In the following study, the authors report the use of shelters and seasonal activity in a population of the the whiptail lizard *Aspidoscelis costata* in an area of central Mexico. The natural history information they obtained can be used for evaluating future conservation measures for this species. Pictured here is an adult male of this teiid, photographed as it was searching for food. © Víctor Mundo-Hernández

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Seasonal activity and use of shelters in a population of *Aspidoscelis costata* (Squamata: Teiidae) in central Mexico

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Abstract: We describe the seasonal activity and use of shelters in a population of *Aspidoscelis costata* in an area of central Mexico. We visited this locality each month from July of 2013 to April of 2015, and during each visit observed the frequency in which the shelters were used and the microhabitats where they were located. We recorded the climatic conditions (dry or rain), use of the shelters (temporary or permanent), and their respective position (sun or shade). The lizards chose to use temporary shelters and those exposed to the sun more frequently (63% and 53% respectely, of 90 lizards), with similar frequencies shown during the dry and rainy seasons. These results suggest that *A. costata* chooses refuges with characteristics that allow them to maximize such resources as the availability of sunlight, access to food, and protection from predators. Nonetheless, we believe these results should be reexamined in future studies, especially those conducted in different locations.

Key Words: Activity, habitat preferences, lizards, seasonality, weather conditions

Resumen: Describimos la actividad estacional y el uso de refugios en una población de *Aspidoscelis costata* en un área del centro de México. Visitamos esta localidad cada mes desde julio de 2013 hasta abril de 2015, y durante cada visita observamos la frecuencia con que se utilizaron los refugios y los microhábitats donde se encontraban. Se registraron las condiciones climáticas (seco o lluvioso), el uso de los refugios (temporales o permanentes) y su respectiva posición (sol o sombra). Los lagartos optaron por utilizar refugios temporales y los expuestos al sol con más frecuencia (63% y 53% respectivamente, de 90 lagartos), con frecuencias similares mostradas durante las temporadas seca y lluviosa. Estos resultados sugieren que *A. costata* elige refugios con características que les permitan maximizar tales recursos como la disponibilidad de luz solar, el acceso a los alimentos y la protección contra los depredadores. Sin embargo, creemos que estos resultados deben ser reexaminados en futuros estudios, especialmente aquellos realizados en diferentes lugares.

Palabras Claves: Actividad, condiciones climáticas, estacionalidad, lagartijas, preferencias de hábitat

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INTRODUCTION

In a study on diversity and endemism of the Mexican herpetofauna, among the reptiles the family Teiidae ranked third in the number of records collected, and when comparing the genera, *Aspidoscelis* ranked second in the number of records for reptiles (Ochoa-Ochoa and Flores-Villela, 2006). *Aspidoscelis costata* is endemic to Mexico and has been considered a species subject to special protection by SEMARNAT (2010); additionally, Wilson et al. (2013) assessed this taxon an Environmental Vulnerability Score of 11, which places it in the medium vulnerability category. Because the conservation status of this species eventually might come to be regarded as threatened, additional studies on its behavior, including its thermal requirements, available sites for hibernation and nesting, shelters, predators, and prey availability, would be useful for future conservation assessments (Aguilar-Moreno et al., 2010, Andersson et al., 2010; Santos et al., 2011; Dubey et al., 2012; Allison, 2014).

Animals often avoid predators by using shelters in which they reduce the likelihood of being caught (Creesman and Garay, 2009). Lizards use rocks, bushes, logs, cracks, and other areas with restricted access as shelters, in an effort to defend themselves against predators (Cooper, 2003; Whiting et al., 2003). Because lizards spend much of their time inside shelters, their choice of shelters is relevant to their survival (Martin and Salvador, 1996). Thus, the ability to identify and characterize these sites is a fundamental step in the conservation of lizard populations, as it would allow for their protection and eventually facilitate the persistence and recovery of a species (Heinricks et al., 2010).

In this study we analyzed the choice of microhabitats and refuges used by *A. costata*. Accordingly, we believe that our efforts can be used to establish future management strategies and conservation protocols that would promote the maintenance of this species, as our study is the first to describe the use of shelters in this species.

MATERIALS AND METHODS

Study Area

The study area is located in central Mexico (18°48'53.20" N, 99°37'06.16"W; WGS 84; elev. 1,655 m; Fig. 1), within the Río Balsas physiographic region; the area consists of a mixture of crop fields and deciduous forest, along with shrubs as secondary vegetation (INEGI, 2009). The soil in this region is Leptosol, with low rocks, and the geographic and physiographic location and climate favor the establishment of animal and plant communities on sites that show potential for management and protection (Luna et al., 2007). The climate is semi-warm (mean annual temperature 28°C) and sub-humid (with 1,000 to 1,100 mm of annual rainfall), with the rains occurring mostly during the summer months (INEGI, 2009) (Fig. 2).

Shelters and Microhabitat

We recorded the use of shelters by *Aspidoscelis costata* each month from July 2013 to April 2015 by direct observation; we walked trails from 1000 to 1500 h. In each trial, we searched for individuals that were active within 10 m of the observer (Cooper, 1997; Martín and López, 2000). During our observations, we avoided traversing the same areas to avoid repeated counts of the same individuals (Martín and López, 1999). Each time an individual was observed, we recorded the type of shelter the lizard used for hiding. In some cases, however, the lizards continued

with their activities and showed no obvious response to the presence of the observer (Cooper, 1997; Martín and López, 2000). In such cases, we recorded the lizards as not using any shelter (Whiting et al., 2003). We categorized each of the shelters as in the shade or sun, and the relative position of the shelter as to the amount of sunlight it received (Villavicencio et al., 2012). We also categorized the shelters used by the lizards as temporary or permanent, in relation to the amount of time spent there by the lizards. We considered the temporary shelters as those located under bushes and rocks, and the permanent shelters as those located in burrows in the ground.

We grouped the data for the climatic seasons as dry (December to May) and rainy (June to November) and applied a one-way ANOVA to compare the use of the shelters to the respective seasons. We made a logarithmic transformation of the variables to meet the criteria of normality and homoscedasticity prior to the analysis. We conducted all the analyses with Statgraphics Plus 5.0 for Windows, and report the means as ± 1 SD.

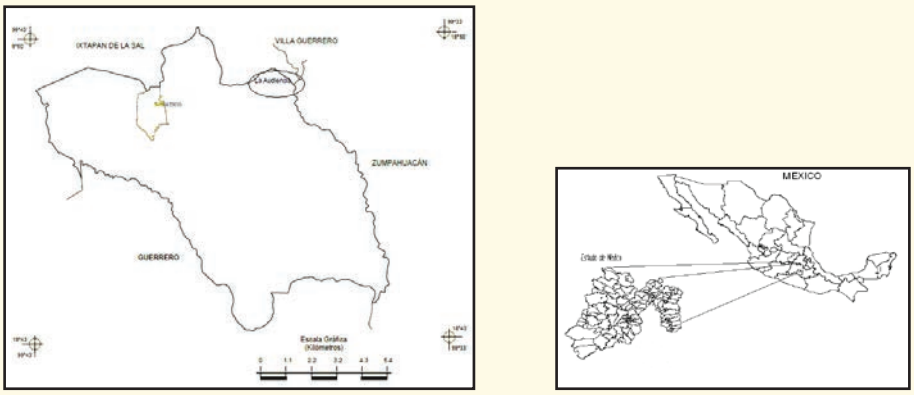

Fig. 1. Location of the study site for *Aspidoscelis costata* in central Mexico (modified from INEGI, 2009).

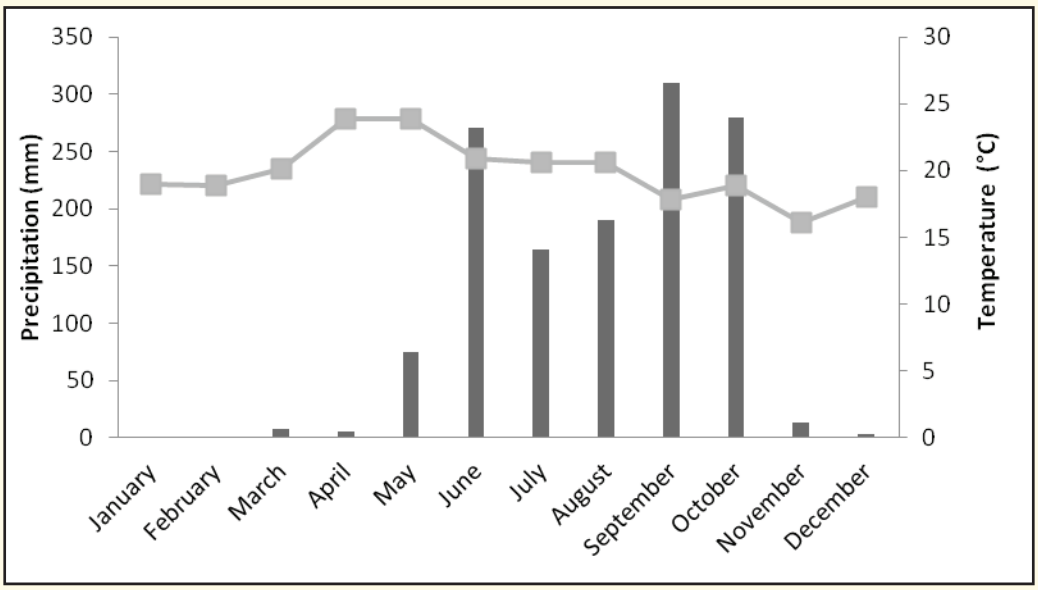

Fig. 2. Monthly mean temperatures (lines) and rainfall (bars) at the study site for *Aspidoscelis costata* in central Mexico, during the two years of the study (INEGI, 2014).

RESULTS

During the 22 months of sampling for *Aspidoscelis costata* we recorded a total of 90 lizards, 48 during the rainy season and 42 during the dry season. We found that *A. costata* most frequently used temporary shelters (53%), as opposed to permanent ones (19%; $\bar{x}$ = 13.0 ± 7.3598, ANOVA-F_{87} = 16.0, $P < 0.01$). Rocks most often were used as temporary shelters (38.8%), followed by bushes (14.4%). Burrows were used by 19% of the lizards. When individual lizards were observed, 29% remained motionless and did not seek shelter.

We found that lizards used shelters located with direct exposure to the sun significantly more often than those located in the shade (63 and 37%, respectively; $\bar{x}$ = 56.0 ± 15. 5172, ANOVA-F_{89} =14.4, $P < 0.01$).

The frequency in which lizards were recorded was similar between rainy and dry seasons across both years of sampling (dry: $\bar{x}$ = 4.9 ± 1.9 (monthly), ANOVA-F_{88} = 2.4, $P > 0.05$; rainy: $\bar{x}$ = 33.3 ± 6.5, ANOVA-F_{88} = 0.6, $P > 0.05$).

DISCUSSION

Based on our results, during the annual activity cycle of *Aspidoscelis costata* rocks were the primary shelter used by these lizards at our study site in central Mexico. The use of rocks as refuges is a common behavior seen in the genus *Aspidoscelis* (Mesquita and Colli, 2003; Pianka and Vitt, 2003). Although morphologically *A. costata* appears to be adapted to horizontal surfaces where its locomotion is more effective, this species also requires rocky microhabitats and refuges with favorable thermal conditions that are less accessible to detection by predators (Kearney, 2002). The use of rocks as refuges provides areas of high conductivity and thermal stability, which offer ectotherms from open areas the necessary conditions for thermoregulation (Cooper, 1999; Sabo, 2003; Whiting et al., 2003), except for the coldest months when individuals of *A. costata* were not seen because they were in hibernation.

Although a greater abundance of individuals of *A. costata* has been observed during the dry season (VMH, pers. observ.), we found no significant differences in abundance between the dry and rainy seasons during our two years of sampling. In central Mexico, the habitat of *A. costata* generally experiences a warmer and more seasonally predictable dry season, as compared to the amount of rainfall occurring in forested habitats at higher elevations. During the daylight hours, the dry season offers better thermal conditions for ectotherms, compared to the rainy season; however, the similarity in the use of shelters by *A. costata* during both seasons suggests that the thermal or water requirements are not the primary stress factors for *A. costata* at the study site. Perhaps other factors, such as the availability of food or predation, may be driving the use of shelters (Rivera-Vélez and Lewis, 1994).

Several studies have concluded that the main causes associated with the differential use of microhabitats in lizards are related to feeding and the detection of predators (Rocha, 1991; Grover, 1996; and Clóvis and Verrastro, 2008). Our results suggest a preference for shelters that provide access to sunlight, as well as with enough visibility to avoid predators (Belliure et al., 1996; Martín and López, 1999). Predation likely is the most important factor that influences the pattern of activity and selection of shelters by *A. costata* (Angert et al., 2002; Pal et al., 2010), but experiments to test this hypothesis are necessary to evaluate the possibility of other factors that might influence the activity of these lizards.

In addition, antipredatory strategies in sunny microhabitats involve the ability of lizards to quickly move to shelters. This ability may be associated to the characteristics of active foraging and escape shown by members of the genus *Aspidoscelis* (Pianka and Vitt, 2003). Their activity and decisions to escape safely depend on the types of shelters being used (Martín, 2002; Mundo-Hernández, 2010).

Consequently, our results show the need for continued studies on habitat use, using different individuals and including external variables, in addition to considering situations that might reflect different behaviors in individuals. In summary, although our results show that *A. costata* has certain preferences for shelters and specific microhabitats, it is essential to consider all the sites described are important to the activities of individuals of this species.

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Literature Cited

Aguilar-Moreno, M. F. J. Rodríguez-Romero, A. Aragón-Martínez, J. A. Muñoz-Manzano, G. Granados-González, and O. Hernández-Gallegos. 2010. Dimorfismo sexual de *Aspidoscelis costata costata* (Squamata: Teiidae) en el sur del Estado de México, México. Revista Chilena de Historia Natural 83: 585–592.

Allison, F. K. 2014. Landscape- and Micro-scale Habitat Selection by Greater Short-horned Lizards. Unpublished MSc. thesis, University of Alberta, Alberta, Canada.

Andersson, M., A. Krockenberger, and L. Schwarzkopf. 2010. Experimental manipulation reveals the importance of refuge habitat temperature selected by lizards. Austral Ecology 35: 294–299.

Angert, A. L., Hutchison, D., Glossip, D., and Losos, J. 2002. Microhabitat use and thermal biology of the collared lizard (*Crotaphytus collaris collaris*) and the fence lizard (*Sceloporus undulatus hyacinthinus*) in Missouri Glades. Journal of Herpetology 36: 23–29.

Belliure, J., L. M. Carrascal, and J. A. Díaz. 1996. Covariation of thermal biology and foraging mode in two Mediterranean lacertid lizards. *Ecology* 77: 1,163–1,173.

Clóvis S. B., and L. Verrastro. 2008. Annual activity of the lizard *Liolaemus occipitalis* (Squamata, Liolaemidae) in the coastal sand dunes of southern Brazil. Iheringia 98: 156–160.

Cooper, W. E., Jr. 1997. Escape by a refuging prey, the Broad-headed Skink (*Eumeces laticeps*). Canadian Journal of Zoology 75: 943–947.

Cooper, W. E., Jr. 1999. Tradeoffs between courtship, fighting, and antipredatory behaviour by a lizard, *Eumeces laticeps*. Behavior Ecology Sociobiology 47: 54–59.

Cooper, E. W. Jr. 2003. Sexual dimorphism in distance from cover but not escape behavior by the Keeled Earless Lizard *Holbrookia propinqua*. Journal of Herpetology 37: 374–378.

Cressman, R., and J. Garay. 2009. A predator-prey refuge system: evolutionary stability in ecological systems. Theoretical Population Biology 76: 248–257.

Dubey, S., B. Croak, D. Pike, J. Webb, and R. Shine, R. 2012. Phylogeography and dispersal in the Velvet Gecko (*Oedura lesuerii*), and potential implications for conservation of an endangered snake (*Hoplocephalus bungaroides*). BMC Evolutionary Biology 12: 67.

Grover, M. C. 1996. Microhabitat use and thermal ecology of two narrowly sympatric *Sceloporus* (Phrynosomatidae) lizards. Journal of Herpetology 30: 152–160.

Heinricks, J. A., Bender, D. J., Gummer, D. L., and N. H. Schumaker. 2010. Assessing critical habitat: evaluating the relative contribution of habitats to population persistence. Biological Conservation 143: 2,228–2,237.

INEGI (Instituto Nacional de Estadística y Geografía). 2009. (www.inegi.gob.mx/geo/default.aspx?c=124ye=15; accessed 7 February 2015).

Kearney, M. 2002. Hot rocks and much too-hot-rocks: seasonal patterns or retreat site selection by a nocturnal ectotherm. Journal of Thermal Biology 27: 205–218

Luna, I., J. J., Morrone, J. J., and D. Espinosa, D. (Eds.). 2007. Biodiversidad de la Faja Volcánica Transmexicana, Universidad Nacional Autzeonoma de México, México, D.F., Mexico.

Martín, J. 2002. Evolución de estrategias antidepredatorias en reptiles. Pp. 471–478 *In* M. Soler (Ed.), Evolución: La base de la Biología. Proyecto Sur de Ediciones, S.L., Granada, Spain.

Martín, J., and P. López, P. 1999. Nuptial coloration and mate guarding affect escape decisions of male lizards *Psammodromus algirus*. Ethology 105: 439–447.

Martín, J., and P. López, P. 2000. Costs of refuge use affect escape decisions of Iberian Rock Lizards *Lacerta monticola*. Ethology 106: 483–492.

Martín, J., and A. Salvador. 1996. Microhabitat selection by the Iberian Rock Lizard *Lacerta monticola*: effects on density and spatial distribution of individuals. Biological Conservation 79: 303–307.

Mesquita, D.O., and G. R. Colli. 2003. Geographical variation in the ecology of populations of some Brazilian species of *Cnemidophorus* (Squamata, Teiidae). Copeia 2003: 285–298.

Mundo-Hernández, V. 2010. Distancias de Escape de *Aspidoscelis costata costata* (Squamata: Teiidae). Unpublished MSc. thesis, Universidad Autónoma del Estado de México, México, D.F., Mexico.

Ochoa-Ochoa, L. M., and O. Flores-Villela. 2006. Áreas de diversidad y endemismo de la herpetofauna mexicana. Comisión Nacional para el Conocimiento y Uso de la Biodiversidad and Universidad Nacional Autónoma de México, México. D.F., Mexico.

Pal, A., M. M. Swain, and S. Rath. 2010. Observations on microhabitat use and activity patterns in *Sitana ponticeriana* (Sauria: Agamidae). Russian Journal of Herpetology. 17: 22–30.

Pérez-Almazán, C., V. Mundo-Hernández, N. L. Manríquez-Morán, M. Á. Balderas-Plata., and X. Antonio-Némiga. 2015. Primer reporte de conducta gregaria en el género *Aspidoscelis*. BIOCYT Biología, Ciencia y Tecnología 8: 540–544.

Pianka, E. R., and L. J. Vitt. 2003. Lizards, Windows to Evolution of Diversity. University of California Press, Berkley, California, United States.

Punzo, F. 2007. Sprint speed and degree of wariness in two populations of whiptail lizards (*Aspidoscelis tesselata*) (Squamata Teiidae). Ethology Ecology and Evolution 19: 159–169.

Rivera-Vélez, N. and A. R. Lewis. 1994. Threshold temperatures and the thermal cycle of a heliothermic lizard. Journal of Herpetology 28: 1–6.

Rocha, C. F. 1991. Composicão do habitat e uso do espaco por *Liolaemus lutzae* (Sauria: Iguanidae) em uma área de Restinga. Revista Brasileira de Biologia 51: 839–845.

Rubio-Blanco, T. 2010. Termorregulación y actividad en la lagartija *Aspidoscelis costata costata* (Squamata: Teiidae). Unpublished MSc. thesis, Universidad Autónoma del Estado de México, México, D.F., Mexico.

Sabo, J. L. 2003. Hot rocks or no hot rocks: overnight retreat availability and selection by a diurnal lizard. Oecologia 136: 329–335.

Santos, X., M. Feriche, R. Leon, A. Filippakopoulou, M. Vidal-Garcia, G. A. Llorente, and J. M. Pleguezuelos. 2011. Tail breakage frequency as an indicator of predation risk for the aquatic snake *Natrix maura*. Amphibia-Reptilia 32: 375–383.

SEMARNAT (Secretaría de Medio Ambiente y Recursos Naturales). 2010. Norma Oficial Mexicana NOM-059-SEMARNAT-2010, Protección ambiental-Especies nativas de México de flora y fauna silvestres-Categorías de riesgo y especificaciones para su inclusión, exclusión o cambio-Lista de especies en riesgo. Diario Oficial de la Federación, 30 de diciembre de 2010, Ciudad de México, Mexico.

Villavicencio, J. H., J. C. Acosta, M. G. Blanco, and J. A. Marinero. 2012. Ecología térmica de la lagartija endémica *Liolaemus eleodori* (Iguania: Liolaemidae) en el Parque Nacional San Guillermo, San Juan, Argentina. Multequina 21: 17–23.

Whiting, M. J., P. S. Lailvaux, L. T. Reaney, and M. Wymann. 2003. To run or hide? Age-dependent escape behaviour in the Common Flat Lizard (*Platysaurus intermedius wilhelmi*). Journal of Zoology 260: 123–128.

Wilson, L. D., V. Mata-Silva, and J. D. Johnson. 2013. A conservation reassessment of the reptiles of Mexico based on the EVS measure. Contribution to Special Mexico Issue. Amphibian & Reptile Conservation 7: 1–47.

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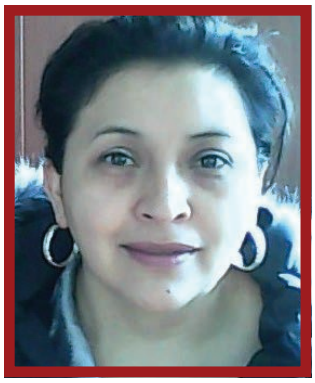

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