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Aspects of the ecology of a distinct population of *Xenosaurus platyceps* from Querétaro, México

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Lizards in the genus *Xenosaurus* (Xenosauridae) show a flattened morphology, which is presumably an adaptation for their crevice-dwelling habits. Despite their general morphological similarities (Ballinger et al., 2000a), there is considerable variation among species and populations in ecological traits, and even populations of nominally the same species (e.g., *X. grandis grandis* and *X. g. agrenon*; Ballinger et al., 1995; Lemos-Espinal et al., 2003a) show variation, sometimes as much as between different species.

Populations of *Xenosaurus* are often geographically isolated (e.g., Pérez Ramos et al., 2000; Nieto Montes de Oca, 2001), and movement appears to be minimal (Lemos-Espinal et al., in press), and thus each population may be relatively isolated genetically and subject to local adaptation. Unfortunately, there are very few studied populations of *Xenosaurus* and in only one species has more than one population been studied (*X. grandis*; Ballinger et al., 1995; Lemos-Espinal et al., 2003a). In order to further our understanding of variation within this genus, we report on the ecology of a distinct population of *X. platyceps* from Querétaro. This is the second population of *X. platyceps* for which we have ecological data (see Lemos-Espinal et al., 1997b for a population of *X. platyceps* from Tamaulipas). These two populations are separated by 280 km. Both populations are found in oak forest, although the Querétaro population is in denser forest than the Tamaulipas population. In addition, the area in which the Querétaro population lives is rockier and on a greater slope than the Tamaulipas population.

The study population was located 5 km North to the town of Tilaco, at Cerro de la Carnpana (Cañada de Acatitlán), Querétaro (21º 10'41.1"N, 99° 10'4.1"W. 1180 m elevation). The vegetation at this site is low density oak forest (*Quercus aristata, Q. castanea, Q. crassipes, Q. laeta, Q. laurina and Q. mexicana*).

Lizards were collected by hand on 31 October 1998, 1 November 1998, 19–21 March 1999, 5–7 April 1999, 7–21 April 2000, 18–20 December 2000. We made several measurements and observations on each captured lizard. While in the field we measured snout-vent length with a clear plastic ruler (SVL; to nearest mm), and body mass with a spring scale (BM; to nearest 0.1 g). In addition, body temperature (T_b; nearest 0.1ºC) was taken with a quick-reading cloacal thermometer immediately upon capture. We also measured air temperature (T_a; shaded therroometer 1 cm above substrate where individual first observed), and substrate temperature (T_s; shaded thermometer touching substrate where individual first observed). We recorded the body position of each lizard (i.e., entirely inside the crevice, just head and front legs out of crevice).

We recorded several characteristics of the crevice in which lizards were found, including the thickness of the crack, the depth of the crevice, the height of the crevice from the ground, and the slope of the crack relative to horizontal ground. We measured the rock in which the crevice was found We noted whether the occupied crevice was found in the open sun, the shade, or in a sun/shade mosaic. We also counted the number of crevices and other potential refuges (e.g., holes) along five 50 m transects randomly located in the study site.

Lizards were collected by hand, humanely sacrificed by intracranial injection of alchohol and preserved shortly after collection (initially in 10% formalin, and finally in 70% ethanol; deposited in the herpetological collection of the Laboratorio de Ecología of the Unidad de Biología, Tecnología y Prototipos). We measured various morphological traits of preserved specimens to assess sexual dimorphism in these structures. We measured head width (HW; at the widest point), head length (HL; from anterior edge of ear to tip of snout), and femur length (FL; from knee to middle of pelvic region) to the nearest 0.01 mm using calipers. Sexual dimorphism in HW, HL, and FL was analyzed using analysis of covariance with SVL as the covariate after log transforming the dependent variables and the covariate (all three variables were significantly influenced by SVL). Unless noted, the slopes in the ANCOVAs were homogeneous and interaction terms removed from the final model.

We also dissected lizards to obtain information on litter size and diets. Diet items were identified to order, and the percent of prey volume for each taxon was calculated for each stomach (volume estimated by volumetric displacement; to nearest mm^3).

Table 1. Mean and Least Squares Mean (LSM) for the body measurements (in mm) of male and female *Xenosaurus platyceps* from a population in Querétaro, México. Means are given ± 1 $s_{\bar{x}}$. See text for abbreviations.

	Male (n = 33)		Female (n = 40)	
	Mean	Least Squares Mean	Mean	Least Squares Mean
SVL	90.7 ± 2.3	–	98.6 ± 1.7	–
logHW	1.282 ± 0.013	1.304 ± 0.002	1.305 ± 0.007	1.290 ± 0.002
logHL	1.307 ± 0.013	1.326 ± 0.004	1.323 ± 0.007	1.308 ± 0.004
logFL	1.299 ± 0.013	1.320 ± 0.003	1.328 ± 0.008	1.311 ± 0.003

Mean SVL (based on field measures) was 97.3 ± 1.6 mm (n = 74; range 52 to 113 mm). The average BM of individuals was 19.6 ± 0.8 9 (n = 74; range 4.0 to 30.0 g). Females had larger mean SVLs than males (table 1; $F_{1,71}$ = 7.82, P = 0.0066). Males had wider heads than females after correcting for body size (table 1; HW: $F_{1,69}$ = 13.70, P = 0.0004). Head width in males grew at a faster rate relative to SVL than did head width in females (logSVL*sex interaction: $F_{1,69}$ = 14.82, P = 0.003; $\text{slope}_{\text{male}}$ = 1.065, $\text{slope}_{\text{female}}$ = 0.864). Males also had longer heads than females after correcting for body size (table 1; HL: $F_{1,70}$ = 9.74, P = 0.0026). Males had larger FLs than females after correcting for body size (table 1; $F_{1,70}$ = 5.92, P = 0.018).

Most *X. platyceps* were completely within their crevice (36 of 78, 46.2%) or with only their head out of the crevice (33 of 78; 42.3%). Six lizards (7.7%) were found with their heads and front legs outside the crevice. Three (3.8%) were found completely out of a crevice.

The majority of *X. platyceps* were found in crevices (60 of 75; 80%); however, 15 individuals were found in holes in the rock (20%). Along transects, we found 7 holes (29.2%) and 17 crevices (70.8%). Lizard use of holes and crevices at the study site did not differ significantly from what was expected based on the availability of holes and crevices as determined by the transects, however, there was a trend to use crevices more often than expected (Yates' Corrected χ_1^2 = 2.72; P = 0.099).

We found lizards in crevices in the shade 38.7% of the time (29 of 75), crevices in the open 58.7% of the time (44 of 75), and in a shade-open mosaic 2.7% of the time (2 of 75).

The thickness of the crevice used or the diameter of the hole used by *X. platyceps* averaged 1.54 ± 0.07 cm (n = 60, range 0.6 to 3.0 cm). The depth of the crevices or holes was 21.5 ± 1.1 cm on average (n = 72, range 7 to 47.0 cm). *Xenosaurus platyceps* individuals used crevices that had a mean height above ground level of 28.6 ± 2.6 cm (n = 75, range 0 to 110 cm).

The larger an individual (SVL), the larger the opening of the crevice in which it was found, however, body size explained very little of the variation in crevice or hole opening size (n = 56, r^2 = 0.065, P = 0.058; thickness = 0.53 + 0.10SVL). No relationship was found between the size of a lizard and the depth of the crevice in which it was seen (n = 68, r^2 = 0.007, P = 0.51). The height of a crevice was not related to the size of the individual living in it (n = 71, r^2 = 0.026, P = 0.18). The size of the rock containing the crevice or hole was not related to the size of the lizard (n = 71, r^2 = 0.023, P = 0.21).

Table 2. Comparisons of mean and least squares mean body temperatures of *Xenosaurus platyceps* as a function of sex, body position, month, and solar insolation. Means are given ± 1 $s_{\bar{x}}$ with n in parentheses.

	Mean
Sex	
Male (33)	20.4 ± 0.5°C
Female (43)	20.7 ± 0.5°C
Body Position	
All inside (36)	18.6 ± 0.5°C
Head out (33)	21.9 ± 0.4°C
Head and front legs out (6)	23.0 ± 0.8°C
Totally out (3)	24.5 ± 1.2°C
Month	
February (11)	17.7 ± 0.3°C
March (25)	17.3 ± 0.1°C
April (24)	23.2 ± 0.3°C
July (7)	24.6 ± 0.3°C
October (6)	21.1 ± 0.3°C
November (5)	24.0 ± 0.4°C
Cover	
Open (44)	20.5 ± 0.4°C
Open/Shade mosaic (2)	20.9 ± 1.9°C
Shade (29)	20.2 ± 0.6°C

Seventy-six individuals were found alone in their crevice (97.4%). One pair (2.6%) was found, and it was a female-neonate pair.

Mean T_b was 20.6 ± 0.4 C (n = 78; range = 16.2 to 26.4 C). Mean T_a was 18.7 ± 0.3 C (n = 78; range = 15.4 to 24.2 C), and mean T_s was 18.8 ± 0.3 C (n = 78; range = 15.6 to 24.2 C). Air temperature and T_s were highly positively correlated (n = 78. r^2 = 0.98, P < 0.0001; $T_s = -0.53 + 1.02T_a$). Body temperature was significantly influenced by both T_a (n = 78, r^2 = 0.62, P < 0.0001; $T_b = 2.23 + 0.98T_a$) and T_s (n = 78, r^2 = 0.65, P < 0.0001; $T_b = 1.01 + 1.04T_s$).

Males and females had similar T_bs (table 2; $F_{1,74}$ = 0.17, P = 0.63). Lizards that were found entirely within the crevice had lower T_bs than lizards with any part of their body outside the crevice and the individuals found completely out of a crevice had the highest T_bs (table 2; Kruskal-Wallis: H_3 = 26.5, P < 0.0001). Body temperatures did not differ between the six months for which data are available (table 2; Kruskal-Wallis: H_5 = 63.3, P < 0.0001). Lizards whose crevices were in the open, open/shade mosaic, and shade did not differ in mean T_b (table 2; Kruskal-Wallis: H_2 = 0.28, P = 0.87).

We used stepwise regression to determine which aspects, if any, of a crevice were related to T_b, T_a, and T_s. Of the four crevice characteristics measured (thickness, height, depth, and rock size), thickness was retained in the regression model for T_s (n = 59, r^2 = 0.071, P = 0.041; T_s = 16.8 + 1.23thickness). For T_a, the size of the crevice or hole opening was retained in the model (n = 59, r^2 = 0.075, P = 0.04; T_a = 16.6 – 1.32thickness). Body temperature was not affected by any of the crevice characteristics.

Table 3. Diet of *Xenosaurus platyceps* from Querétaro, México.

Prey Taxon	Number of Stomachs	Number of Items	Percent of Diet	Total Volume (cm^3)	Percent of Diet by Volume
Araneae	4	4	2.14	0.38	0.60
Insecta					
Coleoptera					
Adults	15	26	13.9	4.73	7.46
Larvae	3	3	1.6	0.61	0.96
Hemiptera					
Larvae	1	1	0.53	0.9	1.42
Isoptera					
Termitidae	1	1	0.53	0.8	1.26
Lepidoptera					
Larvae	16	16	8.55	9.1	14.21
Orthoptera					
Acrididae	66	136	72.73	46.8	73.91

The two smallest females with embryos were 92 mm and 95 mm SVL. Mean litter size was 2.7 ± 0.3 (n = 15, range = 1 to 6). The most common litter size was 3 (7 of 15; 46.7,%). There. was no significant relationship between female SVL and litter size (Spearman's Correlation: n = 15, Z = – 0.551, P = 0.58).

The overall sex ratio was 43 females: 33 males, which is not different from 1:1 (χ_1^2 = 1.32, P = 0.25).

The diet of *X. platyceps* (74 stomachs examined) consisted primarily of insects (table 3). On the basis of the number of items and the volume of items consumed, as well as their frequency of occurrence in stomachs, orthopterans, and in particular Acridids, were by far the most important prey items. Coleopterans and lepidopterans were of secondary importance. Of the 74 stomachs examined, 5 (6.8%) were empty.

Female *Xenosaurus platyceps* in Querétaro were larger than males. This is similar to the other population of *X. platyceps* from Tamaulipas. Given the 1:1 sex ratio, it is unlikely that differential mortality of males and females contributed to sexual dimorphism. Male *X. platyceps* had larger heads than females, as did *X. platyceps* from Tamaulipas. Although the evolutionary origin of sexual dimorphism in this species is not known, evidence from *X. newmanorum* suggests it may be related to intrasexual selection involving male-male aggression (Smith et al., 1997).

It is noteworthy that we observed three individuals of *X. platyceps* completely outside any crevice or hole. In previous studies, no *Xenosaurus* had been observed completely outside their crevice (Ballinger et al., 1995; Lemos-Espinal et al., 1996, 1997b, 1998, 2003a), although we know they must occasionally leave their refuges to move (Lemos-Espinal et al., in press for *X. newmanorum*). Such behavior may be related to movement or it may be related to body temperature or thermoregulation since individuals that were completely outside their crevices or holes had the highest T_b although sample sizes were small.

The vast majority of *X. platyceps* in Querétaro occurred alone, but *X. platyceps* from Tamaulipas show some degree of aggregation (Lemos-Espinal et al., 1997b). Our finding of one fe-

male-neonate pair may be related to parental care (Lemos-Espinal et al., 1997a, b).

Mean T_b of *X. platyceps* in Querétaro is among the lowest observed in the genus, but conspecifics from Tamaulipas had a lower mean T_b (Lemos-Espinal et al., 1997b). These two conspecific populations were similar in their relative independence of T_b from environmental temperatures (Lemos-Espinal et al., 1997b).

Crevice use did not affect T_bs of *X. platyceps* in our study. The nature of the crevices and holes used by *X. platyceps*, or the large rocks the crevices or holes occur in, may limit their usefulness for or impact on thermoregulation (e.g., Huey et al., 1989; Webb and Shine, 1998).

Females in this population of *X. platyceps* appear to mature around 92–95 mm SVL. This is the smallest SVL at maturity among those *Xenosaurus* for which we have data (Ballinger et al., 2000b; Lemos-Espinal et al., 2003a). In particular, maturity occurs at a substantially smaller SVL (by 6–9 mm) than in the population of *X. platyceps* in Tamaulipas (Ballinger et al., 2000b). Additional study is necessary to determine if these differences are the result of differences in the proximate environment or reflect genetic differences in these populations.

Mean litter size for this population was very similar to the litter sizes of most other *Xenosaurus* (Ballinger et al., 2000b; Lemos-Espinal et al., 2003a).

The diet of *X. platyceps* from Querétaro is similar to the diet of *X. platyceps* in Tamaulipas, as well as the other *Xenosaurus* for which we have diets (Ballinger et al., 1995; Lemos-Espinal et al., 2003b).

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