

INFLUENCE OF MICROHABITAT FEATURES ON SPECIES RICHNESS AND
RELATIVE ABUNDANCE IN SMALL
MAMMAL COMMUNITIES OF SAGUARO NATIONAL PARK, ARIZONA

December 19, 2001

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We trapped small mammals and measured microhabitat variables (ground cover type, vegetation density by height) in 13 random locations within Saguaro National Park, where small mammal habitat relationships had not previously been quantified. We captured 575 individuals of 14 species in 4038 trapnights. Of the 10 species trapped > 20 times, we found statistically significant associations with ground cover type or vegetation structure for 9 species. We established associations for 7 species with primary vegetation type, these results agreed with known patterns of distribution. The cactus mouse (*Peromyscus eremicus*) was found to be a microhabitat generalist, and brush mice (*Peromyscus boylii*) showed preferences for grass cover and woody debris. Among the pocket mice (*Chaetodipus* and *Perognathus* species), we found little overlap between the desert pocket mouse (*C. penicillatus*) and Bailey's pocket mouse (*C. Bailey*), though these species are often considered sympatric. The rock pocket mouse (*C. intermedius*) and the Arizona pocket mouse (*P. amplus*) were associated with low ground cover, though *P. amplus* preferred sparse areas including bare ground. Merriam's kangaroo rat (*Dipodomys merriami*) shared habitat associations and was found to be sympatric with *P. amplus*. Predictably, the cliff chipmunk (*Eutamias dorsalis*) was associated with rocky cover and tall trees. Relationships described here contribute to a deeper understanding of the ecology of these species, particularly in a regional context, which can facilitate conscientious resource management.

Key words: Arizona, Saguaro National Park, Rincon Mountains, microhabitat, relative abundance

INTRODUCTION

Patterns of species richness and abundance are fundamental to understanding ecological processes (Fleming 1973), population dynamics (O'Connell 1989), and community structure (Asquith et al. 1997). Investigation of these patterns is an important component of managing resources to conserve biodiversity (Wilson et al. 1996). Yet demographic changes that we see in mammal communities are often reflections of interactions at the habitat level; individuals are affected through impacts to the resources they rely on (Morrison et al. 1998). Understanding the habitat relationships of a species is fundamental to conservation and management (Litvaitis et al. 1996; Sureda and Morrison 1999).

While managers are often (justifiably) concerned with issues pertaining to threatened or endangered species, more common and less conspicuous small mammals are an important component of local biological diversity and warrant responsible management. Small mammals can also be related to predator species of management concern; packrats and white-footed mice (*Neotoma* and *Peromyscus* species) captured in this study are important components of the diet of the federally threatened Mexican Spotted Owl (*Strix occidentalis lucida*) (Seamans and Gutierrez 1999), which nests in the Rincon Mountains.

Although small mammal distributions have been the focus of several studies in mountain ranges of southern Arizona, no published study has quantified small mammal microhabitat associations in these ranges. Microhabitat information from the Rincon Mountains is limited to reports of voucher specimens listed in Hoffmeister (1986) and unpublished reports or checklists used by Saguaro National Park (Dengler 1963, Hibbard 1979, Doll et al. 1989, Davis and Sidner 1992). Information for the Tucson Mountains is included in the checklist by Doll and colleagues (1989). Habitat information in these sources is limited to observational descriptions.

The objective of this study was to quantify influences of microhabitat characteristics on the relative abundance of small mammal species quantified within dominant vegetation types in Saguaro National Park, and on overall small mammal richness and relative abundance. These data will help resource managers to better understand potential impacts of resource use, and provide a basis for comparison in other regional studies.

MATERIALS AND METHODS

Saguaro National Park is comprised of 2 units, Rincon Mountain District (RMD) and Tucson Mountain District (TMD), each of which encompasses the majority of its respective mountain range. These units

are separated by the city of Tucson, Arizona. The Rincon Mountains is the largest roadless mountain range in southern Arizona, although it is flanked by housing developments to the south and west. The Tucson Mountain District is surrounded by urban development on 3 sides. The total area of the park is 41,300 hectares, of which 31,500 is designated wilderness. Elevations within the park range from 612 to 2642 m. Five life zones are present, from Arizona upland desertscrub where saguaro (*Carnegiea gigantea*), mesquite (*Prosopis* species), and palo verde (*Cercidium* species) dominate, to mixed conifer forests where pine and fir (*Pinus* and *Abies*) are dominant. Dominant vegetation communities are Madrean montane conifer forest, Madrean evergreen forest and woodland, Semidesert grassland, Interior southwestern riparian deciduous forest and Sonoran desertscrub (Brown 1982).

Plot location and grid layout

We randomly located 9 points within 3 elevational gradients in RMD, allocating points according to proportion of park area located in each gradient. We placed 2 points at low elevation (610 - 1220 m), 4 at mid elevation (1220 - 1830 m), and 3 at high elevation (1830-2640 m). We randomly located 4 points in TMD, though because of its relatively low elevation (760 to 1430 m) we did not stratify by elevation. We placed 3 trapping grids along a 1 km line bisecting each point ($n=13$), with a minimum distance of 200 m between grids. We marked the position of each grid on the ground and recorded its location with a GPS unit. We used 2 grid patterns; 3 rows each with 7 traps (25 m between rows, 15 m between traps within a row), and 5 rows each with 5 traps (uniform 12.5 m spacing). We visited all ($n=39$) trapping grids in spring and re-sampled 27 during the post-monsoon summer.

Mammal trapping

For all grids we used Sherman live traps baited with oatmeal, peanut butter, and black oil sunflower seeds. We maintained trap lines for three consecutive nights at each point. As a precaution against cold nighttime temperatures we dug small trenches for the traps and covered them with litter, leaving only the entry exposed. All traps were checked before sunrise to protect animals from daytime heat.

We identified animals using standard measurements. For each individual we recorded species, sex, age, reproductive condition, weight, lengths of right hind foot, tail, ear, and combined head and body. We made additional comments regarding specific identification characters. We marked each animal with a permanent black marker to facilitate recognition if recaptured.

Microhabitat sampling

We used the point-intercept method (Bonham 1989) to sample vegetation along a 50 m transect in each trapping grid. We used a 4 m pole to measure ground cover type, vegetation density and species composition along the transects. We classified ground cover as rock, bare ground, annual forb, grass, or woody debris. We measured density and composition of vegetation by recording the number and species of each vegetation contact with the measuring pole at 3 height categories (0-0.5, 0.5-2, 2-4 m), contacts were visually estimated in the highest category (> 4 m). We took pole measurements every 1 m along the 50 m transect.

Analysis

We expressed relative abundance as number of animals trapped per sample effort, with effort represented as number of trap-intervals (Beauvais and Buskirk 1999). We considered trap-intervals as the number of traps multiplied by the number of trap-nights, counting sprung traps as half-nights because of their unavailability once sprung (Beauvais and Buskirk 1999). We used vegetation species lists generated from point-intercept transects to categorize plots into 4 different categories; desertscrub, semidesert grassland, oak woodland-chaparral, and pine forest. Oak woodland and chaparral were combined due to small sample size of chaparral plots and the presence of burned oak woodland or scrub within these plots which created a mosaic of both vegetation communities (Table 1).

To determine which microhabitat variables influenced relative abundance of each mammal species, we used multiple regression analysis. We used vegetation density (total number of pole contacts) within each height category and ground cover types as explanatory variables and relative abundance within each grid as the response variable. Regression coefficients are interpreted as estimates of influence from microhabitat variables on relative abundance of small mammal species. Level of significance was arbitrarily set at $P < 0.10$. Use of multiple regression analysis to generate these values requires each estimate of influence to be considered in combination with all other microhabitat values rather than allowing estimates to be interpreted independently.

RESULTS

We captured a total of 575 individuals over the course of 174 nights on 39 trapping grids resulting in 4038 trapnights. After accounting for sprung traps (including misfires; $n=73$), adjusted trap success was 15.5%. We captured individuals of 14 species representing 7 genera. Fifty animals were identified to genera only; *Neotoma* ($n=7$), *Peromyscus* ($n=21$), or *Chaetodipus* ($n=22$). We captured fewer than 20

individuals of 4 species; yellow-nosed cotton rat (*Sigmodon ochrognathus*) ($n=2$), Arizona cotton rat (*Sigmodon arizonae*) ($n=1$), deer mouse (*Peromyscus maniculatus*) ($n=1$), and Harris' ground squirrel (*Ammospermophilus harrisi*) ($n=1$); species with larger sample sizes were included in analysis (Tables 1 and 2).

Vegetation type associations

Statistically significant associations ($P<0.10$) with vegetation type were found for 7 of 10 species (Table 1); influences of vegetation type were not significant for *N. albigula* though a microhabitat association was found for this species. Model fit for *C. penicillatus* was close to significant ($P=0.0108$), and so associations were considered for this species. Desertscrub was associated with highest relative abundances of most species; *D. merriami* (mean 0.021, SE 0.011), *P. amplus* (mean 0.033, SE 0.008), *C. baileyi* (mean 0.026, SE 0.006), *C. intermedius* (mean 0.029, SE 0.018), and *C. penicillatus* (mean 0.05, SE 0.016). Semidesert grassland had highest frequency of *P. eremicus* (mean 0.019, SE 0.005), oak woodland/chaparral was associated with greatest relative abundance of *P. boylii* (mean 0.08, SE 0.014), and pine forest had the highest number of *N. mexicana* (mean 0.023, SE 0.006) and *E. dorsalis* (mean 0.025, SE 0.005).

Ground cover associations

All ground cover types were found to have significant ($P<0.10$) associations for 1 or more mammal species, and relative abundance of 7 of 10 species were influenced ($P<0.10$) by 1 or more ground cover types (Table 2).

No meaningful relationships were found for *Neotoma* species, though *N. albigula* showed a slight negative response (estimate -0.001, SE 0.001) to forb cover. *P. eremicus* abundance decreased (estimate -0.041, SE 0.024) with a combination of forb and rock cover, *P. boylii* was negatively associated with forbs (estimate -0.002, SE 0.001) and woody debris (estimate -0.018, SE 0.005). Grass cover had positive influence on abundance of 3 *Heteromyid* species, although *C. baileyi* showed stronger responses to woody debris (estimate of 0.014, SE 0.002) and a forb/grass combination (estimate 0.003, SE 0.002), and bare ground had an additional (although weak) influence on *P. amplus* (estimate 0.001, SE 0.001) and *D. merriami* (estimate 0.002, SE 0.001). *D. merriami* was also negatively associated with woody debris (estimate -0.008, SE 0.004). *E. dorsalis* abundance was positively influenced by rock cover (estimate 0.001, SE <0.001).

It is worthwhile to note that the largest estimates of influence of ground cover were with overall species richness; we found that overall richness increased with grass cover (estimate 0.1, SE 0.056) and bare ground (estimate 0.064, SE 0.038), and decreased with forb cover (estimate 0.056, SE 0.03). Overall species abundance was influenced only by presence of bare ground (estimate 0.009, SE 0.004). *N. mexicana*, *C. intermedius*, and *C. penicillatus* were the only species for which we did not find a ground cover association, although the pocket mice did display a relationship with vegetation structure.

Vegetation density associations

Vegetation density had significant ($P < 0.01$) association with relative abundance for 7 of 10 species (Table 3); density failed to affect abundance of either *Neotoma* species or of *C. baileyi*. Frequency of all 7 species showing a significant relationship was associated with low cover (vegetation density below 0.5 m). The only species showing a response greater than 0.001 were *C. intermedius* (estimate 0.002, SE 0.001) and *C. penicillatus* (estimate -0.003, SE 0.001). In general, relationships to low cover were negative; overall species abundance was negatively associated (estimate -0.005, SE 0.002) with density in this height. *P. eremicus* showed a slight negative relationship with density in the 2-4 m category, but there were no other trends in height between 0.5 and 4 m. In the highest category (>4 m), 2 species showed slight positive response to vegetation density; *P. eremicus* (estimate 0.001, SE 0.001) and *E. dorsalis* (estimate 0.001, SE <0.001). Negative responses were stronger; *P. boylii* abundance was influenced the most (estimate -0.004, SE 0.001), *D. merriami* less so (estimate -0.002, SE 0.001). In general associations with high cover were negative, overall abundance was negatively influenced by cover above 4 m (estimate 0.011, SE 0.006).

DISCUSSION

In general, associations with vegetation type and microhabitat influences illustrated by this study are consistent with those reported by other researchers (e.g. Wilson 1968, Price 1978, Stamp and Ohmart 1979, Hoffmeister 1986, Sureda and Morrison 1999). Estimates of influence from ground cover type were greater than those from vegetation density.

C. baileyi and *C. penicillatus* are often sympatric; Hoffmeister's (1986) summary describes differences in habitat and ecological niche between the two as unclear. We found no significant ground cover associations for *C. penicillatus*, although sample size was higher for this species. We found relative abundance of *C. baileyi* to have a strong response to woody debris and slight association with grass cover. Association with woody debris has not been previously reported, though Stamp and Ohmart (1979)

encountered both species in areas without grasses and *C. baileyi* without *C. penicillatus* in grassy areas. We found no positive relationships between either *Chaetodipus* species and shrub or tree density, though Price (1978) found both to prefer large bushes and trees and Stamp and Ohmart (1979) linked *C. penicillatus* to high perennial cover. In fact, aside from a shared preference for desertscrub we found almost no overlap between these species; our entire sample of *C. penicillatus* ($n=44$) was trapped in 2 visits to a bajada locality (elevation 685 m) west of the Tucson Mountains where we found only 4 *C. baileyi*. The remainder of our *C. baileyi* sample ($n=30$) was trapped in 7 localities in both the Tucson and Rincon mountains, at elevations up to 1400 m. It is possible that macrohabitat features may better explain habitat preferences of these species, at least within Saguaro National Park. We did find agreement with Stamp and Ohmart's association of *D. merriami* with open to grassy (patchy) areas in desert scrub. Associations for *P. amplus* were similar to those of *D. merriami*, as there were no areas where the latter was trapped without the former.

Surprisingly, we did not find an association between *Chaetodipus intermedius* and rock cover, despite the fact that rock pocket mice represented our largest sample size ($n=149$). Hoffmeister (1986) suggests that in places where *C. intermedius* is found without rocky cover they have been forced into the area by population pressure from conspecifics living in preferred habitat. Our data may support this concept; our few plots which did have high rock cover also had high relative abundance of *C. intermedius*, though this relationship was confounded by a high frequency of occurrence in other areas. Vegetation type association was consistent with Hoffmeister, we found *P. amplus* in desertscrub.

Neotoma mexicana, another species thought to be associated with rocky habitat (Burt and Grossenheider 1980), also failed to show an association with rock substrate, though other researchers have noted this association as dependant on macrohabitat features (Sureda and Morrison 1999). Presence of this species in pine forests agrees with findings of these authors. *Neotoma albigula* showed no preference for vegetation type, a weak negative response to forb cover and no other significant associations; this species likely responds to variables not considered here such as presence of *Opuntia* (prickly pear and cholla cactus) for food and den construction (Vorhies and Taylor 1940, Hoffmeister 1986).

Peromyscus eremicus appeared as a habitat generalist within low to mid elevations (semidesert grasslands) as reported elsewhere (Stamp and Ohmart 1979, Hoffmeister 1986), showing conflicting response to microhabitat variables. As did other researchers (Wilson 1968, Hoffmeister 1986), we found *Peromyscus boylii* in higher elevations (primarily oak woodland/chaparral though also pine forest), but

we found the species unrelated to heavy brush and rocks. Other studies have reached similar findings (Sureda and Morrison 1999). *Eutamias dorsalis* was associated with rocks and taller trees in pine forest, as reported from other locations (Hoffmeister 1986).

While management based on habitat associations measured at this scale is not practical, these results contribute to an understanding of the basic ecology of these species, particular to this region. Knowledge of specific associations facilitates accurate predictions of how management decisions at the larger scale will affect individual species, and can facilitate interpretation of changes in small mammal community characteristics over time.

ACKNOWLEDGMENTS

We thank Brian Powell of the Sonoran Desert National Parks Inventory and Monitoring Program for facilitating and coordinating this project, Neil Perry and Jason Schmidt for long hours in the field and office collecting and managing data, Aaron Flesch for assistance with data analysis and Bob Steidl for statistical guidance.

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