van Devender *et al.* (2013b) provided preliminary herpetofaunas for two Sky Island mountains ranges in Sonora. A total of 59 species of amphibians (11) and reptiles (48) are known from Sierra la Madera (Table 1). A total of 30 species of amphibians (9) and reptiles (21) are known from Sierra Bacadéhuachi (Van Devender *et al.* 2013b).

The region also has greater species richness than the Sierra Zetasora of the Northern Jaguar Preserve with a herpetofauna of 51 species (11 amphibians and 40 reptiles; Rorabaugh *et al.* 2011).

Additional species known elsewhere in the SMO in Sonora and nearby Chihuahua may be discovered in the Yécora area. *Salvadora bairdi* (AMNH 102194) is known in the SMO from near Milpillas on the Chihuahua-Sonora border, 120 km south of the Yécora area. Several species, including *Anaxyrus woodhousii*, *Coluber taeniatus*, *Conopsis nasus*, *Crotalus pricei*, *Crotalus scutulatus*, *Phrynosoma hernandesi*, *Spea multiplicata*, *Thamnophis elegans*, and *Thamnophis sirtalis* occur in the Yépomera area in Chihuahua to the east (Van Devender and Lowe 1977; Lemos-Espinal and Smith 2009). *Agkistrodon bilineatus* (Babb and Dugan 2008), *Anaxyrus kelloggi* (UAZ 39456), *Phyllorhynchus browni* (UAZ 42842), *Trimorphodon lambda* (UAZ 44879), and *Urosaurus bicarinatus* (UAZ 39969) are known from the area immediately south of the transect in TDF or thornscrub. Confirmed records of *Coleonyx variegatus* (UAZ 48196), *Crotalus tigris* (ROM 18169), and *Heloderma suspectum* (UAZ 46437) are known from west of the study area near Tecoripa. Another five amphibians (all anurans) and six reptiles (2 turtles and 4 snakes) all with strong tropical affinity occur in TDF near Álamos (Schwalbe and Lowe 2000; Palacio-Baéz and Enderson 2012), but have not yet been found near Yécora.

With the exception of the Sierra Zetasora within Northern Jaguar Reserve north of Sahuaripa in FTS

(Rorabaugh *et al.*, 2011) and the Sierras la Madera and Bacadéhuachi (Van Devender *et al.* 2013b), there are no published herpetofaunas for eastern and northeastern Sonora. These local herpetofaunas and the mainland SMO herpetofauna in the Yécora area presented here contribute to our understanding of the regional biodiversity, but additional studies are needed in individual Sky Island ranges and other areas in the SMO. The fauna of the Mesa Tres Ríos-Sierra Huachinera area, the wettest highlands on the Sonora-Chihuahua border in the northernmost SMO, would be especially interesting to explore.

Notable Observations

We recorded eight geographic distributional records during this study (1 frog, 7 snakes) and of these, two were new additions to the state herpetofauna (Bonine *et al.* 2006; Enderson *et al.* 2006; Enderson and Bezy 2007b, c, d, e, f; Van Devender and Enderson 2007). The most notable of these observations is that of *Eleutherodactylus interorbitalis* (Figure 11) near the Río Maycoba at MEX 16. This discovery marked the second known locality for the species and extends the distribution ca. 560 km (by air) north of the type locality near the Tropic of Cancer in coastal Sinaloa, Mexico (Enderson and Bezy 2007e). Additional *E. interorbitalis* localities were discovered in July 2005 (MABA-son-trv-15409) and July 2006 (MABA-son-trv-15410). The first Sonora locale lies 0.30 - 0.75 km above the west bank of the Río Maycoba in open oak woodland with a rocky, grass understory. MABA-son-trv-15410, discovered in July 2006, is from west of Arroyo San Nicolás in TDF and MABA-son-trv-15409 is west-northwest of Tepoca, also in TDF. Each of these localities is on steep basalt slopes above watercourses.

Our observations of *E. interorbitalis* within the study area indicate that it is a diminutive, nocturnal and terrestrial frog that is difficult to locate if not vocalizing. Listening for the distinctive and remarkably loud male breeding call –a single peep, repeated at varying intervals –made our observations possible. We documented males vocalizing on the nights of July 6-8 and July 22-23 from talus slopes, boulders, road cuts, and outcroppings.

During the years 2005-2008, we made concerted efforts to coordinate our early summer expeditions to coincide with the onset of monsoon rains in early July for the express purpose of conducting nocturnal anuran field searches. During a period of three nights from 6 July - 9 July 2005, Enderson and Bezy observed prodigious anuran breeding aggregations and surface activity resulting from the first significant summer rains. On 6-8 July we recorded 16 of the 18 anuran species known from the study area (Table 1) and observed vocalizing males in 15 species. Near the village of El Kipor (6.3 km by air east of Maycoba - 28° 24' 17" N 108° 35' 52" W) and in Yécora on 7 July 2005 we observed breeding aggregations of *Hyla wrightorum* and *Gastrophryne mazatlanensis* that we estimate numbered in the tens of thousands. In all years of this study, we observed substantial breeding aggregations of *H. wrightorum* at both sites in the broad, shallow marsh-like wetlands that form after summer rains in the basins adjacent to El Kipor and Yécora. On the night of 7 July 2005, while driving east on MEX 16 between Yécora and El Kipor (ca. 55 km) during a steady rain, we witnessed what appeared to be a rapid

frog terrestrial mass migratory event. Although we did not quantify our observation, we estimate that between the hours of 18:00h - 23:00h we encountered several hundred thousand juvenile *Lithobates* cf. *magnaocularis* crossing the highway. On the return to Yécora (traveling west) between the hours of ca. 00:15h - 02:15h rain had ceased and the frogs had seemingly disappeared. Although our observations were not quantified, we provide them here as they present a strong contrast to the global trend of amphibian declines (McCallum 2007; see Hale et al. 2005 for a regional summary) and hope they encourage future studies of the anuran populations in the area.

Our early season anuran surveys also resulted in the discovery of four new localities of the rare terrestrial Madrean endemic frog, *Craugastor tarahumaraensis* (Figure 12) known previously from two localities in Sonora (UAZ 28133 and UAZ 57337-PSV). We observed calling males at two localities (east of Kipor and El Aguajito). At the locality east of El Kipor, we heard the simultaneous advertisement calls of *C. tarahumaraensis* and *Craugastor augusti* separated by ca. 10 m. Our observations of *C. tarahumaraensis* may suggest a short period of breeding activity. At El Aguajito on 7 July 2005, we observed 12 calling males after a moderate thunderstorm. The following night (after moderate rain), the number of calling males decreased to one.

Taxonomic Uncertainty

Throughout this study we were faced with the challenging task of establishing, within the study area, the taxonomic identity of three wide-ranging morphologically variable and possibly composite taxa;



FIGURE 11. *Eleutherodactylus interorbitalis* from west of the Río Maycoba. Photo by EFE, July 2005.



FIGURE 12. *Craugastor tarahumaraensis* near Mesa del Campanero. Photo by EFE, August 2007.

Lithobates cf. *magnaocularis* (Figure 13), *Aspidoscelis* cf. *costata* (Figure 14), and *Crotalus* cf. *molossus* (Figure 15). Although we took high-resolution photographs of salient features and compared them with species descriptions, relevant literature, and preserved specimens at UAZ, our assessments were often restricted by our inability to collect specimens and correspondingly we could not identify these three taxa to their respective individual species. Thus, our species assignments pertaining to them are tentative, and should be considered as open questions. In all cases, the geographic distributional boundaries of the taxa in question are nebulous and may abut or contact related species. We therefore provide summaries of our observations for each taxon to hopefully stimulate future systematic research.

Lithobates cf. *magnaocularis*

Pantheranid frogs (*Rana pipiens* complex) can demonstrate extraordinary polymorphism (Streicher et al. 2012). We observed conspicuous and variably patterned leopard frogs (Figure 13) during all periods surveyed (April- October) from seasonally dry tropical lowlands along the Río Yaqui through the mesic temperate highlands of the eastern transect boundary in pine-oak forest. Using our regional knowledge in conjunction with the publications of Frost and Bagnara (1974), Platz and Mecham (1979), Platz and Frost (1984), Grismer (2002) and Lemos-Espinal and Smith (2007, 2009b) we determined that five species could possibly occur within the transect: *L. chiricahuensis*, *L. forreri*, *L. lemosespinali*, *L. magnaocularis*, and *L. yavapaiensis*. Of these species, one – *L. forreri* – can be reliably identified by the presence of continuous, unbroken dorsolateral folds. We observed no frogs with this character in the field and our examination of preserved UAZ specimens from the study area failed to reveal its presence.

Lithobates lemosespinali (Smith & Chizar, 2003) is, as described, very similar to *L. chiricahuensis* and is reportedly endemic to southwestern Chihuahua. Lemos-Espinal and Smith (2007) report that it differs from *L. chiricahuensis* “primarily in lacking white-dotted tubercles on the posterior surface of the thighs”. As of this writing, we do not recognize *L. lemosespinali* (Smith & Chizar 2003) as a distinct taxonomic unit primarily on the basis of inadequate sampling and profound polymorphism in *L. chiricahuensis* as demonstrated by Streicher et al. (2012). We await additional research supporting the distinctiveness of *L. lemosespinali*.

Lithobates chiricahuensis is known from Madrean highlands extending discontinuously southwest from southern Arizona across the Sierra Madre Occidental to the Ciudad de Durango, Durango (Streicher et al. 2012). *L. chiricahuensis* is typically distinguished by size and body morph– e.g., “stocky” body proportions (Platz and Mecham 1979; pers. obs.). We encountered no frogs fitting the description of *L. chiricahuensis*. Nonetheless, we consider its occurrence within the study area to be possible based on the proximity of published historical *L. chiricahuensis* populations (Platz and Mecham 1984).

The remaining frogs, *L. magnaocularis* and *L. yavapaiensis* are indistinguishable, in our view, using the diagnostic characters published in Frost and Bagnara

(1974), Platz and Frost (1984), and Lemos-Espinal and Smith (2009a,b). However, molecular evidence consistently indicates their genetic distinctiveness (Zaldivar-Riveron et al. 2004; Hillis and Wilcox 2005; Pfeiler and Markow 2008; Oláh-Hemmings et al. 2010). Further, the results published in Oláh-Hemmings et al. (2010) genetically confirm the presence of *L. magnaocularis* in the Rios Sahuaripa, San Ignacio, Sonora, and Yaqui - historically postulated as *L. yavapaiensis* localities (O'Brien et al. 2008; Rorabaugh 2008; Rorabaugh et al. 2011). We thus conservatively assign all leopard frogs within the MEX 16 transect to *Lithobates cf. magnaocularis*.

Aspidoscelis cf. costata

In his synopsis of the genus *Cnemidophorus* (= *Aspidoscelis*) Edward Cope (1892) stated, “discrimination of the North American species of this genus is the most difficult problem in our herpetology”. Although Cope’s assessment was published over a century ago, an egregious contemporary example of his inference is presently located in central Sonora near the western edge of the MEX 16 transect where the distributions of at least four

taxa within the *Aspidoscelis sexlineatus* species group are possibly contiguous: *A. burti burti*, *A. b. stictogramma*, *A. costata barrancorum*, and *A. c. griseocephala*.

We observed whiptail lizards (Figure 14) in all floristic divisions within the study area from the Rio Yaqui near Tónichi (192 m) to Arroyo Hondo (1,458 m) ca. 2.8 km west of Chihuahua – separated by ca. 100 km by air – and examined UAZ voucher specimens from near Tónichi, (UAZ 38932-38935), Cajón de Onapa (UAZ 38888-38932), and near Nuri (UAZ 38885-38887, UAZ 38936, and UAZ 45676) all labeled as *A. burti*. For each of the specimens examined, the distance between paravertebral stripes ranged from 11-18 granules (dorsal scale rows), well within the reported range of *A. costata* (Duellman and Zweifel 1962) and out of the range for *A. b. burti* and *A. b. stictogramma* (Duellman and Zweifel 1962; Walker and Cordes 2011). However, considering the unresolved evolutionary relationships and geographic status of the *sexlineatus* species group (Reeder et al. 2002) in Sonora, we conservatively assign the specimens to *A. cf. costata*.

We also tentatively assign our field observations to *A. cf. costata* on the basis of color pattern. The individuals



FIGURE 13. Composite image of *Lithobates cf. magnaocularis* from the MEX 16 study area. Photos by EFE, 2004–2008

shown in figure 14 demonstrate the degree of variation we observed within the MEX 16 transect. In general, boldly spotted lizards with obscured dorsal stripes were observed from areas of lower tropical vegetation west of Mesa del Campanero. To the east of Mesa del Campanero in temperate forests and grassland, we observed brightly striped individuals with little or no spotting. In all individuals photographed, we note the presence of widely separated paravertebral stripes often with a comparatively faint and wide mid-dorsal stripe. We did not assess ontogenetic or sexual dimorphism.

Crotalus cf. molossus and C. cf. basiliscus

During the years 2005-2009, we encountered 17 rattlesnakes that we here designate as *Crotalus cf. molossus* (Figure 15). Three taxa are purported to occur in the area: *C. basiliscus*, *C. m. molossus*, and *C. m. nigrescens* (Bogert and Oliver 1945; Price 1980; Schwalbe and Lowe 2000; Campbell and Lamar 2004; Rorabaugh 2008; and Enderson et al. 2009). The first published record of *C. basiliscus* in Sonora is reported by Bogert and Oliver (1945). Although Bogert and Oliver (1945) do not report hybridization between *molossus* and *basiliscus*, they include a summary of morphometric tabulations compiled by Laurence Klauber who stated that in reference to the Álamos specimens, "it is clear that your specimens are closer to *basiliscus* than to *molossus*, although they show some evidence of bridging the gap between the two". Klauber's assessment may infer hybridization, however, Klauber (1956) would later clarify the notion of hybridization with the following statement, "I have given further consideration to the relationship between *C. m. molossus* and *C. b. basiliscus* based on additional specimens of the latter from northern Sinaloa and southern Sonora and have not changed my

previous expressed opinion, that despite certain tendencies of the northern specimens of *C. basiliscus* toward *molossus*, they are a separate species. It will require material from between Guaymas on the north and Guirocoba and Alamos, Sonora, on the south, to demonstrate whether there are any important evidences of intergradation or hybridization between the two."

We are unaware of any published work detailing hybridization between the two, although it is frequently mentioned (e.g., Price 1980; Campbell and Lamar 2004). Clearly, a thorough systematic study is needed and thus, in the absence of additional data, we have referred all specimens in the area to *C. cf. molossus* or *C. cf. basiliscus* and present the following summary of our observations.

We found *C. cf. molossus* in all floristic divisions of the MEX 16 transect from areas of lowland thornscrub to cool mesic pine forest. We observed snakes resembling *C. cf. basiliscus* in lowland thornscrub between Curea and Nuri (Figure 15 – lower right). Although we observed significant variation in *C. cf. molossus*, we found it to be predictively variable and note a trend in color patterns (Figure 15) that may be associated with elevation or geographic distribution. The images in figure 15 are of snakes observed within the transect and depict a color pattern gradient from west-to-east (left-to-right) and north-to-south (top-to-bottom). Individuals of *C. cf. molossus* from west of 109.35° W (ca. 700 m) resemble *C. m. molossus*; east of 109.08° W (ca. 1,335m) resemble *C. m. nigrescens*; south of 28.31° N (ca. 500 m) resemble *C. basiliscus*, and between these areas (ca. 700-1,400 m) *C. cf. molossus* seems to possess composite color patterns of two or more of the taxa in question (*C. m. molossus*, *C. m. nigrescens*, and *C. basiliscus*).



FIGURE 14. Composite image of *Aspidoscelis cf. costata* from the MEX 16 study area. Photos by EFE, 2004–2008

Our observations suggest at least partial ecological segregation of color patterns in the study area. Whether some of the striking variation in color pattern represents intergradation, hybridization, or perhaps the presence of a currently unrecognized taxon remains unclear.

Protected species

A total of 36 species in the Yécora herpetofauna are legally protected by the Mexican government in the Norma

Oficial Mexicana, NOM-059-SEMARNAT-2010 (Diario Oficial de la Federación 2010; Table 1). This includes 15 species with Amenazada (threatened) and 21 species Protegida (Pr, special protection) status. Additional species in the Yécora herpetofauna that are rare or have very limited distributions warrant nomination for protection. These include *Geophis dugesii*, *Phrynosoma ditmarsii*, *Pseudoficimia frontalis*, *Sceloporus slevini*, *Storeria storeroides*, *Sympholis lippiens*, *Tantilla wilcoxi*, and *Tropidodipsas repleta*.



FIGURE 15. *Crotalus cf. molossus* from the MEX 16 study area showing the color pattern gradient from west to east (left-to-right) and north-to-south (top-to-bottom). Snakes are shown in west-east and north-to-south. Photos by Kevin Bonine (upper left), TRV (upper middle - UAZ 57056-PSV) and EFE, 2004–2008.

TABLE 2. Species reaching their northern distributional limit in the MEX 16 Transect

TAXON	SOURCE	LOCALITY - MUNICIPIO
<i>Pseudoeurycea bellii</i>	UAZ 12138	Mesa del Campanero - Municipio de Yécora
<i>Pachymedusa dacnicolor</i>	UAZ 56714-PSV	South of Güisamopa – Municipio de Sahuaripa
<i>Smilisca baudinii</i>	UAZ 45964	Río Yaqui crossing at MEX16 – Municipio de Soyopa
<i>Syrrhophus interorbitalis</i>	UAZ 56549-PSV	East of Yécora - Municipio de Yécora
<i>Lithobates magnaocularis</i>	Frost and Bagnara 1976	Yécora - Municipio de Yécora
<i>Heloderma horridum</i>	UAZ 56579-PSV	Sierra El Dátil - Municipio de Soyopa
<i>Sceloporus nelsoni</i>	UAZ 56713-PSV	Sierra El Dátil - Municipio de Soyopa
<i>Plestiodon parviauriculatus</i>	UAZ 45083	East of Sierra El Chuchupate - Municipio de Yécora
<i>Imantodes gemmistratus</i>	UAZ 56042-PSV	West of Mesa del Campanero - Municipio de Yécora
<i>Leptodeira splendida</i>	UAZ 56548-PSV	East of Yécora - Municipio de Yécora
<i>Pituophis deppei</i>	Smith et al. 2005	West of Yécora - Municipio de Yécora
<i>Pseudoficimia frontalis</i>	UAZ 56368-PSV	East of the Sierra El Dátil - Municipio de Soyopa
<i>Tropidodipsas repleta</i>	MZFC 12057	Sierra El Dátil - Municipio de Soyopa
<i>Micrurus distans</i>	UAZ 56584-PSV	West of Maycoba - Municipio de Yécora

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