Habitat Use of Texas Horned Lizards in Southern Texas

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ABSTRACT

Microhabitat characteristics for the Texas horned lizard (*Phrynosoma cornutum*) were quantified from information gained from radio-tracking in Duval County, Texas. Microhabitat characteristics were assessed from known locations of lizards and random locations and included soil pH, soil particle size distribution, soil organic content, percent herbaceous vegetation, vegetation height, percent bare ground, vegetative basal area for bunch grasses, plant stem density, soil temperature, percent canopy cover, percent grasses, and percent forbs. Lizards (n = 16) disproportionately used the range of values for 11 of the 14 (soil pH, soil particle size distribution, soil organic content, percent bare ground, plant stem density, soil temperature, percent canopy cover, percent grasses, and percent forbs) microhabitat characteristics from their availability. Microhabitat characteristics recorded at bedding sites were used pro rata to availability. Soil moisture at bedding sites averaged 2.2% during the months July through October. Lizards would not bury themselves in soil for several days after precipitation; instead, the bases of trees and bunch grasses were used as bedding sites.

KEYWORDS: bedding site characteristics, habitat characteristics, *Phrynosoma cornutum*

Habitats of Texas horned lizards (*Phrynosoma cornutum*) have been described, but to our knowledge no one has quantified the characteristics of selected microhabitats. Price (1990) reported Texas horned lizards have been found in a variety of habitats ranging from open deserts to grasslands, located from sea level to 1,830 m elevation. Soil types included deep, pure sands, sandy loams, coarse gravels, conglomerates, and desert pavements of alluvial plains and mesa tops. Jameson and Flury (1949), Milstead et al. (1950), Minton (1959), Whitford and Creusere (1977), and Price (1990) reported that Texas horned lizards inhabited different ecological associations including shortgrass prairie, mesquite (*Prosopis glandulosa*)-grasslands, shrublands, desert scrub, and desert grasslands. Milstead and Tinkle (1969) reported finding Texas horned lizards in terrain consisting of low, gently rolling sand dunes with about 20% cover from desert vegetation. Whiting et al. (1993) suggested spatial distribution of Texas horned lizards was dependent on the presence of harvester ants (*Pogonomyrmex barbatus*) and open, partially vegetated habitat. They also reported that Texas horned lizards selected mechanically disturbed areas

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(asphalt airstrip, dirt roads, and mowed areas), which they believed allowed for greater ease of movement. Fair and Henke (1997a) also believed Texas horned lizards selected areas that were easily traversed, reporting that lizards favored the use of recently burned areas over areas with built-up ground litter.

Because Texas horned lizards are a federal Species of Concern and a threatened species within Texas, a better understanding of habitat use is needed to develop recommendations for managing the species. Microhabitat data can provide insight as to the quality of habitat necessary to maintain a population. Therefore, our objective was to determine microhabitat preferences for Texas horned lizards in south-central Texas.

MATERIALS AND METHODS

Study Area

The study was conducted from March through October 1994 on the Marvin and Marie Bomer Wildlife Management Area (BWMA), an experimental wildlife management area operated by the Department of Animal and Wildlife Sciences of Texas A&M University-Kingsville, and on the adjoining Pena Ranch. The BWMA is a 48.2-ha area located 19.3 km south of Benavides in Duval County, Texas. The climate is subtropical and semiarid. The mean annual rainfall is 65.7 cm (Natl. Oceanic and Atmos. Adm., 1994), although rainfall can vary greatly from year to year (Norwine and Bingham, 1986). The mean annual temperature is 22.1° C (Natl. Oceanic and Atmos. Adm., 1994).

The BWMA soils are well to moderately well-drained, loamy fine sands and fine sandy loams with moderate-slowly draining lower soil layers and moderate shrink-swell potential (Nat. Resour. Conserv. Serv., unpublished data). The topography is nearly level to gently sloping uplands ranging in elevation from 106 to 109 m above sea level. Although the habitat of the BWMA is not widely diverse, it is representative of southern Texas where populations of Texas horned lizards are considered stable (Donaldson et al., 1994).

Past agricultural practices on the BWMA included planting kleingrass (*Panicum coloratum*) and buffelgrass (*Cenchrus ciliaris*) in what is now the Conservation Reserve Program (CRP) land. Other sections of the BWMA were root plowed, each root plowed area being 2 to 3 ha in size. Sides of the root plowed areas were left in brush lines up to 10 m wide. Approximately half of the management area is under CRP control and the current land management emphasizes the production of northern bobwhites (*Colinus virginianus*). Quail management techniques conducted on the BWMA include burning portions of the CRP on a rotational basis, burning and discing non-CRP land on a rotational basis, and shredding roads. These activities keep most of the BWMA in early to mid-seral stages.

Habitat Assessment

Twenty-six horned lizards were captured by pitfall and funnel trapping, systematic searches, and random sightings (Fair and Henke, 1997b). Lizards were equipped with backpacks containing radio-transmitters (Model SM1, AVM Instrument Co., Livermore, CA) and located every 1 to 2.5 hours from sunrise to sunset for 5 days each month from initial capture (beginning in May) through October. Due to differential capture dates and survival rates of lizards, we were unable to obtain observation data on each captured lizard throughout the entire study period; however, a total of 1,434 lizard observations was obtained .

Microhabitat characteristics for Texas horned lizards were assessed from a random sample of horned lizard observations; however, to reduce dependency among observations only one observation per lizard per day was used for analyses (Swihart and Slade, 1985). One hundred plots from points where Texas horned lizards were observed were sampled each month. A 0.25-m^2 Daubenmire quadrat was placed at each lizard observation point with the location of the lizard being the center of the quadrat and microhabitat characteristics within the quadrat were recorded. In addition, 100 random plot locations were sampled each month. Microhabitat characteristics for random plots were assessed within 0.25-m^2 Daubenmire quadrat along two transects. Each transect was 500 m long, spaced 100 m apart, and traversed the study area. Plot locations were determined by walking a random number of meters (0 to 50 m) along the transect and then walking a random number of meters (0 to 50 m) perpendicular to the transect, either to the left or right of the transect line. A random number table was used to assign distances and direction (Steel and Torrie, 1980); if the number was even then the perpendicular distance was measured to the right of the transect line, and if the number was odd then the perpendicular distance was measured to the left of the transect line. Microhabitat characteristics at horned lizard bedding sites (i.e., sites where the lizards were buried in the soil) were recorded using a 0.25-m^2 Daubenmire quadrat as previously described.

Microhabitat characteristics recorded within each horned lizard plot and each random plot included soil pH, soil particle size distribution, soil organic content, percent herbaceous vegetation, vegetation height, percent bare ground, vegetative basal area for bunch grasses, plant stem density, soil temperature, percent canopy cover, percent grasses, and percent forbs. Soil pH was analyzed as described by Hendershot et al. (1993). Soil particle size distribution was analyzed using the hydrometer method (Gee and Bauder, 1986). Soil organic content was analyzed by the rapid colorimetric procedure as described by Texas Agricultural Extension Service (1980). Percent herbaceous vegetation was calculated as described by Bonham (1989). Percent forbs and percent grasses represented the percentage of each vegetation type from the total count of herbaceous plants within the 0.25-m^2 Daubenmire quadrat. Cacti were included with the forbs. Vegetation height was measured using a meter stick to the nearest 0.5 cm. Percent bare ground was estimated using the ocular estimation method (Gysel and Lyon, 1980). The percent bare ground values measured the amount of the 0.25-m^2 Daubenmire quadrat not covered by ground litter or herbaceous plants at ground level. Vegetative basal area was measured as outlined by the National Academy of Sciences (1962) and was calculated from basal circumference. Plant stem density was measured as described by Gysel and Lyon (1980). Stem density was measured as the number of individual plants within each 0.25-m^2 Daubenmire quadrat. Bunch grasses were considered 1 stem for each clump. Soil temperature was measured by inserting a thermometer 2.5 to 3.5 cm into the soil and taking the reading at 1 minute. The percent cover was measured with a photometer as described by Gysel and Lyon (1980), with readings taken at ground level and at 1 m above the ground (full light). An additional measurement of soil water content was calculated for bedding sites of Texas horned lizards. Soil water content was calculated by the gravimetric method using a drying oven (Topp, 1993).

Measurements for each microhabitat characteristic were initially partitioned into 5 intervals, each interval comprising 20% of the recorded values for random locations for each microhabitat characteristic. Organic matter, percent sand, soil temperature, stem density, and pH intervals were created *a posteriori* by combining intervals to ensure there was at least 1 expected value in each interval, a requirement of the Chi-square analysis (Neu et al., 1974).

Differential use of habitat was determined as described by Neu et al. (1974) using Chi-square analyses and Bonferronni Z-statistics to control the experiment-wise error probability at 0.10 because statistical analyses were considered to have potential biological significance at $P < 0.10$ (Tacha et al., 1982). Microhabitat characteristics were considered preferred or avoided, respectively, if the proportion of available study plots was below or above the corresponding 90% confidence interval. Expected values for each microhabitat characteristic were calculated from the percent occurrence on the BWMA as determined by the random plots.

Three assumptions must be met to use the Neu et al. (1974) analysis of habitat utilization. The first is that animals must have free access and mobility to select any of the available habitats. This assumption was tested and satisfied by monitoring movements of Texas horned lizards in a concurrent study (Fair, 1995). It was determined a horned lizard could traverse the research area in <1 week. The second assumption is that observations are collected in a random, unbiased manner. This assumption was met by randomly choosing lizard locations and random plots. The third assumption is that observations are independent. To reduce dependency among lizard plots, plots used in analyses were from individual lizards that had at least a 24-hour interval between successive relocations (Swihart and Slade, 1985).

Bedding site characteristics were tested for differential use as described for lizard observation plots. Expected values were calculated using all lizard observation plots.

RESULTS AND DISCUSSION

Texas horned lizards disproportionately used the range of values for 11 of 14 microhabitat characteristics, which included percent bare ground, percent forbs, percent canopy cover, percent organic matter, soil pH, soil temperature, percent sand, plant stem density, percent clay, percent grass, and percent silt, from their availability (Tables 1 and 2). Texas horned lizards in southern Texas preferred areas with >80% canopy cover that consisted of <20% forbs and a plant stem density of <25 stems/0.25 m^2. Sandy loam soils with a pH >8.0, an organic matter content of 0.9 - 1.8%, and soil temperatures between 23 - 31 C also were preferred. Horned lizards in our study avoided areas with 40-60% canopy cover that consisted of <20% grass and bare ground and >80% forbs, and a plant stem density of >26 stems/0.25 m^2. Soils with a neutral pH, temperature >31 C, percent organic matter content <0.9% and >2.7%, and soil particle size distribution <66% sand and >16% clay also were avoided by Texas horned lizards. Three microhabitat characteristics (basal area of bunch grasses, percent total herbaceous vegetation, and vegetation height) were used *pro rata* to availability (Table 3).

Table 1. Habitat characteristics used disproportionately to availability by Texas horned lizards at the 0.10 significance level, as determined from 0.25-m^2 random and lizard observation plots on the Bomer Wildlife Management Area, Duval County, Texas during 1994.

	Random locations			Lizard locations					
Habitat characteristic	$\bar{x}$	SE	Range	$\bar{x}$	SE	Range	χ^2	df	*P*-value
Percent bare ground	31.06	0.23	0.0 - 99.0	36.73	0.39	0.0 - 92.0	11.65	4	0.0202
Percent canopy cover	43.12	0.34	1.5 - 99.3	29.90	0.47	2.3 - 99.1	44.64	4	0.0001
Percent forbs	55.54	0.26	0.0 - 100	47.01	0.47	0.0 - 100	10.18	4	0.0375
Percent grass	41.66	0.26	0.0 - 100	49.35	0.47	0.0 - 100	8.94	4	0.0628
Plant stem density	17.72	0.20	0 - 149	8.18	0.21	0 - 47	35.32	1	0.0001
Percent organic matter	1.17	0.04	0.3 - 4.1	1.20	0.06	0.1 - 2.7	39.77	3	0.0001
Soil pH	7.44	0.03	5.9 - 8.8	7.57	0.06	6.0 - 8.7	20.77	3	0.0001
Soil temperature (C)	32.07	0.15	20.0 - 53.3	27.25	0.16	17.8 - 43.3	182.3	3	0.0001
Percent sand	73.16	0.13	30.0 - 87.5	75.93	0.17	62.5 - 90.0	14.69	2	0.0006
Percent silt	12.14	0.10	2.5 - 27.5	11.55	0.15	2.5 - 25.0	8.38	3	0.0388
Percent clay	14.70	0.11	5.0 - 50.0	12.52	0.15	5.0 - 22.5	5.25	1	0.0220

Table 2. Occurrence of Texas horned lizards in selected intervals of selected habitat characteristics on Bomer Wildlife Management Area, Duval County, Texas.

Habitat characteristic	Interval	Proportion of random locations	Lizard locations	Expected number of lizard locations	Proportion observed in each interval (p_i)	Bonferronni's 90% confidence interval for p_i	Preference outcome
Percent bare ground[a]							
	0.0 - 20.0	0.451	55	74.4	0.333	$0.248 \leq p_1 \leq 0.419$	Avoided
	20.1 - 40.0	0.247	54	40.7	0.327	$0.242 \leq p_2 \leq 0.412$	Neutral
	40.1 - 60.0	0.147	23	24.2	0.139	$0.077 \leq p_3 \leq 0.202$	Neutral
	60.1 - 80.0	0.110	24	18.2	0.145	$0.082 \leq p_4 \leq 0.209$	Neutral
	80.1 - 100.0	0.045	9	7.4	0.055	$0.013 \leq p_5 \leq 0.055$	Neutral
Percent grass[a]							
	0.0 - 20.0	0.362	45	59.7	0.273	$0.192 \leq p_1 \leq 0.354$	Avoided
	20.1 - 40.0	0.172	31	28.4	0.188	$0.117 \leq p_2 \leq 0.259$	Neutral
	40.1 - 60.0	0.168	26	27.7	0.158	$0.091 \leq p_3 \leq 0.224$	Neutral
	60.1 - 80.0	0.116	21	19.1	0.127	$0.067 \leq p_4 \leq 0.188$	Neutral
	80.1 - 100.0	0.182	42	30.3	0.255	$0.176 \leq p_5 \leq 0.334$	Neutral

Table 2. Continued.

Percent forbs[a]						
0.0 - 20.0	0.222	52	36.6	0.315	$0.231 \leq p_1 \leq 0.399$	Preferred
20.1 - 40.0	0.120	19	19.8	0.115	$0.057 \leq p_2 \leq 0.173$	Neutral
40.1 - 60.0	0.174	28	28.7	0.170	$0.102 \leq p_3 \leq 0.238$	Neutral
60.1 - 80.0	0.170	28	28.1	0.170	$0.102 \leq p_4 \leq 0.238$	Neutral
80.1 - 100.0	0.314	38	51.8	0.230	$0.154 \leq p_5 \leq 0.307$	Avoided
Percent canopy cover[a]						
0.0 - 20.0	0.086	5	8.8	0.049	$0.000 \leq p_1 \leq 0.099$	Neutral
20.1 - 40.0	0.121	8	12.4	0.078	$0.016 \leq p_2 \leq 0.140$	Neutral
40.1 - 60.0	0.333	14	34.0	0.137	$0.058 \leq p_3 \leq 0.217$	Avoided
60.1 - 80.0	0.293	36	29.9	0.353	$0.243 \leq p_4 \leq 0.463$	Neutral
80.1 - 100.0	0.167	39	17.0	0.382	$0.270 \leq p_5 \leq 0.494$	Preferred
Stem density[a]						
0 - 25	0.786	161	129.7	0.976	$0.952 < p_1 < 0.999$	Preferred
26 - 150	0.214	4	35.3	0.024	$0.001 < p_2 < 0.048$	Avoided

Table 2. Continued.

Soil temperature (C)[a]						
15.0 - 23.0	0.194	30	31.2	0.186	$0.118 \leq p_1 \leq 0.255$	Neutral
23.1 - 31.0	0.269	116	43.3	0.720	$0.641 \leq p_2 \leq 0.800$	Preferred
31.1 - 39.0	0.367	14	59.1	0.087	$0.037 \leq p_3 \leq 0.137$	Avoided
39.1 - 55.0	0.170	1	27.4	0.006	$0.000 \leq p_4 \leq 0.020$	Avoided
Soil pH[a]						
< 6.7	0.042	8	6.9	0.049	$0.011 \leq p_1 \leq 0.086$	Neutral
6.7 - 7.3	0.432	48	70.8	0.293	$0.213 \leq p_2 \leq 0.372$	Avoided
7.4 - 8.0	0.413	74	67.7	0.451	$0.364 \leq p_3 \leq 0.538$	Neutral
> 8.0	0.114	34	18.6	0.207	$0.136 \leq p_4 \leq 0.278$	Preferred
Percent soil organic matter[a]						
0.00 - 0.90	0.486	52	79.7	0.317	$0.236 \leq p_1 \leq 0.398$	Avoided
0.91 - 1.80	0.317	88	51.9	0.537	$0.449 \leq p_2 \leq 0.624$	Preferred
1.81 - 2.70	0.157	23	25.8	0.140	$0.080 \leq p_3 \leq 0.201$	Neutral
2.71 - 4.50	0.032	1	5.3	0.006	$0.000 \leq p_4 \leq 0.020$	Avoided

Table 2. Continued.

Percent sand[a]							
	30.0 - 66.0	0.130	6	21.2	0.037	$0.005 \leq p_1 \leq 0.068$	Avoided
	66.5 - 78.0	0.653	111	107.1	0.677	$0.599 \leq p_2 \leq 0.755$	Neutral
	78.5 - 90.0	0.218	47	35.7	0.287	$0.211 \leq p_3 \leq 0.362$	Neutral
Percent clay[a]							
	5.0 - 16.0	0.738	134	121.1	0.817	$0.758 \leq p_1 \leq 0.876$	Preferred
	16.5 - 60.0	0.262	30	42.9	0.183	$0.124 \leq p_2 \leq 0.242$	Avoided
Percent silt[a]							
	0.0 - 6.0	0.075	13	12.3	0.079	$0.032 \leq p_1 \leq 0.127$	Preferred
	6.5 - 12.0	0.356	63	58.4	0.384	$0.299 \leq p_2 \leq 0.469$	Neutral
	12.5 - 18.0	0.510	87	83.6	0.530	$0.443 \leq p_3 \leq 0.618$	Neutral
	18.5 - 30.0	0.059	1	9.7	0.006	$0.000 \leq p_4 \leq 0.020$	Neutral

[a]See Table 1 for Chi-square values, degrees of freedom, and *P*-values for each habitat characteristic.

Thirty different bedding sites were located for 16 Texas horned lizards. Soil moisture at bedding sites averaged 2.2% during the months July through October (Table 4). Bedding sites were not located in May or June. Minimum and maximum soil moisture levels were 0.88% and 5.49%, respectively. Microhabitat characteristics for bedding sites were used in accordance with availability (Table 5).

Abiotic and biotic factors must be within tolerable limits for a species to survive in a given area (Nebel, 1990). Values of microhabitat characteristics for our lizard observation plots must have been consistent with the range of tolerance for Texas horned lizards; otherwise their population should decline on the BWMA. However, the population of Texas horned lizards on the BWMA has been stable (S.E. Henke, unpubl. data).

Table 3. Habitat characteristics used in accordance to availability by Texas horned lizards at the 0.10 significance level, as determined from 0.25-m^2 random and lizard observation plots on the Bomer Wildlife Management Area, Duval County, Texas during 1994.

	Random locations			Lizard locations					
Habitat characteristic	$\bar{x}$	SE	Range	$\bar{x}$	SE	Range	χ^2	df	*P*-value
Basal area of bunch grasses (cm^2)	44.65	0.43	5.0 - 2027	60.92	1.16	14.1-2919	6.43	4	0.1693
Percent total herbaceous vegetation	34.65	0.23	0.0 - 100	31.32	0.40	0.0 - 100	6.38	4	0.1728
Vegetation height (cm)	33.73	0.21	0.0 - 132.1	32.40	0.37	0.0 - 122	7.28	4	0.1217

Table 4. Soil moisture content (%) for bedding sites of Texas horned lizards on the Bomer Wildlife Management Area and Pena Ranch, Duval County, Texas during 1994.

Month	*n*	$\bar{x}$	SE	Range
July	4	1.59	0.15	1.18 - 2.00
August	14	2.43	0.33	0.88 - 5.49
September	4	1.84	0.14	1.57 - 2.30
October	6	2.32	0.29	1.29 - 3.52
Total	28	2.20	0.19	0.88 - 5.49

Table 5. Descriptive statistics for measured habitat characteristics at bedding sites (n=30) of Texas horned lizards on the Bomer Wildlife Management Area and adjoining Pena Ranch, Duval County, Texas during 1994.

Habitat characteristic	Bedding sites $\bar{x}$	SE	Range
Percent bare ground	46.88	1.05	5.0 - 90.0
Percent herbaceous vegetation	13.25	0.88	0.0 - 80.0
Vegetation height (cm)	22.43	0.95	0.0 - 94.6
Percent forbs	46.67	1.33	0.0 - 100
Percent grass	45.00	1.33	0.0 - 100
Plant stem density, (stems per 0.25 m^2)	6.17	0.63	0 - 47
Basal area of bunch grasses (cm^2)[a]	40.60	---	--- - ---
Percent organic matter	1.16	0.14	0.1 - 2.7
Soil pH	7.42	0.10	6.4 - 7.8
Percent sand	78.83	0.40	67.5 - 90.0
Percent silt	10.50	0.32	5.0 - 17.5
Percent clay	10.67	0.35	5.0 - 17.5

[a]Only 1 plot contained a bunch grass for both bedding and hibernation site plots.

The morphology of Texas horned lizards, with their wide, flat torso and short legs, makes navigation difficult in sites containing a lot of ground clutter. Therefore, it is not unreasonable for Texas horned lizards to avoid sites with a large quantity of leaf litter. We agree with Whiting et al. (1993) that a high number of plant stems potentially create a difficult terrain for the lizards to negotiate.

The lizards were located in open areas during the morning hours, either thermoregulating, feeding, or moving. By afternoon the lizards typically were found resting under cover, out of direct sunlight and hidden from predators. Sites with intermediate canopy cover were not often used by Texas horned lizards, potentially because these sites did not allow the lizards to adequately thermoregulate nor did they provide sufficient cover from predators.

It is worth noting that some of the microhabitat characteristics were autocorrelated. For example, sites with high production of grasses contain more organic materials in the

soils than sites composed primarily of woody species or sites of scant vegetation (Plaster, 1992). Also, fine-textured or clay soils tend to contain higher amounts of organic matter than coarse soils (Plaster, 1992). Because the quantity and type of vegetation and soil composition affects organic content and that Texas horned lizards most often used sites with moderate amounts of vegetation, by default sites that contained intermediate levels of organic content appeared "preferred." Also, the soil pH within the A horizon located on the BWMA did not vary greatly. About 43% of the random plots contained pH levels between 6.7 and 7.3; however, lizards were found in sites within this pH range less often than was expected. Potentially this could be an artifact of another habitat characteristic, and that lizards were not utilizing habitat based on soil pH.

Prieto and Whitford (1971) reported the mean critical thermal minimum and maximum internal temperatures for Texas horned lizards to be 9.46 C and 47.91 C, with a preferred mean temperature of 38.5 C. Because of their wide body close to the ground, horned lizards will gain surface heat via radiation and conduction. To maintain a viable body temperature, horned lizards must be able to dissipate additional heat either physiologically or behaviorally. A preference for substrates of cooler temperatures in south Texas may be a behavioral adaptation to meet this thermoregulatory need. However, the soil temperature results potentially could be biased by when the random samples were collected. Although random plots were assessed throughout the day, more samples were collected during the late afternoon than during early morning and midday.

The disposition towards sandy soils and away from clay and silty soils by Texas horned lizards can likely be attributed to the lizard's behavior of burying itself. The friability of sandy soils eases this action to a swimming motion more so than digging. Texas horned lizards prefer soil textures classified as sandy loam, sandy clay loam, and loamy sand.

Before July, horned lizards were not observed burying themselves during the day or night. Beginning in July the lizards often buried themselves prior to becoming inactive. However, lizards did not bury themselves after rain showers until after the upper soil layer had dried, which typically required 1 to 2 days after a rain. Potential reasons for lizards not burying themselves after rainfall include excessive energy expenditure to dig into moist soil and decreased soil temperature causing the lizard's temperature to fall below critical levels required for activity. Also, the lizards usually selected sites with small to moderate amounts of herbaceous vegetation for bedding sites. This could potentially be attributed to plant root systems in the upper layers of the soil affecting the ability of Texas horned lizards to dig into the soil.

Although our sample size was small and only from one locale, the described microhabitat characteristics are useful for their descriptive nature into the requirements of Texas horned lizards. The information herein can be useful in the management of this Texas threatened species.

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