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DIURNAL BED-SITE SELECTION OF URBAN-DWELLING JAVELINA IN PRESCOTT, ARIZONA

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Abstract: Javelina (*Tayassu tajacu*) are an economically important big game species in the southwestern United States, but are considered nuisance wildlife in urban areas. We radiotracked individuals from 6 herds to identify diurnal bed sites of urban-dwelling javelina in 1992–93. We compared microsite habitat characteristics at 46 diurnal javelina bed sites with the same characteristics at 49 random plots. Characteristics of bed sites included south- and east-facing sites with >20% slope, >50% shrub cover, and chaparral habitat with >75 cm dbh trees. Javelina also selected sites where visibility was completely obstructed by dense vegetation and–or rocks within 3–4 m.

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Javelina evolved in dense tropical forests of Central America (Sowls 1984). Knipe (1956) suggested javelina migrated into the southwestern United States in the mid-1700s, but it is possible that they may have existed in the Southwest before then. Javelina have adapted to a variety of plant communities, diverse climatic conditions, and varied topography. Their distribution in Arizona has greatly increased in the last 100 years (Day 1985).

Javelina habituate well to human developments and become a management problem in some areas. As residential areas expand, they encroach on undeveloped areas that support javelina and other wildlife. Human-javelina conflicts include landscape destruction, injured pets, and frightened homeowners. Homeowners often compound conflicts by providing food and water sources. When human-javelina conflicts exceed public acceptance levels (Wittmann et al. 1998), resource managers are required to address the problem.

Because bed sites are likely to be the best example of javelina cover needs (Day 1985), availability of these sites could influence javelina density and distribution in residential areas.

Day (1985) described ideal javelina bedding grounds as sites with protection from environmental extremes, escape cover, loose soil for digging bedding pads, and proximity to permanent water. In southern Texas, Ilse and Hellgren (1995) found javelina bed sites had a visibility range of 3.0–6.5 m ($\bar{x}$ = 4.75, SD = 1.06) and were always located within dense vegetation. Studies of bed-site characteristics of desert-dwelling javelina have described bed-site macrohabitat as dense vegetation often occurring in combination with boulders and other topographic inlets (e.g., caves, crevices, and mines; Ellisor and Harwell 1979, Day 1985). In southern Arizona, Schweinsburg (1969) and Phelps (1971) found that when ambient air temperatures approached 25° C, non-urban dwelling javelina bedded in dense vegetation. Javelina select for warmer sites during winter in the same way they select for cooler areas in warm months (Sowls 1984). In the only study examining urban-dwelling javelina microhabitat characteristics, Bellantoni and Krausman (1991) reported that, on a year-round basis, urban-dwelling javelina preferred to bed in areas with little slope ($\bar{x}$ = 2.2%) and on north- and east-facing aspects.

Our objective was to characterize urban-dwelling microsite habitat characteristics of bed sites of urban-dwelling javelina. Characterizing these sites may assist city planners, local homeowners, and resource managers in managing javelina in residential environments.

STUDY AREA

We conducted the study in the north-central Arizona city of Prescott (elevation 1,609 m). Nearly 28,000 people lived within the 80-km^2 incorporated area of Prescott, which had become a prime retirement community and was being rapidly developed. Predominant land uses within Prescott were 50% undeveloped, 38% residential, 7% public, and 5% commercial/industrial (Ticer et al. 1994).

Topography was moderately rugged, with about 20% of the area containing interspersed boulder outcrops. Overstory vegetation was primarily ponderosa pine (*Pinus ponderosa*) and pinyon (*Pinus edulis*)-juniper (*Juniperus* spp.) woodland associations (Brown 1994). Understory vegetation was dominated by interior chaparral consisting of shrub live-oak (*Quercus turbinella*), mountain mahogany (*Cercocarpus montanus*), silktassel (*Garrya flavescens*), skunk-bush sumac (*Rhus trilobata*), and manzanita (*Arcostaphylus pungens*). Little herbaceous cover was present in scattered openings.

Average annual precipitation was 65 cm in Prescott (National Climatic Data Center 1992–93). Most rain fell during winter (55%) and summer monsoons (26%). Average monthly temperature was derived from the means of averaged daily high and low air temperatures. Summer (Jun–Aug) temperatures for the 1992 field season averaged 21.3 °C (±1.0 °C). Average winter (Dec–Feb) temperatures during the 1992–93 field season averaged 3.2 °C (± 3.0 °C) during the day.

The study area contained a centralized downtown area surrounded by residential developments interspersed with undeveloped areas. Few fences separated homes, and densely vegetated washes and undeveloped lots of land connected these areas to adjacent developments.

METHODS

We captured and radiomarked 8 javelina from 6 herds during March–September 1992 as part of a concurrent study to investigate habitat use and activity patterns of urban-dwelling javelina (Ticer et al. 1994). Collared javelina were located ≥1 time weekly during daytime hours (0601–1800 MST) from April 1992 to March 1993. Bed sites were identified as we located radiomarked individuals.

At each bed site, we measured percent slope, aspect, and ruggedness. Ruggedness was indexed by overlaying a uniform grid of 98 dots over a topographic map containing an 0.8-km radius plot (Beasom et al. 1983). Dots intersecting contour lines were counted, and ruggedness was calculated as the ratio of dot-contour intersections to total number of dots (n = 98) in the grid. The ruggedness index reflects habitat complexity by incorporating habitat features such as vertical relief (e.g., draws and rock outcrops), rather than just slope (Beasom et al. 1983).

Fourteen habitat variables were measured within a 40-m^2 circular plot (radius = 3.6 m) centered on the javelina bed site. Plot variables included dominant woody species; nearest distance (m) to hiding cover; distance (m) to nearest canopy opening (>20 m^2); dbh of the dominant tree in the plot; species richness of cactus (*Opuntia* spp. and *Cholla* spp.), shrubs, and trees; percent cover of cactus, shrubs, trees, and

Table 1. Habitat characteristics of urban-dwelling javelina bed sites and random plots, Prescott, Arizona, 1992–93.

	Bed sites (n = 46)			Random plots (n = 49)			
Variable	$\bar{x}$	SE	Range	$\bar{x}$	SE	Range	P[a]
Slope (%)	19.3	1.28	4.0–40.0	11.9	1.30	3.0–38.0	<0.001
Ruggedness	0.5	0.02	0.3–0.8	0.4	0.02	0.1–0.8	<0.001
Distance to closest hiding cover (m)	2.4	0.18	0.5–6.4	7.4	0.98	1.8–25.0	<0.001
Distance to canopy opening (m)	2.9	0.24	0.0–7.0	1.3	0.30	0.0–10.0	<0.001
Tree dbh (cm)	48.5	4.27	10.2–132.1	28.1	2.70	0.0–76.2	<0.001
Species richness							
Shrubs	3.3	0.16	1.0–5.0	2.1	0.21	0.0–5.0	<0.001
Trees	1.6	0.12	0.0–4.0	1.4	0.13	0.0–3.0	0.434
Cactus	0.4	0.08	0.0–2.0	0.1	0.04	0.0–1.0	0.007
Plant height (m)							
Shrubs	2.1	0.17	0.8–6.1	1.7	0.18	0.2–7.3	<0.001
Trees	7.6	0.75	3.0–27.0	5.4	0.71	0.0–21.0	0.001
Cover (%)							
Shrubs	38.7	3.62	4.0–94.0	15.0	2.55	0.0–61.0	<0.001
Ticer							
Trees	39.9	4.63	0.0–95.0	23.1	3.24	0.0–80.0	0.014
Cactus	1.3	0.43	0.0–15.0	0.7	0.45	0.0–20.0	0.009
Rock	27.9	3.28	0.0–80.0	9.9	2.59	0.0–70.0	<0.001

[a] Mann-Whitney U-test comparing bed sites and random sites.

rocks; and mean height (cm) of cactus, shrubs, and trees. We defined dominant species as the woody species with the greatest percent cover. We measured the distance from the bed site to where a cardboard replica of a bedded adult javelina (61 × 31 cm) was no longer visible in each of 4 cardinal directions. We used the lowest of these 4 measurements for analyses. Percent woody plant and rock cover were determined by measuring the total length of these features along 2 randomly oriented perpendicular transects centered on the plot, divided by the combined transect length. Only rocks capable of concealing a bedded adult javelina (≥61 × 31 cm) were measured. Mean woody plant height was the average height of woody plants closest to the bed site in each of the quadrants created by the transects.

We generated random points within the boundaries of study area using Arc-Info software (Environmental Systems Research Institute, Redland, California, USA) with a Geographical Information System. Random plots never occurred within private yards or developed areas. At each random plot, we collected the same data as at bed sites. We used Mann-Whitney U-tests to test for differences in habitat characteristics of continuous variables between bed sites and random plots (Sokal and Rohlf 1995). Log-likelihood G-tests were used to determine if bed sites differed from random plots with respect to 4 aspect categories (316–45, 46–135, 136–225, and 226–315 degrees). If differences ($P < 0.05$) were found, Bonferroni simultaneous confidence intervals were calculated (Neu et al. 1974, Byers et al. 1984), followed by Jacobs' D statistics to indicate direction and magnitude of avoidance or selection (Jacobs 1974). We descriptively compared javelina use of aspect to the monthly mean air temperatures of the area from climate data accumulated between 1941 and 1970 (Sellers and Hill 1974).

RESULTS

We quantified habitat characteristics at 46 javelina bed sites (5–12 bed sites from each of 6 herds) and 49 random plots from April 1992 to March 1993. Javelina bed sites were located in areas with steeper, more rugged terrain than random plots (Table 1). Aspect of bed sites did not differ ($G = 6.81$, 3 df, $P = 0.078$) from random plots. Most javelina bed sites occurred on east-facing (40.0%), south-facing (28.0%), and north-facing (24.0%) aspects between April and October, when mean minimum monthly air temperatures exceeded 13.5°C (National Climatic Data Center 1992–93). However, between November and March, when mean minimum monthly air temperatures fell below 8.9°C, javelina used south-facing (52.4%) aspects more than east-facing (33.3%) or north-facing (9.5%) aspects. Javelina used bed sites that were closer to hiding cover and farther from canopy openings than random plots (Table 1).

Dominant trees at bed sites had greater dbh than dominant trees at random plots (Table 1). Species richness of trees did not differ from random plots. However, species richness of shrubs and cactus and height of shrubs and trees were higher at bed sites (Table 1). Pine (37.0%), oak (34.8%), and juniper (23.9%) were the most common tree species encountered at bed sites. Silktassel (34.8%), shrub live-oak (30.4%), and mountain mahogany (21.7%) were the most common shrubs at bed sites. Prickly pear (*Opuntia* spp.) was the most common cactus species found, occurring at 30.4% of the bed sites. Only 10% of the random plots contained cactus, all of which were prickly pear. Javelina bed sites contained more shrub, cactus, tree, and rock cover than random plots (Table 1).

DISCUSSION

Bed sites of urban-dwelling javelina provided dense cover in steep, rugged terrain. Javelina use of aspect at bed sites did not differ from random plots; however, the *P*-value was indicative of a trend towards javelina selection of aspect. For most of the year, javelina used bed sites with >20% slope or >0.25 ruggedness index on south and east-facing exposures. However, when mean monthly temperatures were near freezing, javelina used southern aspects to take advantage of greater solar radiation on cool, sunny days. We believe this shift to warmer aspects allows them to live in cooler environments than where they evolved (Woodburne 1969). Sowls (1984) speculated that javelina used different aspects to behaviorally thermoregulate and reduce metabolic costs. Daubenmire (1974) suggested that the net effect of solar radiation is greater on steep slopes, as the angle of sun exposure is less acute.

Our findings differed from Bellantoni and Krausman (1991), who documented that urban javelina in Tucson, Arizona, selected gentle ($\bar{x}$ = 2.2%) north- and east-facing slopes. We believe this contrast is due to differences in climatic conditions at the study areas. Tucson occurs in a Sonoran Desertscrub community that is warmer and lower elevation than woodland associations of Prescott. Thus, javelina in the Tucson area may seek aspects and slopes that provide cooler conditions.

The greater use of rock and vegetation cover we observed may be important to urban javelina in Prescott for 2 reasons. The dense cover provided by rocks, trees, and shrubs reduces wind velocity, thus minimizing body heat loss through convection (Gates 1962, Schmidt-Nielson 1964). Additionally, rocks re-radiate stored energy. Rock and vegetation cover likely are used by javelina in warmer climates of southern Arizona and southern Texas to avoid warm temperature extremes. Javelina can behaviorally thermoregulate with rocks and shrubs as thermal cover by varying placement of bed sites within the cover. The cooler the air temperatures, the closer javelina will bed to one another to minimize heat loss (Sowls 1984). Also, densely vegetated areas may provide cover for movement from bedding to feeding sites as observed by Ellisor and Harwell (1979) and Ticer et al. (1994). Distance to hiding cover at javelina bed sites was similar to that found by Ilse and Hellgren (1995) at non-urban javelina bed sites in southern Texas. Ilse and Hellgren (1995) suggested that javelina require such dense bed sites because they repeatedly use the same ones, increasing the risk of predation.

Another important habitat component in the Prescott study area was prickly pear. Prickly pear has been documented as being important to javelina (Jennings and Harris 1953, Knipe 1956, Neal 1959, Eddy 1961, Sowls 1984). Theimer and Bateman (1992) found javelina feed selectively on specific prickly pear plants and the characteristics of a particular cactus is an indicator of habitat quality. Ellisor and Harwell (1979) found that javelina density was highest where prickly pear canopy cover was 0.7–1.8%. At javelina bed sites in our study, prickly pear canopy cover was 1.3%. As found elsewhere, prickly pear cactus in Prescott contributes substantially to overall habitat quality by providing food, water, and cover for javelina.

MANAGEMENT IMPLICATIONS

We found that javelina prefer areas with dense cover, varied habitat structure, and aspects that optimize solar warming in cold months. This information will help design vegetation manipulations to reduce attractiveness to javelina, while preserving most elements of vegetation corridors. When the threshold of public acceptance of javelina is exceeded and agency action required (Wittmann et al. 1998), we believe vegetation modification at bed sites is the most feasible option in our study area.

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