

Spatial-Temporal Activity Patterns of the Mexican Plateau Horned Lizard in a Natural Protected Area

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ABSTRACT.—Lizard activity patterns are restricted by both intrinsic and extrinsic variables. The Mexican Plateau Horned Lizard (*Phrynosoma orbiculare*) is endemic to México and an ambush forager and viviparous species that becomes dormant during the cooler months. The objective of this study was to determine the spatiotemporal activity patterns of *P. orbiculare* and the environmental conditions related to its occurrence in the natural protected area Statal Park Sierra Morelos, State of Mexico, México. We conducted samplings during 2018 and 2019. We assessed temporal activity patterns with Watson's U^2 test to determine differences in activity hours between age classes, sexes, and seasons, and we evaluated spatial activity patterns through a hotspot analysis. We conducted a logistic regression model by using landsat 8 bands and indices as independent variables. Differences in temporal activity patterns (activity timing) were detected between age classes and seasons (in the juvenile group) but not between sexes. Within the natural protected area, *P. orbiculare* aggregated in solar glades. There is an important contribution of ultrablue and blue landsat bands to *P. orbiculare* occurrence. Differences in activity between age classes could be related to the heat acquisition rate of smaller individuals; meanwhile, no differences between sexes suggests that the thermal optima of females are similar to male optima. Hotspot analysis and the distribution model reveal that *P. orbiculare* appears on the windward slope where sunrise occurs. Solar glades are important for the species occurrence and should be protected in the studied area. These data allow future monitoring studies to help prevent population declines and illegal extraction.

The activity patterns of lizards (commonly studied through spatial distribution, activity windows, and home ranges) are related to abiotic and biotic factors that can be classified under environmental, ecological, or intrinsic variables. Environmental factors include temperature (Bergallo and Duarte-Rocha, 1993; Huang et al., 2020), humidity (Lorenzon et al., 1999; Treilbts et al., 2016), light (Frankenberg and Werner, 1979; Middendorf and Simon, 1988; Hiroiuki-Oda et al., 2020), and vegetation type (Kacolis et al., 2010). Ecological factors include prey availability (Gordon et al., 2010) and predation risk (Martín et al., 2009). Lastly, intrinsic variables include sex (Wone and Beauchamp, 2003; Moeller et al., 2005), age or body size (Aragón et al., 2004; Herczeg et al., 2007), and foraging mode (Cooper et al., 2001).

The *Phrynosoma* genus consists of 17 Horned Lizard species separated into four well-differentiated clades (Nieto-Montes de Oca et al., 2014), of which all are ambush predators (Vitt and Pianka, 2003). These species have a dormancy period during the cool months in temperate zones (Wone and Beauchamp, 2003; Mook et al., 2017) and in subtropical zones (Gómez Benítez, pers. obs.). Therefore, these lizards can be considered low-active species throughout the year, especially during lethargy months, in comparison to other squamate reptiles. Additionally, the dormancy period is not exclusive to adult *Phrynosoma*, as this behavior has been noted in hatchlings as well (Mook et al., 2017).

Seasonal variation in environmental conditions is a well-studied phenomenon that affects the activity patterns of *Phrynosoma* species. Parker (1971) reported a change in the

activity pattern of *Phrynosoma solare* because of season, with activity being greater later in the morning during the cool months and early in the morning during warm months. Seasonal variation was also documented in *Phrynosoma platyrhinos* (Pianka and Parker, 1975) as activity was unimodal from March to May and bimodal during the remaining months in which lizards were active. The same change was observed in *Phrynosoma mcallii* (Wone and Beauchamp, 2003) between spring (almost unimodal) and summer (bimodal, avoiding being active at midday). These differences in activity patterns can occur differentially between age classes as in *Phrynosoma douglassi*, in which adults did not modify activity patterns but juveniles did, avoiding the hottest hours of the day (Guyer and Linder, 1985).

Previous studies concerning spatial activity patterns of *Phrynosoma* have focused on the species' home range and individual movements. In *P. mcallii* (Wone and Beauchamp, 2003) and *P. solare* (Baharav, 1975), males travel longer distances and have larger home ranges than females. Aside from sexual differences in movement patterns, seasonal variation has been observed in activity patterns, such as in *Phrynosoma cornutum* in which home range size was maximal in June just before the dormancy period, which lasts from September to March, during which movement was minimal (Fair and Henke, 1999).

Despite substantial data on activity patterns in the *Phrynosoma* genus, there is currently a paucity of data concerning the environmental conditions related to *P. orbiculare* activity. Therefore, this study aims to determine the variation in spatial-temporal activity patterns of *P. orbiculare* between seasons, sexes, and age classes, as well as evaluate the relationship between the used areas and independent environmental variables.

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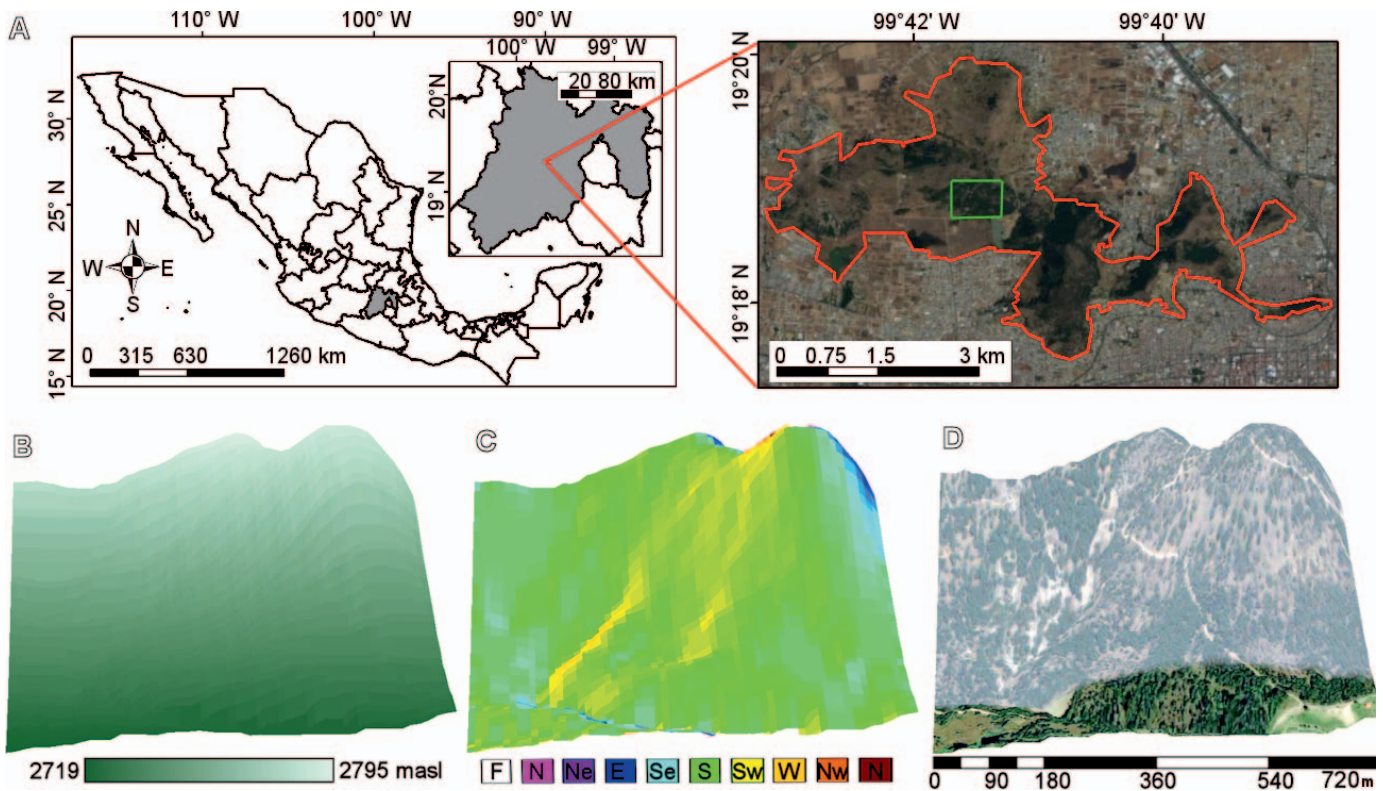


FIG. 1. Statal Park Sierra Morelos, Toluca de Lerdo and Zinacantepec, State of Mexico, México (A). Red line contours the natural protected area, and green rectangle shows the specific study area elevation of SPSM from 2,719 to 2,795 masl (B); aspect where F means flat, N north, Ne northeast, E east, Se south east, Sw south west, W west, and Nw north west (C); vegetation from SPSM (D), scale of the studied area is presented.

MATERIAL AND METHODS

Study area.—State Park Sierra Morelos (SPSM) is a natural protected area located in the municipalities of Toluca de Lerdo and Zinacantepec ($19^{\circ}20'00''\text{N}$ – $19^{\circ}17'47''\text{N}$, $99^{\circ}39'00''\text{W}$ – $99^{\circ}43'25''\text{W}$, WGS84; ~2,700 meters above sea level [masl]), State of Mexico, México, that is surrounded by urban human settlements (Fig. 1). The climate is described as tempered subhumid with summer rains (Cwb Köppen climate classification), and the area shows well-demarcated seasons. Currently, more than 50% of the SPSM territory has undergone anthropogenic disturbance through the erection of building structures. However, the samplings were carried out only in the preserved undisturbed area. The arboreal stratum is mainly formed by *Eucalyptus* (planted as part of a reforestation program) and *Pinus* species; the herbaceous stratum consists of bunch-grass microhabitat that individuals of *P. orbicularis* use as perches and for shelter (Fig. 1). Several recreational activities are performed in SPSM, and illegal extraction of wood and animals, including adult individuals of *P. orbicularis*, by the metropolitan area inhabitants has been noted (Gómez Benítez, pers. obs.).

Study species.—*Phrynosoma orbicularis* is a Horned Lizard endemic to México, and its distribution in central Mexico includes the State of Mexico, Puebla, and Hidalgo (Méndez-de la Cruz et al., 2003). Mating season occurs from May to August, gestation occurs throughout autumn and winter, and hatchlings first appear in spring (Sherbrooke, 2003; Suárez-Rodríguez et al., 2018). Previous observations of the study population suggest that *P. orbicularis* become dormant during the same period in which females are pregnant.

Data collection.—We conducted sampling from May 2018 to April 2019 with monthly samples during spring, summer, and

midautumn, and weekly samples during the second half of autumn and winter due the lower availability of active individuals. We collected *P. orbicularis* individuals by hand ($n = 327$), sexed them by evaluating the size of postanal scales (Sherbrooke, 2003), measured snout–vent length (SVL), and estimated the age using SVL (methods assessed by skeletochronology by Hernández-Navarrete, 2018). Geographical coordinates and time of capture were recorded for each individual, and lizards were released at the point of capture.

Temporal activity patterns.—We used circular statistics for activity pattern analysis. We tested differences in mean vector (μ), considering the circular standard deviation (SD), between season, age classes, and sexes. Comparisons in sexes and seasons were computed separately for adult and juvenile-offspring (nonmature) categories. Because the data did not achieve the Von Mises distribution nor were evenly distributed around the circle, according to Rao's spacing test, comparative procedures were conducted with the nonparametric Watson's U^2 test, which assess if two samples came from the same population or from two populations having the same direction, and searches for differences between the two cumulative relative frequency distributions (Zar, 2010). Statistical analyses were performed using Oriana 4.02, Kovach computing services, at $\alpha = 0.05$ (Zar, 2010).

Spatial activity patterns.—We conducted a hotspot analysis with the Getis*Ord statistics on a fishnet (each quadrant measures 25×25 m to maintain consistent resolution with landsat data) spatially joined to the geographical coordinates of the sightings to identify aggregation areas. Getis*Ord statistics identify entities with high values surrounded by other similar entities; an entity with a high number of events (species occurrence) could be interesting but is not necessarily significant for the species

occurrence or aggregation. A fixed distance band for the analysis was calculated using Euclidean distance, ensuring that every feature has at least one neighbor for each season, age class, and sex by using the follow equation:

$$D = \sqrt{[(x1 - x2) * 2 + (y1 - y2) * 2]}$$

where $x1$ and $y1$ are coordinates for point A, $x2$ and $y2$ are coordinates for point B, and D is the distance between points A and B.

We conducted this analysis for each season, age class, and sex within ArcMap from ArcGis 10.5, Esri.

Environmental conditions and Phrynosoma orbiculare occurrence.—We carried out binomial logistic regression (Arntzen, 2006) and species distribution model prediction using the maximum likelihood method for each season, with geographical coordinates (indicator of species presence recorded) as dependent variables, and satellite imagery and indices corresponding to the seasons during which the study was conducted as explicative independent variables with the software TerrSet 18.31, Idrisi. Because of the low number of observations resulting from transforming the *P. orbiculare* observation points from autumn and winter to Boolean raster format, the number of observations was too low for logistic regression, so we carried out the analysis with all of the data from both seasons and two sets of the independent variable representatives for autumn and winter. Landsat bands were transformed to reflectance with a dark-object subtraction reflectance correction, and thermal bands were converted to at-satellite brightness temperature (Chavez, 1996). We assessed the quality of the satellite bands through the quality assessment band with respect to the degree of cloudiness, snow, cloud shadow, atmospheric opacity, or sensor quality. Because of the high quality achieved by the used bands (100% in all the quality categories), the use of a quality mask for corrections was not needed. We conducted a linear regression between independent variables with each other and with the dependent variable to eliminate related independent variables and to ordinate the order of the variables (the independent variables most correlated with the dependent variable goes first) for the logistic regression analysis. Selected variables in order were as follows: shadow index, band 2 (blue), band 1 (ultrablue), band 5 (near infrared), band 6 (short wave infrared), band 10 (thermal band), and Normalized Difference Moisture Index. We tested the model fit with Pseudo R^2 and relative operating characteristic (ROC) statistics. Pseudo R^2 values greater than 0.2 and ROC greater than 0.5 indicate a good fit (Clark and Hosking, 1986). The following equation was used for the logistic regression:

$$\ln\left(\frac{P}{1-P}\right) = b_0 + b_1 * x_1 + b_2 * x_2 \dots b_k * x_k + \text{error_term}$$

where P is the probability that the dependent variable is 1, x is the independent variable, and b is the estimated parameter (coefficient of the independent variable).

An error term represents the margin of error within a statistical model and refers to the sum of the deviations within the regression line of the residuals.

RESULTS

Temporal activity patterns.—A mean vector comparison between age classes (Fig. 2A) reveals differences in temporal activity patterns between adults and nonmature individuals (adults vs. juveniles: $U^2 = 0.265$, $P < 0.020$; adults vs. offspring: $U^2 = 0.401$, P

TABLE 1. Median angle and circular standard deviation of *Phrynosoma orbiculare* activity patterns in the State Park Sierra Morelos, Toluca de Lerdo and Zinacantepec, State of Mexico, México. Values are presented in units of hours.

Parameter	μ	SD
Offspring	14:25	01:46
Juveniles	14:07	01:39
Adults	13:29	01:46
Males (adults)	13:30	01:54
Females (adults)	13:29	01:38
Males (JO ^a)	14:21	01:38
Females (JO)	14:09	01:42
Spring (adults)	13:31	01:48
Summer (adults)	14:03	01:52
Autumn (adults)	13:25	01:36
Winter (adults)	14:41	01:19
Spring (JO)	14:30	01:40
Summer (JO)	14:19	01:42
Autumn (JO)	13:24	01:18
Winter (JO)	13:28	01:30

^a JO = juvenile offspring.

< 0.001; Fig. 2; Table 1), but no differences between juveniles and offspring were recorded ($U^2 = 0.090$, $0.500 > P > 0.200$). There were no difference between sexes (Fig. 2B,C) in adults ($U^2 = 0.095$, $0.500 > P > 0.200$) or juvenile-offspring ($U^2 = 0.121$, $0.200 > P > 0.100$). Differences in activity pattern by seasons (Fig. 2D) were not observed from comparisons between adults (spring vs. summer: $U^2 = 0.052$, $P > 0.500$; spring vs. autumn: $U^2 = 0.100$, $0.500 > P > 0.200$; spring vs. winter: $U^2 = 0.134$, $0.200 > P > 0.100$; summer vs. autumn: $U^2 = 0.104$, $0.500 > P > 0.200$, summer vs. winter: $U^2 = 0.134$, $0.200 > P > 0.100$; autumn vs. winter: $U^2 = 0.142$, $0.200 > P > 0.100$), but in nonmature individuals (Fig. 2E), there were some differences (spring vs. summer: $U^2 = 0.164$, $0.100 > P > 0.050$; spring vs. autumn: $U^2 = 0.309$, $P < 0.005$; summer vs. autumn: $U^2 = 0.315$, $P < 0.005$). Winter comparisons within the juvenile-offspring category were disregarded because of the low number of individuals.

Spatial activity patterns.—Within the SPSM, *P. orbiculare* becomes aggregated in the south face at sunlight glades independently of age (Fig. 3A), sex (Fig. 3B), or season (Fig. 3C). Nevertheless, an area between the principal glades (site 2, between 1 and 3; Fig. 3) was occupied by offspring with 95% significance and by juveniles with 90% significance, but this area is not significant for adults. The same area was significant during spring and summer but not in the cooler months. There are no coldspots (clusters with low values) at any significance level in any category (Fig. 3).

Environmental conditions and Phrynosoma orbiculare occurrence.—The descriptive variables that have a greater relationship with the presence of *P. orbiculare* are band 1 (ultrablue) that has a negative effect in spring, and band 2 (blue) has a positive effect on summer and autumn/winter (Table 2). The band with the lowest ratio was thermal infrared 10. The regression models for each season had a good fit according to their Pseudo R^2 and ROC (Table 2). The potential distribution model obtained shows that the maximum probability of finding *P. orbiculare* is reduced through the seasons (Table 2) as well as the high probability sites (Fig. 4).

DISCUSSION

Activity pattern differences between age classes suggest that, before reaching sexual maturity, individuals opt for a tigno-

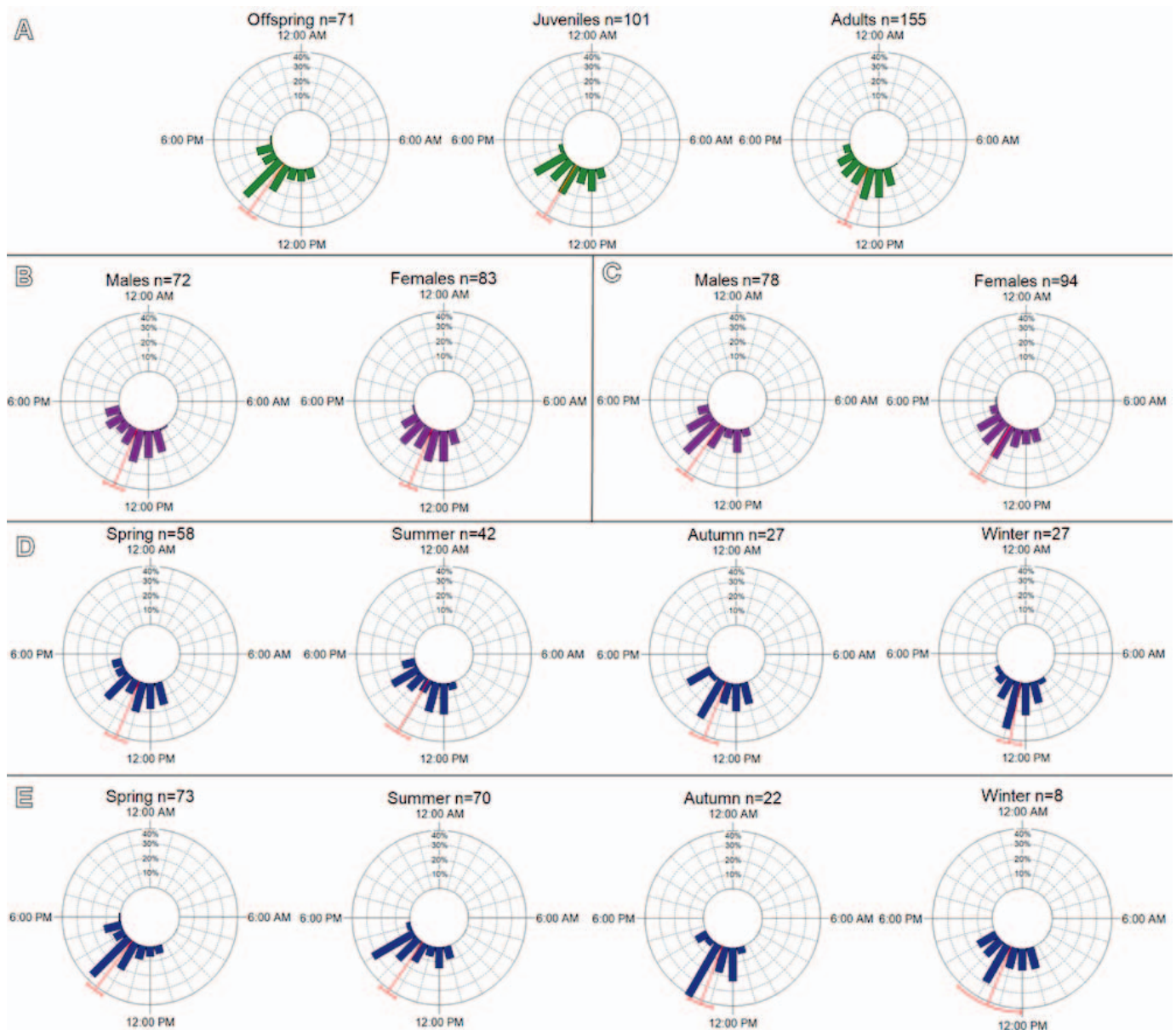


FIG. 2. Circular histogram of temporal activity patterns in *Phrynosoma orbiculare* by ontogeny (A), sexes (B for adults and C for juveniles and offspring), and seasons (D for adults and E for juveniles and offspring) in the Statal Park Sierra Morelos, Toluca de Lerdo and Zinacantepec, State of Mexico, México. Red lines represent the mean vector and its extensions the confidence interval.

thermic thermoregulation strategy, with offspring and juveniles of *P. orbiculare* obtaining heat through conduction by coming in contact with objects that were previously heated during the hours of greatest solar incidence (around 1200 h) in the SPSM. Furthermore, this finding suggests that during that time, the activity of nonmature organisms is low or that smaller individuals are not exposed to very high temperatures to avoid overheating (Herczeg et al., 2007; Vitt and Caldwell, 2014). The idea that organisms evade the highest temperatures of the day is supported by the seasonal variation present in offspring and juveniles whose activity patterns during autumn are closer to the hours in which there is a higher temperature without significantly occupying the 1200 h when the solar incidence is higher. In other words, young individuals are not active during the highest temperatures even during the coldest months. Young individuals, but not adults, evading the highest temperatures of the day to avoid overheating is a behavior also

described in *P. douglassi*; offspring start to reduce their activity at 1200 h and increase activity again at 1700 h (Guyer and Linder, 1985).

From the comparison between sexes, it was found that there is no difference in the hours of activity of males and females. *Phrynosoma orbiculare* females remain pregnant for at least 8 months, live longer, and therefore are larger than males (Hernández-Navarrete, 2018). Given the above results, activity patterns between sexes would be expected to be different because of their differential thermoregulation physiology. Contrary to this hypothesis, our results suggest that the females of *P. orbiculare* do not sacrifice their thermal optimum (which is similar to male optima because of the thermoregulation schedules and sites used) to meet the embryo optimum or that the thermal optimum of the females and the optimal thermal for a good embryonic development is the same. These suggestions are supported by the fact that there are no differences in thermal

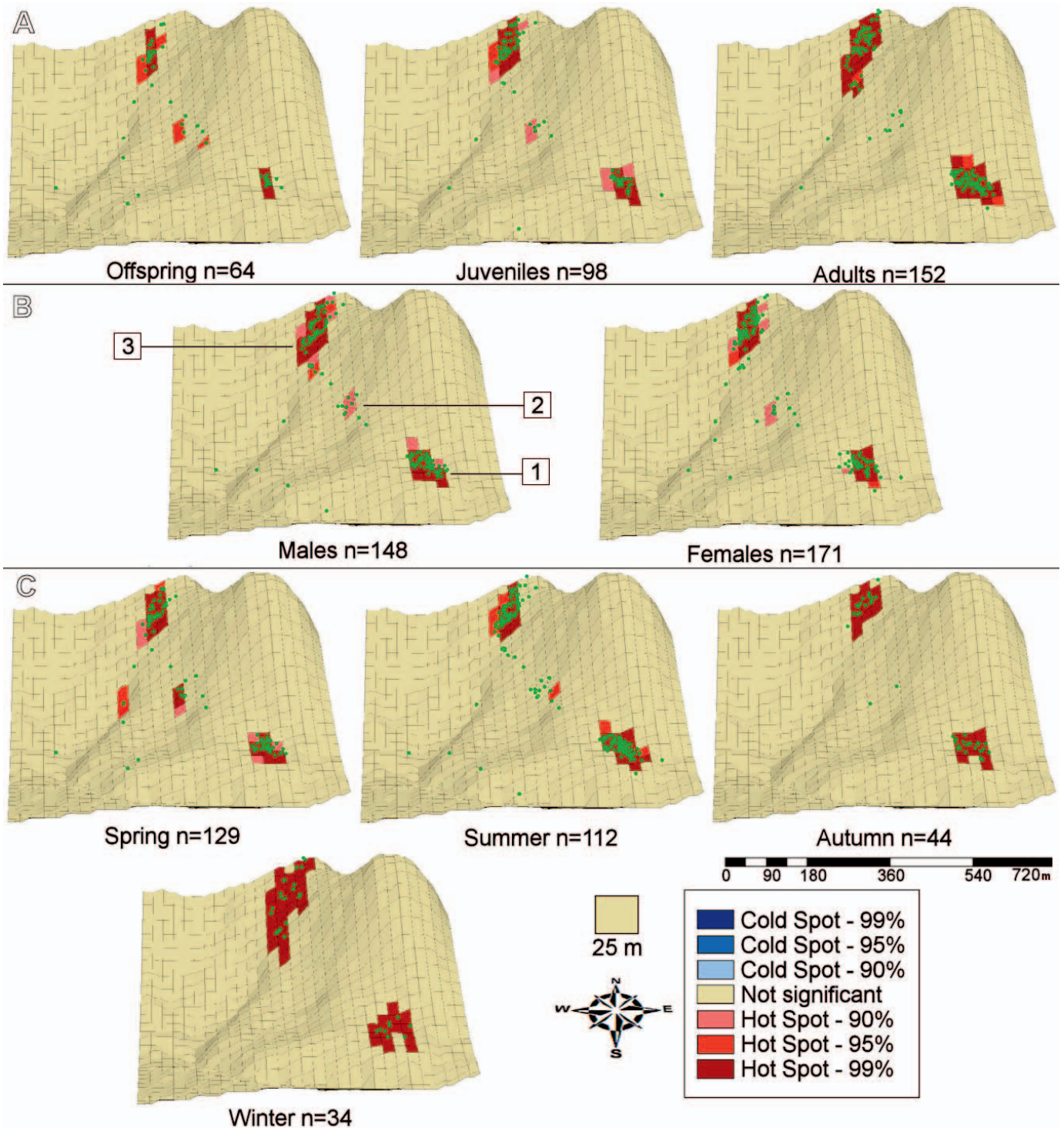


FIG. 3. Hotspots of *Phrynosoma orbiculare* in the Statal Park Sierra Morelos, Toluca de Lerdo and Zinacantepec, State of Mexico, México, for ontogeny (A), sexes (B), and seasons (C). Green points correspond to each individual observed. Principal hotspot sites are marked and numbered in males hotspots.

traits (body temperature, preferred temperature, critical thermal minimum and maximum) in *P. orbiculare* between sexes (Domínguez-Guerrero et al., 2020). Further studies are necessary to determine temperature differences between pregnant and nonpregnant females to test this hypothesis.

When the temporal activity of *P. orbiculare* is compared with that of other species of the genus for which the activity schedules have been reported, namely, for *P. solare* (Parker,

1971), *P. platyrhinos* (Pianka and Parker, 1975), *P. mcallii* (Wone and Beauchamp, 2003), and *P. douglassi* (Guyer and Linder, 1985), a pattern related to parity mode seems to be revealed. Oviparous species distribute at higher altitudes and have activity schedules with a bimodal distribution, perch at dawn, take refuge during noon, and become active at sunset once the solar incidence has been reduced (Parker, 1971; Pianka and Parker, 1975; Wone and Beauchamp, 2003). Additionally, during

TABLE 2. Correlation coefficients and fit indicators for the logistic regression model and maximum probability of *Phrynosoma orbiculare* occurrence for potential distribution model in the State Park Sierra Morelos, Toluca de Lerdo and Zinacantepec, State of Mexico, México. Higher correlation coefficients and good fit values are bolded.

Parameter ^a	Spring	Summer	Autumn/Winter	
Variables				
Intercept	608.95	−669.65	−595.18	
SI	−326.58	880.35	436.5452	333.5875
B2 (blue)	136.66	1,268.14	−24.7050	716.1485
B1 (ultrablue)	− 746.81	−572.94	646.3771	−429.5082
B5 (near infrared)	−119.01	102.02	31.6385	102.9106
B6 (SWI)	87.93	−136.07	−50.9217	58.2971
B10 (thermal band)	−1.62	−85.43	0.5771	−1.1470
NDMI	3.30	−85.43	−36.8753	−21.6714
Fit indicators				
Pseudo R ²	0.32	0.21	0.25	
ROC	0.92	0.83	0.89	
Maximum probability (%)	61	51	45	

^a SI = shadow index; SWI = short wave infrared; NDMI = normalized difference moisture index.

the cold months, they modify this pattern and assume a unimodal distribution, occupying only the hours closest to 1200 h (Parker, 1971; Pianka and Parker, 1975; Wone and Beauchamp, 2003). On the other hand, the two viviparous species with reported data, namely, *P. orbiculare* and *P. douglassi*, are distributed at lower altitudes and perch at times when the solar incidence is high, presenting a unimodal temporal activity pattern that remains even during the colder months (Guyer and Linder, 1985). In the genus *Phrynosoma*, viviparity may have arisen twice because of the cold climate that the species faced (Hodges, 2004). The above evidence suggests that the environmental pressure incident on the *Phrynosoma* species shaped not only their reproductive strategy but also their activity pattern behavior; these ecological traits may have coevolved.

The *P. orbiculare* hotspots indicate that, regardless of sex, age, or season, this species aggregates in the sun glades of the SPSM to take advantage of the highest temperatures available in the natural protected area. This is supported by the sites of high probability in which the species can be found according to the potential distribution model. In addition to *P. orbiculare* taking advantage of the sun glades, the sites where the species aggregates are on mountain faces directed to the south and southeast (the direction in which the sunrise occurs in México), our results reveal the importance of solar radiation for *P. orbiculare* occurrence. The altitudinal gradient of the SPSM is not

related to hotspot sites, but this could be because of the fact that the study area covers only a small part of the altitudinal distribution recorded in the species (1,371–3,352 masl; Montanucci, 1987). The importance of solar radiation was previously observed in *P. platyrhinos*, which use soil mounds beneath shrubs directly exposed to solar incidence, heat basking at morning and avoiding high temperatures in the early evening using that microhabitat (Newbold and Macmahon, 2014). The absence of coldspots suggest that *P. orbiculare* is a highly aggregated species.

A hotspot area located between the two main sites (sites 1 and 3; Fig. 3) had no significance in only the following three groups of the nine evaluated: adults, autumn, and winter. This site (site 2; Fig. 3) is the one with the highest vegetation coverage in the tree stratum and, therefore, the lowest solar incidence, which explains its lack of significance during the colder months. This finding corroborates observations in *P. orbiculare*, *Phrynosoma braconnieri*, and *Phrynosoma taurus*, species in which a preference for sunny microhabitats was observed and they used shady sites less frequently (Woolrich-Piña et al., 2012). The low solar incidence also explains why it is preferred by smaller individuals who can perch in this area without being exposed to very high temperatures because they acquire heat at a higher rate than adults (Herczeg et al., 2007; Vitt and Caldwell, 2014).

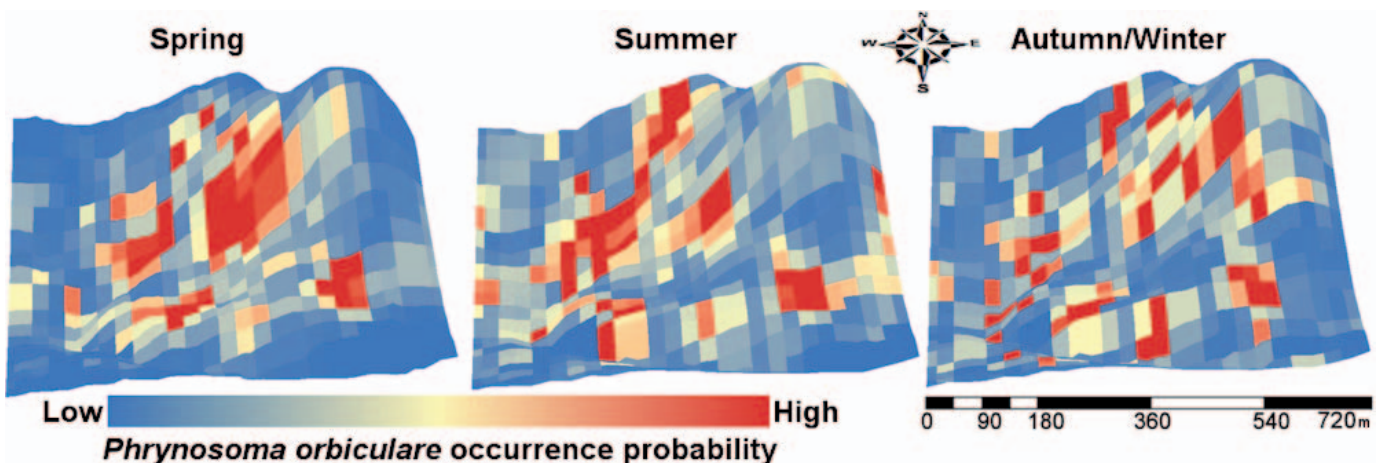


FIG. 4. Potential distribution model of *Phrynosoma orbiculare* in the State Park Sierra Morelos, Toluca de Lerdo and Zinacantepec, State of Mexico, México. Higher probability corresponds to maximum probability of occurrence for each season.

Bands 1 and 2 of the landsat 8 satellite were the most correlated variables with *P. orbiculare* occurrence. These bands correspond to images that reflect short wavelengths (in the visible wave spectrum they range from violet to blue through the deeper blue). The first one is commonly used to interpret suspended particles. The second one is usually used to separate vegetation from bare soil or deciduous plants from perennials (Acharya and Yang, 2015), which explains why it becomes relevant solely in the seasons in which the pastures begin to acquire yellowish colorations, whereas the areas with greater density in the tree stratum (composed mainly of perennials conifers) remain reflecting blue. Thus, in this sense, the blue band separates the forested areas from the sun glades, discriminating the *P. orbiculare* basking and perch areas, just as the zones with a higher presence of bunch-grasses that the species uses as refuge. To explain the importance of the band 1, it should be mentioned that the solar radiation reflected by aerosols in the atmosphere increases as the wavelength of the radiation shortens. Therefore, this band can be used to interpret, with low precision, study area solar radiation and fine aerosol particles (including smoke in the SPSM that is near of Toluca de Lerdo, a highly industrialized municipality). Thus, because of the relationship between band 1 (solar radiation) and the distribution of *P. orbiculare*, it can be deduced that sun glades in the SPSM are important factors for determining distributional hotspots, revealing the importance of solar incidence for thermoregulation in the studied species. Woolrich-Piña et al. (2012) reported that *P. orbiculare* use sunny (with a lizard directly exposed to solar radiation) microhabitats, more than shaded and mosaics, which supports the conclusions presented here on the importance of solar incidence for the activity of the Mexican Plateau Horned Lizard.

Despite how representative *P. orbiculare* is for México (it is a species endemic to México that is widely distributed in the Mexican territory and provides cultural ecosystem services), little is known about the ecology of this lizard. Because of this limited information, *P. orbiculare* is difficult to raise in captivity. Furthermore, the species is disturbed by anthropogenic activities and is now threatened according to Mexican laws in NOM-059-SEMARNAT-2010. Spatiotemporal activity patterns allow us to understand the conditions of daytime, substrate, tree cover, and temperatures preferred by this species. These data are valuable in multiple aspects. For example, although customary protocols dictate that animals in captivity must be fed at certain times and exposed to a source of heat during certain hours a day, species such as *P. orbiculare* must be given the necessary conditions to become dormant because this could be related to embryonic arrest. Additionally, conservation programs on the species should consider the changes of ontogenetic and seasonal activity patterns, as well as the exposure to the sun that the organisms require during the different seasons. Failure to reproduce the preferred conditions of this species in the wild may have impacts on its biological clock. The use of techniques detailed in this study is proposed to describe the activity patterns of unstudied species because of the accuracy they provide about the species activity patterns; aggregation; and differences in age classes, sex, and seasons to delimit the species hotspots and complement a real distribution model with a potential distribution model. For studies dealing with a small area such as the present one, the use of satellite images is proposed because of their resolution and because each pixel represents a faithful image of reality. In conclusion, *P. orbiculare* is a diurnal, mainly active at afternoon, highly

aggregated species. Additionally, both temporal and spatial activity patterns, with bands related to *P. orbiculare* occurrence, show the importance of adequate basking site conditions in solar glades for the species. The Mexican Plateau Horned Lizard is capable taking advantage of the same areas throughout its entire life by regulating the time during which they are active. The data presented within also reveal the importance of solar glades, made up of grasslands and bunch-grasses, surrounded by an arboreal stratum of perennial conifers, and conservation efforts in SPSM should take these data into consideration. Additionally, hotspot identification will help to plan surveillance strategies in the protected natural area, which suffers from illegal extraction of *P. orbiculare* as well as other herpetofaunistic species with which it coexists.

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