Demographic features and habitat preferences of southern pygmy mice (*Baiomys musculus*) in Colima, Mexico

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Abstract: In Colima, Mexico, we conducted 8-night mark–recapture grid studies of southern pygmy mice (*Baiomys musculus* (Merriam, 1892)) in January 2003–2007 in dry deciduous and tropical moist forests. For 40 000 trap-nights, 436 individuals were captured 764 times (comprising 18.6% of small mammals). The male:female ratio was 1:1.37, 82.9% were adults, 51.4% of females were pregnant or lactating, and coastal animals, on average, were heavier than those inland. Females moved farther than males. *Baiomys* was on 17 of 25 grids (densities 1.82–106.24 individuals/ha). Moon illumination did not affect capture or recapture probabilities, but trap-night did (overall, probability increased 1.66%/night). Grids with *Baiomys* had less bare ground and a more open canopy. Capture sites had more grass, less dead wood and bare ground, a more open and lower canopy, and greater distance to trees. Logistic regression indicated coastal capture sites had more forbs, grasses, and woody plants, and thicker vegetation at 1 m height with trees being relatively distant. Variables differed somewhat for northern sites, and the equation for all grids included 10 of 14 environmental variables. *Baiomys* frequented edge of an unimproved road traversing one grid. *Baiomys musculus*, widespread in Colima, exhibited preference for habitats with relatively dense ground cover and at least a partially open canopy.

Résumé : Nous avons mené des études de marquage–recapture de 8 nuits de souris pygmées du sud (*Baiomys musculus* (Merriam, 1892)) sur grilles en janvier 2003–2007 en forêt décidue sèche et en forêt tropicale humide à Colima, Mexique. Au cours de 40 000 pièges-nuits, nous avons capturé 436 individus à 764 reprises (représentant 18,6 % des petits mammifères). Le rapport mâles:femelles était de 1:1,37; les adultes représentaient 82,9 % des captures; 51,4 % des femelles étaient enceintes ou allaitaient; les animaux de la côte étaient en moyenne plus lourds que ceux de l'intérieur. Les femelles se déplaçaient plus loin que les mâles. Les *Baiomys* étaient présents sur 17 des 25 grilles (densités de 1,82–106,24 individus/ha). L'éclairement de la lune n'affectait pas les probabilités de capture ou recapture, mais la nuit de trappage avait une influence (globalement, la probabilité augmentait de 1,66 % / nuit). Les grilles contenant des *Baiomys* avaient moins de sol découvert et une canopée plus ouverte. Les sites de capture se caractérisaient par une herbe plus abondante, une importance réduite du bois mort et du sol découvert, une canopée plus basse et plus ouverte et une distance plus grande des arbres. Une régression logistique indique que les sites de capture sur la côte possèdent plus de plantes herbacées, d'herbes et de plantes ligneuses, que la végétation est plus dense à la hauteur de 1 m et que les arbres sont relativement éloignés. Les variables sont un peu différentes dans les sites nordiques et les équations pour toutes les grilles incluent 10 des 14 variables environnementales. Des *Baiomys* fréquentaient la bordure d'une route non améliorée qui traversait une des grilles. Les *Baiomys musculus*, très répandus à Colima, montrent une préférence pour les habitats qui possèdent une couverture végétale au sol relativement dense et une canopée au moins partiellement ouverte.

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Introduction

The southern pygmy mouse (*Baiomys musculus* (Merriam, 1892)) is distributed from southwestern Nayarit and central Veracruz in Mexico to northwestern Nicaragua, although it is not present on the Yucatan Peninsula or in the Caribbean tropical lowlands (Wilson and Reeder 2005). Analysis of mitochondrial DNA sequences from the cytochrome-*b* gene indicates genetic subdivision of populations in Jalisco, Colima, and Michoacán from those farther to the south and east (Amman and Bradley 2004). This species originally was described as *Sitomys musculus* by Merriam (1892), with the type specimen from near Colima, Colima, Mexico. Its close relationship with the northern pygmy mouse (*Baiomys taylori* (Thomas, 1887)) was recognized early. Mearns (1907) was the first to consider *Baiomys* to be a distinct genus and to use the current name combination *Baiomys musculus* (Packard and Montgomery 1978).

Much less is known about *B. musculus* than its more northerly congener, *B. taylori*. In particular, descriptions of its ecology, demographics, and habitat use, while known to be varied, have been described only in general terms. The primary informational sources are Packard's (1960) monograph on the genus *Baiomys* that included detailed information on *B. musculus* and a later literature summary (Packard and Montgomery 1978) containing a review of data existing at the time. The species has a relatively extensive distribution and has not been considered to be of particular conservation concern. However, over much of its range, *B. musculus* primarily is found in Pacific tropical subtropical dry forest, which increasingly is being subjected to habitat degradation and widespread clearing (Sánchez-Azofeifa et al. 2005). The present status of *B. musculus* throughout its range is not well documented, and it is becoming increasingly difficult to study the species in relatively undisturbed habitats.

For >35 years, the authors have conducted surveys of small mammals throughout the state of Colima, Mexico. Our findings and those of other investigators indicate that *B. musculus* occurs throughout much of the state (Fig. 1) in a variety of habitats. Indeed, at many sites, we found *B. musculus* to be one of the most common rodents encountered. Over a 5-year period (2003–2007) we have conducted detailed studies of the mammalian fauna at three locations using short-term mark–recapture techniques on a series of 25 trapping grids. This approach has allowed us to learn considerably more about the ecology, demography, and habitat use of several species of small mammals, including *B. musculus*. While our multiyear investigation has focused on a particular time of year (the dry season in January), much of what we have learned should be directly applicable to other months of the year. For this project, our objectives were (*i*) to identify basic ecological characteristics of *B. musculus*, including core demographic features such as sex ratio, reproductive status, and age structure; (*ii*) to investigate in detail habitat use by *B. musculus*; (*iii*) to obtain robust estimates of population density and of probability of capture; and (*iv*) to acquire information on relative movement by males and females. For comparisons, we obtained data from two habitat regions (coastal dry forest and upland moist forest) using identical methods. We also sampled the major habitat types within each study site.

Materials and methods

Study area and trapping

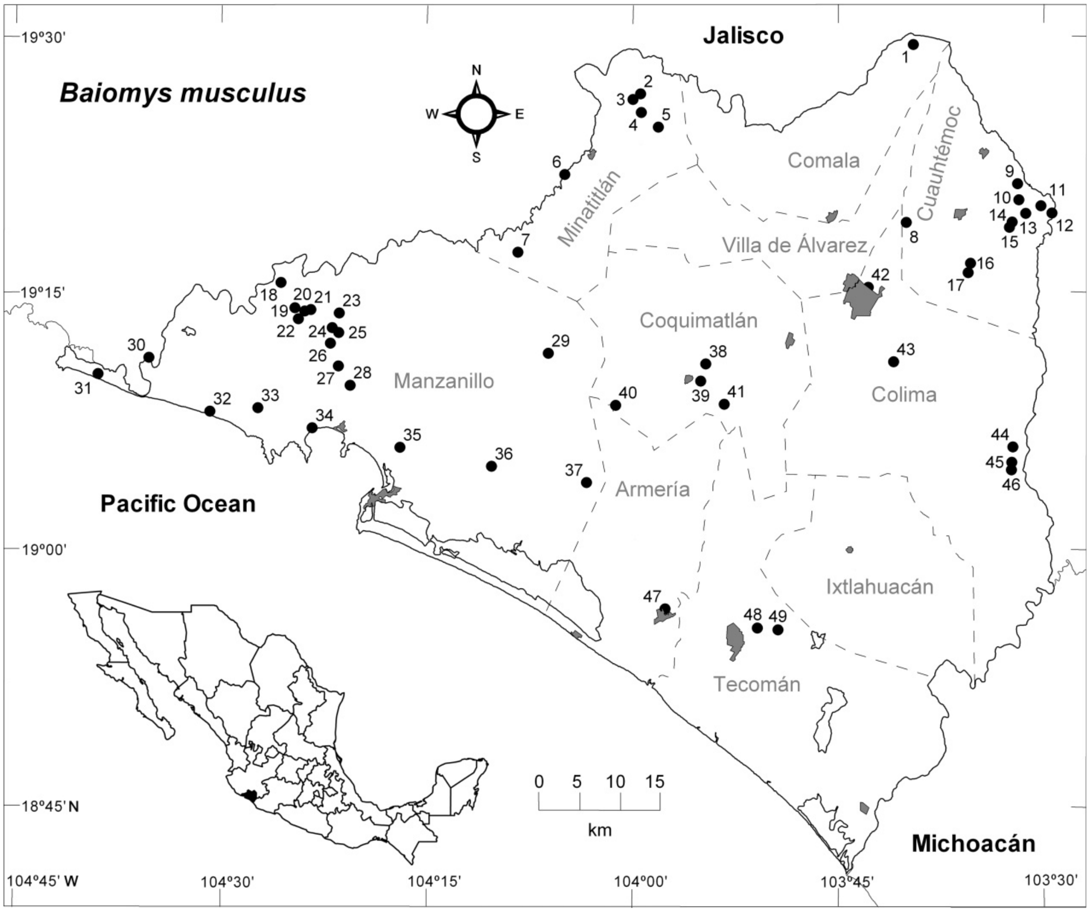
This study was conducted at three locations within the state of Colima, Mexico. The initial study site was in coastal habitat immediately adjacent to the Pacific Ocean at Playa de Oro (Fig. 1, locality 32), where detailed ecological investigations were conducted in 2003, 2004, and 2005. In 2006 and 2007, our research moved inland to northern Colima at Rancho La Angostura (locality 8 in 2006) and to sites in the vicinity of the Miguel de la Madrid Airport (locality 17 in 2006 and 2007, and locality 16 in 2007).

The study grids at Playa de Oro were within 1 km of the ocean at elevations <10 m above sea level (asl), and each grid was uniquely located so that none of the 15 grids (5/year) overlapped spatially. As described by Schnell et al. (2008), reporting on a parallel study of the marsh mouse (*Peromyscus perfulvus* Osgood, 1945), the habitat at Playa de Oro was primarily tropical dry deciduous forest, with thorn-forest and mangrove elements. Prominent trees and shrubs included *Coccoloba barbadensis* Jacq., several *Acacia* Mill. including *Acacia hindsii* Benth. and *Acacia farnesiana* (L.) Willd., *Senna pallida* (Vahl) H.S. Irwin & Barneby and *Senna occidentalis* (L.) Link, *Pithecellobium lanceolatum* (Willd.) Benth. and *Pithecellobium dulce* (Roxb.) Benth., *Hyperbaena ilicifolia* Standl., *Crataeva tapia* L., *Prosopis juliflora* (Sw.) DC., and *Guazuma ulmifolia* Lam. Grazing occurred in the area, but major portions of our study grids were not accessible to livestock because of the thickness of the vegetation. Much of the area in the vicinity of our study grids was in agriculture, and parts had been cleared for planting of coconut palms (*Cocos nucifera* L.).

For the inland study sites in northern Colima, elevation ranged from about 700 to 765 m asl. At Rancho La Angostura (locality 8), vegetation included in our grids was tropical moist forest (i.e., tropical subdeciduous forest), but the overall landscape was highly fragmented for cultivated agriculture (mainly oranges and limes; genus *Citrus* L.) and livestock; even so, some areas still retained the original vegetation, where trees were >30 m in height, with some (genus *Ficus*) up to 5 m in diameter. Along the fringes of water courses that bordered agricultural lands of the ranch, some gallery forest persisted. The majority of habitat sampled at this site was open understory within heavily shaded gallery forest with tall trees 5–40 m in height; numerous species of trees were present, the most abundant being *Alnus* P. Mill., *Salix humboldtiana* Willd., *Salix bonplandiana* Kunth, *Cecropia obtusifolia* Bertol., *Ficus*, and *Inga eriocarpa* Benth. (Schaldach 1963). A coffee-tree (*Coffea arabica* L.) plantation was present below this canopy of trees.

Our second set of inland sites was located on property adjacent to the Miguel de la Madrid Airport (localities 16 and 17). While these areas had been highly fragmented and used for agriculture in the past, they have been protected and relatively undisturbed for the past 30 years. Because there had been little alteration, much of the area studied had reverted to tropical moist forest intermixed with grass-dominated habitat (genus *Andropogon* L., often >2 m tall). Characteristic trees were *Brosimum alicastrum* Sw., *Sideroxylon cartilagineum* (Cronquist) T.D. Penn., *Coussapoa*

Fig. 1. Map indicating localities in Colima, Mexico, where the southern pygmy mouse (*Baiomys musculus*) has been captured. Some numbered symbols represent multiple localities that are geographically close (for a list of localities see Table A1). Inset map in lower left indicates location of Colima in Mexico. Grids in coastal Colima were at locality 32, while grids in northern Colima were at localities 8, 16, and 17. Bodies of water are shown (outlined), as are some cities and towns (shaded). Broken lines indicate geographic boundaries of 10 municipalities in the state that are named after the principal city or town in each.



purpusii Standl., *Hura polyandra* Baill., *Guarea glabra* Vahl, *Dendropanax arboreus* (L.) Dcne. & Planch. ex Britt., and *Populus guzmanantlensis* A. Vázquez & Cuevas (Schaldach 1963).

Trapping sessions were in January of each year during the annual dry season. Typically, at this time of year, days were warm and nights were cool (January mean temperature of 24.8 °C for Manzanillo; Instituto Nacional de Estadística, Geografía e Informática 1999). There was little day-to-day variation in temperature during our study, and there was virtually no rain. For each trapping night for each year, we obtained information on the fraction of the moon illuminated from the US Naval Observatory (http://aa.usno.navy.mil/data/docs/MoonFraction.php [accessed 20 June 2007]).

Five trapping grids were established each year (25 total for the 5 years). Grids were dispersed within trapping locations to maximize coverage of the varying vegetation types (Table 1). Each grid consisted of 100 trap stations (10 × 10 square grid), with adjacent stations located 10 m apart. Two Sherman live traps (7.5 cm × 9.0 cm × 23.0 cm; H.B. Sherman Traps, Tallahassee, Florida) were placed at each station, one on the ground and another 1–2 m above ground on a thin plywood platform (12.5 cm × 34.5 cm) attached to a tree or a shrub (hereinafter referred to as arboreal traps). Traps were baited with rolled oats. In all but two cases, grids were sampled for 8 nights (Table 1); the exceptions were grid 5 in 2004, which was run for 9 nights, and grid 1 in 2005, which was checked for 7 nights. Thus, the overall sampling effort on the grids involved 40 000 trap-nights (1 trap-night = 1 trap set for 1 night).

Traps were checked once each day starting at dawn, rebaited as needed, and opened for the full 24 h period. For all *B. musculus*, we recorded trap position (i.e., location in grid and ground vs. arboreal), sex, reproductive status (i.e., judged as reproductively active or not active depending on external condition of reproductive organs), and age (adult or juvenile, based on size, mass, and pelage coloration, for which upper parts of adults vary from dark reddish brown to nearly black, while juveniles tend to be uniformly dusky gray; Packard and Montgomery 1978). Typically, animals were tagged in both ears using uniquely numbered Monel No. 1 ear tags (National Band and Tag Company, Newport, Kentucky) and released at site of capture. For some animals in 2007, only a single ear tag was used.

Distributions of *B. musculus* and *B. taylori* are reported to overlap within a portion of the state of Colima (Packard 1960). Therefore, careful consideration was given to taxonomic verification. In the field, *Baiomys* were identified as

Table 1. Brief description of each grid used in study of southern pygmy mouse (*Baiomys musculus*) in Colima, Mexico, with January sampling dates indicated.

Grid no. (January dates)	Description
2003 (coastal Colima)	
1 (2–5, 9–12)	Thorn forest with some palm trees in proximity to mangroves
2 (2–5, 9–12)	Thorn forest with some palm trees in proximity to mangroves
3 (3–5, 9–13)	Thorn forest adjacent to palm plantation
4 (3–5, 9–13)	Thorn forest adjacent to palm plantation
5 (3–5, 9–13)	Mixture of grassy plots and palm trees associated with undergrowth of thorn forest
2004 (coastal Colima)	
1 (3–5, 9–13)	Mixture of thorn forest and mangrove, with some palms
2 (2–5, 9–12)	Mixture of thorn forest and mangrove, with some palms
3 (2–5, 9–12)	Thorn forest in proximity to palm plantation
4 (3–5, 9–13)	Mixture of grassy plots, palm trees, and thorn forest adjacent to agricultural fields
5 (2–5, 9–13)	Mixture of grassy plots, palm trees, and thorn forest adjacent to agricultural fields
2005 (coastal Colima)	
1 (4–6, 10–13)	Dense thorn forest with abundance of woody vines
2 (3–6, 10–13)	Thorn forest mixed with mangrove and palm trees with dense undergrowth
3 (2–6, 10–12)	Mixture of thorn forest, grassy plots, and xerophilous scrubs
4 (2–6, 10–12)	Mixture of grassy plots, palm trees associated with dense undergrowth of thorn forest, and patches of mangrove
5 (3–6, 10–13)	Mixture of grassy plots, palm trees, and thorn forest
2006 (northern Colima)	
1 (2–6, 10–12)	Tropical deciduous forest with tall, mature trees and dense understory, bordered by small stream
2 (2–6, 10–12)	Tropical deciduous forest with tall, mature trees and dense understory, bordered by small stream
3 (3–6, 10–13)	Thorn forest with sparse understory vegetation intermixed with patches of tall grass (height ca. 1.0–1.5 m)
4 (3–6, 10–13)	Thorn forest with patches of tall grass associated with small stream and riparian habitat of dense vines and large deciduous trees
5 (3–6, 10–13)	Thorn forest with sparse understory vegetation intermixed with patches of tall grass (height ca. 1.0–1.5 m)
2007 (northern Colima)	
1 (2–6, 10–12)	Tropical deciduous forest with some mature trees, thin or sparse understory with some young thorn trees. Included partially cleared, unimproved road traversing grid
2 (2–6, 10–12)	Mixture of tropical deciduous with large, mature trees and thorn-forest elements
3 (2–6, 10–12)	Dense thorn forest with vines creating low, thick canopy cover. Some areas with mature deciduous trees and others with patches of tall grass in open areas
4 (3–6, 10–13)	Dense thorn forest with vines creating low, thick canopy cover. Some areas with mature deciduous trees and others with patches of tall grass in open areas
5 (3–6, 10–13)	Tall dense grasses (1.0–3.0 m) with isolated trees

B. musculus on the basis of body shape, body size, and hindfoot length (Packard 1960; Packard and Montgomery 1978; Eshelman and Cameron 1987). Voucher specimens were preserved from each location and identifications confirmed in the laboratory by examining the rostrum and other aspects of the skull. In addition, mitochondrial DNA sequences from the cytochrome-*b* gene for specimens collected at Playa de Oro were compared with published sequences known to discriminate between *B. musculus* and *B. taylori* (M.C. Wooten, data not shown). All evidence was consistent with the presence of only one species, *B. musculus*, at our three study locations.

Estimation of movement, abundance, and density

For each *B. musculus* captured more than once, we determined the mean distance of its trapping locations from the centroid of those capture sites, a distance hereinafter referred to as distance from centroid (note that for an animal caught twice or more, but always at the same location, the resulting distance was 0 m). This approach to assessing movement is related to the center-of-activity concept as put forth initially by Hayne (1949).

The computer program MARK (White and Burnham 1999; White 2007) was used to estimate abundance (i.e., population size) of *B. musculus* on grids and to estimate probability of capture on a given night. Based on the assumption of a closed population during the trapping period, the program compares relative proportions of marked and unmarked animals in successive samples to provide estimates of abundance, with parameters modeled as functions of each other. We used the closed-capture option. Two parameters considered were p, the probability of capture, and c, the probability of recapture; these in turn were involved in estimating N, the abundance for a given grid. We employed two models indicated by $p(t) = c(t)$, where p and c were modeled as equal but could vary with time (t; i.e., night): model 1, where values were considered to be the same for all coastal grids (2003–2005) and the same for all northern grids (2006–2007), but not necessarily the same for the two areas; and model 2, where values for each of the 17

Table 2. Mean (±SD) values of 14 independent variables measured to provide quantitative assessment of vegetation structure on trap grids used to ascertain habitat preferences, contrasting trap stations where southern pygmy mouse (*Baiomys musculus*) was captured and not captured in Colima, Mexico.

	2003–2005 (coastal Colima)		2006–2007 (northern Colima)		2003–2007 (all Colima grids)	
Variable	Captured (n = 135)	Not captured (n = 1365)	Captured (n = 315)	Not captured (n = 685)	Captured (n = 450)	Not captured (n = 2050)
1. Percent woody plants	5.8±11.69	6.2±9.56	4.1±8.85***	6.6±10.13	4.6±9.81**	6.3±9.75
2. Percent forbs	23.4±26.59***	8.4±15.11	7.8±11.35	7.4±11.21	12.5±18.77***	8.1±13.93
3. Percent grasses	20.4±32.13***	5.1±15.63	32.6±34.15***	23.1±32.84	29.0±33.98***	11.1±24.39
4. Percent litter	26.4±23.68***	42.8±25.07	35.3±27.90	35.6±25.15	32.6±26.99***	40.4±25.32
5. Percent dead wood	8.9±14.75***	15.7±15.08	6.1±9.46***	9.5±10.18	7.0±11.37***	13.6±13.95
6. Percent rocks	0.2±0.69	0.6±3.63	8.9±13.92	9.0±12.52	6.3±12.32***	3.4±8.77
7. Percent bare ground	15.0±16.07**	21.3±22.07	5.1±8.01***	8.7±10.66	8.0±11.94***	17.1±19.94
8. Mean no. of hits at 1 m	2.15±2.524***	1.39±1.617	5.69±7.760***	3.91±5.976	4.63±6.830***	2.23±3.882
9. Percent canopy closed	61.0±36.50***	81.7±25.19	53.7±35.72***	64.6±33.12	55.9±36.07***	76.0±29.22
10. Slope (°)	3.4±3.67	4.0±6.29	5.6±6.66***	9.5±9.41	4.9±6.00*	5.8±7.91
11. Total hits low	3.93±3.219	3.46±3.832	7.36±4.694**	6.42±4.594	6.33±4.579***	4.45±4.332
12. Total hits high	3.50±4.474***	5.88±7.186	2.33±3.852***	4.18±6.987	2.68±4.079***	5.31±7.164
13. Maximum canopy height (m)	6.2±4.04***	7.5±3.59	6.1±4.86***	10.3±9.83	6.1±4.63***	8.5±6.53
14. Mean distance to nearest tree (m)	7.2±1.97***	5.6±2.34	5.6±3.18***	4.4±2.73	6.1±2.96***	5.2±2.54

Note: Statistical differences evaluated using a one-way ANOVA: *, $P < 0.05$; **, $P < 0.01$; ***, $P < 0.001$; no symbol, $P > 0.05$.

grids were estimated separately and independently. Models were compared using the Akaike information criterion as modified to adjust for small-sample bias (AIC$_c$; White 2007).

To convert abundance values into densities, it was necessary to estimate the area of effect of a grid. The immediate area of the grid (8100 m^2; 90 m × 90 m) does not take into account the effective area of the grid outside the outer traps. To estimate area of the edge, we calculated mean distance from centroid, with equal weight being given to each individual mouse caught more than once. The resulting value was added to each side of the central portion of the grid, and we considered corners of the grid area to be rounded with a radius equal to this mean distance from the centroid. Using distance from centroid as reported in the Results, the effective area of each grid was estimated to be 1.098 ha, a value divided into abundance values from MARK to obtain density (no. of individuals/ha) estimates.

Structure of vegetation

Following Schnell et al. (2008), we quantified structure of vegetation by evaluating 14 characteristics (Table 2). For 2004–2007, measurements were made at points about 1 m from each trap station (2000 points total). Percentage of ground cover was estimated (to nearest 5%) for a 1 m square (first seven variables in Table 2). Number of shrub stems hitting a 1 m bar at 1 m height was determined four times (once in each cardinal direction from the central point) and the mean calculated (variable 8). Canopy cover (i.e., percent canopy closed, variable 9) was estimated using a spherical densitometer (model C, Forest Densitometers, Bartlesville, Oklahoma), as was slope (variable 10) with a clinometer. Using a 7.5 m vertical pole marked at each decimetre, we determined the number of decimetre intervals within which vegetation touched the pole; the resulting data were summed for 0–2.5 m (maximum of 25 hits; variable 11) and 2.5–7.5 m (maximum of 50 hits; variable 12). Maximum height of canopy was estimated to the nearest 0.5 m (variable 13). Distance to nearest tree (10 cm diameter at breast height (dbh) or greater) was determined in each of four quadrants (with edges being the cardinal directions) and the mean calculated (variable 14); distances 10 m or greater were tabulated as 10 m.

In 2003, similar measures were taken, but at 25 points/grid instead of 100. The 25 were equally spaced among trap sites. With the resulting values for each variable, we estimated the variable for each trap station using ordinary and point kriging in the computer program Surfer version 8 (Golden Software, Inc. 2002). Resulting values were then treated the same as those for the other years.

Other statistical analyses

We examined the relationship between vegetation characteristics of trap stations where *B. musculus* was captured and not captured using stepwise logistic regression (Systat Software, Inc. 2004*a*). Presence or absence (1 or 0, respectively) of *B. musculus* was the dependent variable, with the 14 structural vegetation variables used as potential independent variables. The significance to include or remove a variable was set at 0.05. McFadden's ρ^2 statistic, which can vary from 0 to 1, was used to evaluate the resulting models as a whole. It mimics R^2, with higher values indicating more significant results; ρ^2 values tend to be lower than R^2 values (Steinberg and Colla 2004; 0.20–0.40 have been considered to be very satisfactory), but low values do not necessarily indicate poor fit of the model.

SigmaPlot version 9 (Systat Software, Inc. 2004*b*) was used to compare graphically vegetation variables for stations where *B. musculus* was captured and not captured. We also employed Surfer version 8 and kriging to map estimated levels for one variable across the complete area of one of the grids. BIOMstat for Windows 3.3q (Rohlf and Slice 1999) was used for a variety of univariate analyses. These included row-by-column (R × C) and goodness-of-fit tests for analysis of frequencies, and one-way ANOVAs, two-way ANOVAs, linear regressions, and correlations in assessments of continuous variables. Multiple-regression analysis was conducted using SigmaStat version 3.5 (Systat Software, Inc. 2006).

Results

General demographic characteristics

Baiomys musculus occurs throughout the state of Colima, Mexico (Fig. 1; for a list of localities see Table A1) based on specimens from our studies and those collected by other investigators. During 5 years (2003–2007) involving 40 000 trap-nights on grids, we captured 436 individuals a total of 764 times. Most were caught in the traps at ground level (725 of 758 for which the specific trap was recorded; 95.6%).

Across all years, the majority of *B. musculus* captured were adults, with mice classified as subadults or juveniles encountered <18% of the time: 2003, 56 adults of 71 (78.9%); 2004, 47 of 49 (95.9%); 2005, 11 of 13 (84.6%); 2006, 44 of 55 (80.0%); 2007, 200 of 244 (82.0%); and all years, 358 of 432 (82.9%). No significant difference among years was detected in the percentage of captures that were of adults (R × C test, $G = 9.24$, df = 4, $P = 0.056$).

Numbers of adult *B. musculus* of each sex each year were as follows: 2003, 24 males and 32 females (57.1% females); 2004, 21 and 26 (55.3%); 2005, 6 and 5 (45.5%); 2006, 18 and 26 (59.1%); 2007, 82 and 118 (59.0%); and all years, 151 and 207 (57.8%). Thus, we captured more females than males in 4 of the 5 years; in 2005, when only 11 individuals were caught, more males were recorded. We evaluated whether the sex ratio differed from 1:1 for each year individually and for all years pooled. For individual years 2003 through 2006, no deviation from the expected 1:1 sex ratio could be demonstrated statistically (goodness-of-fit tests, $G = 1.15$, 0.53, 0.09, and 1.46, respectively, df = 1, all $P > 0.05$). However, for 2007, significantly more females were caught than males ($G = 6.52$, df = 1, $P = 0.011$). Likewise, for all years pooled, there were significantly more females than males ($G = 8.80$, df = 1, $P = 0.003$). No significant heterogeneity was detected in the sex ratio among years ($G = 0.953$, df = 4, $P = 0.917$), and overall sex ratio (males:females) of captured individuals was 1:1.37.

We recorded reproductive condition for 183 adult females. The numbers of females pregnant or lactating by year were as follows: 2003, 15 of 19 (78.9%); 2004, 12 of 15 (80.0%); 2005, 3 of 5 (60.0%); 2006, 14 of 26 (53.8%); 2007, 50 of 118 (42.4%); and all years, 94 of 183 (51.4%). For statistical assessment, the small sample for 2005 was pooled with that for 2004. Significant differences among years were detected in the percentage of adult females that were pregnant or lactating (R × C test, $G = 14.79$, df = 3, $P = 0.002$). In a posteriori comparisons, there were three statistically nonsignificant subsets of years: (1) 2003, 2004–2005, and 2006; (2) 2006 and 2007; and (3) 2004–2005 and 2007. While the results are not clearcut statistically, it appears as if in January a higher proportion of females were reproductively active in coastal than inland populations.

For 172 adult animals, we used a two-way ANOVA to evaluate possible differences in mass, considering both sex (male and female) and location (coastal and northern Colima). We found a significant difference for sex ($F_{1,168]} = 6.160$, $P = 0.014$) and for location ($F_{[1,168]} = 9.16$, $P = 0.003$); females were larger than males, and coastal animals were larger than those in the north. There was no significant interaction of the two factors ($F_{[1,168]} = 0.01$, $P = 0.910$), indicating that there is no evidence of proportional sexual differences varying between coastal and northern Colima. Means and standard deviations were as follows: coastal males, 12.42 ± 1.782 g ($n = 32$, range 9.0–16.0 g); coastal females, 13.30 ± 1.911 g ($n = 33$, range 10.0–16.5 g); northern males, 11.43 ± 1.552 g ($n = 44$, range 8.0–15.0 g); and northern females, 12.24 ± 2.696 g ($n = 63$, range 5.5–19.5 g).

A two-way ANOVA was applied to determine whether distance moved by adult animals varied based on sex or location (i.e., coastal vs. northern) or both. On average, females moved significantly farther than males ($F_{[1,168]} = 5.97$, $P = 0.016$), but no significant difference was detected for location ($F_{[1,168]} = 3.01$, $P = 0.085$); no interaction of sex and location was evident ($F_{[1,168]} = 0.14$, $P = 0.710$). Pooling location data, the mean of the mean distance from centroid for males was 5.86 ± 7.184 m ($n = 76$, range 0–44.7 m), while that for females was 9.10 ± 10.596 m ($n = 96$, range 0–45.0 m).

Pooling all *B. musculus*, irrespective of sex or age, the mean distance from centroid was 7.52 ± 9.295 m ($n = 184$, range 0–45.0 m). This mean was added to each side of the central portion of the grid (90 m × 90 m) and corners were estimated as having an equivalent radius; thus, effective area of a grid was estimated to be 1.098 ha.

We captured *B. musculus* on 17 of the 25 grids, with number of individuals ranging from 2 to 86 (Table 3). Based on our model 1, where estimates of abundance where obtained considering coastal grids and northern grids as separate groups, abundances for the different grids varied from 2.00 to 116.65 individuals/grid (Table 3); these values translate to density estimates of 1.82–106.24 individuals/ha. Estimates of total numbers of individuals present based on model 2 (with each grid estimated separately and independently) were similar, ranging from 2.00 to 115.60 individuals/grid (Table 3). Resulting density estimates ranged from 1.82 to 105.28 individuals/ha. Based on $\mathrm{AIC_c}$ values (1093.03 for model 1, 1177.54 for model 2), model 1 is judged to produce the most reliable results. Standard errors (SEs), in general, also were smaller for the first model (Table 3).

Co-occurring species

Number of individual *B. musculus* and total number of small mammals caught each year on the grids were as follows: 2003, 71 of 286 (24.8%); 2004, 51 of 550 (9.3%); 2005, 13 of 206 (6.3%); 2006, 56 of 468 (12.0%); 2007, 245 of 836 (29.3%); and all years, 436 of 2346 (18.6%). Differences were significant among years in percentage of captured individuals that were *B. musculus* (R × C test, $G = 141.47$, df = 4, $P < 0.001$); in comparisons of all possible combinations of years, two nonoverlapping nonsignificant subsets were identified (2003 and 2007; 2004, 2005, and 2006), indicating that for years included in a group the percentages were not judged to be significantly different.

With respect to other species encountered, the most common on coastal grids at Playa de Oro was *Oryzomys couesi*

Table 3. Total number of individuals captured, estimate (*N*) of number of animals on grid using MARK, and density estimate for southern pygmy mice (*Baiomys musculus*) on individual grids in Colima, Mexico, based on two models involving $p(t) = c(t)$, where probability of capture (*p*) and recapture (*c*) are equal for a given night (*t*) but can vary among nights.

		Model 1		Model 2	
Grid no.	No. of animals captured	*N* ± SE (95% confidence interval)	Density	*N* ± SE (95% confidence interval)	Density
2003 (coastal Colima)					
1	40	45.72±2.904 (42.24–54.62)	41.64	43.10±2.329 (40.83–51.51)	39.25
4	2	2.00[a]	1.82	2.00[a]	1.82
5	29	33.01±2.424 (30.34–40.97)	30.06	32.40±2.596 (29.90–41.83)	29.51
2004 (coastal Colima)					
4	33	37.63±2.605 (34.66–45.94)	34.27	37.64±3.082 (34.42–48.17)	34.28
5	18	20.29±1.873 (18.56–27.31)	18.48	21.19±2.797 (18.73–32.02)	19.30
2005 (coastal Colima)					
1	5	5.22±0.983 (5.01–11.71)	4.75	7.81±5.192 (5.26–35.63)	7.11
2	8	8.71±1.235 (8.07–15.17)	7.93	10.91±3.483 (8.46–26.48)	9.94
2006 (northern Colima)					
1	10	13.11±2.267 (10.86–21.18)	11.94	17.63±7.438 (11.54–47.86)	16.06
2	5	6.28±1.596 (5.19–13.54)	5.72	9.33±6.992 (5.47–44.87)	8.50
3	6	7.65±1.748 (6.30–15.04)	6.97	8.46±3.806 (6.28–27.46)	7.70
4	16	21.29±2.897 (17.94–30.43)	19.39	24.53±6.276 (18.35–46.96)	22.34
5	19	25.37±3.173 (21.53–35.03)	23.11	27.29±5.601 (21.49–46.57)	24.85
2007 (northern Colima)					
1	58	78.51±5.917 (69.78–93.69)	71.50	82.25±9.037 (69.96–107.16)	74.91
2	20	26.74±3.261 (22.74–36.56)	24.35	59.22±28.960 (30.77–162.90)	53.93
3	86	116.65±7.515 (105.09–135.21)	106.24	115.60±9.281 (102.25–139.95)	105.28
4	72	97.58±6.736 (87.40–114.49)	88.87	82.85±4.567 (76.92–95.95)	75.46
5	9	11.74±2.148 (9.71–19.64)	10.69	20.33±11.641 (11.15–68.81)	18.52

Note: For model 1, values were the same for all coastal grids (2003–2005) and the same for all northern grids (2006–2007). For model 2, values for each of the 17 grids were estimated separately and independently.

[a] With only two individuals caught, program MARK was not able to provide a robust density estimate.

(Alston, 1877), representing over one-half of the total individuals captured (574; 55.1%). Numbers of individuals of *Liomys pictus* (Thomas, 1893) (106; 10.2%) and *Sigmodon mascotensis* J.A. Allen, 1897 (96; 9.2%) captured were somewhat lower than for *B. musculus* (135; 13.0%). Other species of small mammals included *Liomys spectabilis* Genoways, 1971, *Nyctomys sumichrasti* (Saussure, 1860), *Osgoodomys banderanus* (J.A. Allen, 1897), *Oligoryzomys fulvescens* (Saussure, 1860), *Peromyscus perfulvus* (see Schnell et al. 2008), *Reithrodontomys fulvescens* J.A. Allen, 1894, *Tlacuatzin canescens* (J.A. Allen, 1893), and *Xenomys nelsoni* Merriam, 1892.

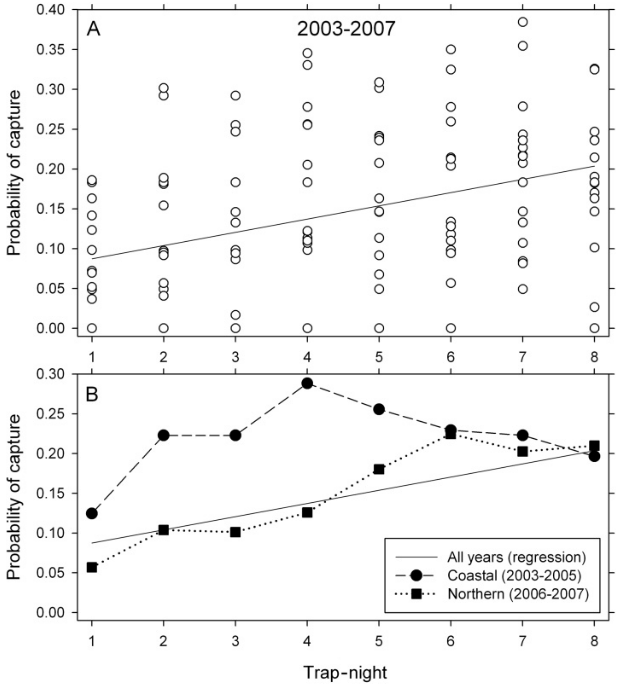
In northern Colima, the most commonly encountered species were *L. pictus* (313 individuals; 24.0%), *B. musculus* (301; 23.1%), and *S. mascotensis* (264; 20.2%). *Reithrodontomys fulvescens* was encountered regularly on grids (131; 10.0%), as were *Peromyscus aztecus* (Saussure, 1860) (110; 8.4%) and *Sigmodon alleni* V. Bailey, 1902 (88; 6.7%). Other species present were *Hodomys alleni* (Merriam, 1892), *N. sumichrasti*, *O. couesi*, *Peromyscus spicilegus* J.A. Allen, 1897, and *T. canescens*.

Probability of capture relative to trap-night and moon illumination

The program MARK provided estimates of probability of capture (*p*) of individual mice for each night (*t*) and for each grid based on our model 2, where the probability of capture (*p*) and recapture (*c*) was constrained to be equal, but where it could vary among nights. Using these data for each night and for each grid in conjunction with values for the fraction of the moon illuminated at midnight on each trap-night, we employed stepwise multiple regression to determine the effect, if any, of trap-night and moon illumination on probability of capture or recapture. The strongest effect was trap-night ($F_{[1,125]} = 20.46$, $P < 0.001$), and moon illumination was not a significant factor ($P = 0.217$), with the resulting regression equation $Y = 0.0708 + 0.0166X$, where Y is the probability of capture of an individual *B. musculus* and X is the trap-night on any given grid (Fig. 2A). Other tests indicated that a linear model was the most appropriate. Not surprisingly, given the small numbers of *B. musculus* captured on some grids, there is considerable variation in estimates of probability of capture, and the amount of variation explained by the regression is not particularly high ($R^2 = 0.141$). The equation indicates that, for nights 1–8, probability of capturing a given individual increased by 1.66% each night.

When obtaining overall estimates of probability of capture on given trap-nights based on all 7 occupied coastal grids (2003–2005) considered simultaneously and then for the 10 northern grids (2006–2007) considered simultaneously, two

Fig. 2. Probability of capture of an individual southern pygmy mouse (*Baiomys musculus*) on a given night. (A) Estimates of probability of capture based on analysis of each grid individually for those grids for which the probability could be calculated (total nightly estimates, $n = 127$). Regression line is shown, with equation being $Y = 0.0708 + 0.0166X$, where Y is the probability of capture of an individual mouse and X is the trap-night on any given grid. Some symbols, particularly those indicating a value of 0, represent multiple points. (B) Estimates of probability of capture based on 7 coastal grids considered simultaneously and on 10 northern grids considered simultaneously. Regression line from panel A is replicated.



patterns emerged (Fig. 2B). For coastal grids, the probability of capture on the first night was 0.125; it increased to trap-night 4 and gradually declined thereafter. For northern grids, the pattern followed closely the trend line discerned when pooling estimates for all grids analyzed separately; probability of capture on the initial night was 0.057 and it tended to increase nightly, with the highest probability of capture being 0.225 on trap-night 6.

Ecological characteristics comparing grids

As indicated, *B. musculus* was captured on 17 of the 25 trapping grids. We contrasted the 14 vegetation-structure measurements between grids where the species was and was not captured, considering both means and standard deviations for grids. When comparing data from the 17 grids where *B. musculus* was trapped and the 8 where none were caught, significant differences were identified for three variables: mean percent bare ground, 10.0% vs. 27.1% ($F_{[1,23]} = 21.77$, $P < 0.001$); standard deviation of percent bare ground, 10.53% vs. 20.43% ($F_{[1,23]} = 19.84$, $P < 0.001$); and mean percent of canopy closed, 66.9% vs. 84.0% ($F_{[1,23]} = 4.74$, $P = 0.040$). The difference for another variable, percent grasses, approached statistical significance (19.5% vs. 3.4%, $F_{[1,23]} = 4.18$, $P = 0.052$). Thus, grids where *B. musculus* was present had less bare ground, less variation in amount of bare ground across trap stations, and a more open canopy, with a suggestion that, on average, percentage of grasses was higher.

Ecological characteristics comparing trap stations

Mean values and standard deviations for the 14 vegetation-structure variables for trap stations where *B. musculus* was caught and not caught are summarized in Table 2 for the grids in coastal Colima (2003–2005) and northern Colima (2006–2007), as well as for all years combined. When comparing variables individually for the latter, all exhibited significant differences between trap stations where caught and not caught (comparison between two rightmost columns in Table 2), while some characteristics when evaluated for coastal or for northern Colima alone were not different statistically. For those eight features statistically different in all three comparisons (Table 2), ground cover at stations where *B. musculus* was captured had higher percentages of grasses and lower percentages of dead wood and bare ground. In addition, capture sites relative to noncapture sites had more hits at 1 m, a more open canopy, fewer hits high on a vertical pole, a lower canopy, and a greater mean distance to nearest tree.

For coastal Colima (2003–2005), the stepwise logistic regression of the 1500 trap stations on the 15 grids, contrasting stations where *B. musculus* was caught and not caught, resulted in the equation $Y = -4.601 + 0.036X_2 + 0.031X_3 + 0.178X_8 + 0.148X_{14} + 0.020X_1$, where Y is the dependent variable (which initially was coded as 1 when the species was caught at a station and 0 when not caught), X_2 is percent forbs, X_3 is percent grasses, X_8 is mean hits at 1 m, X_{14} is mean distance to nearest tree, and X_1 is percent woody plants (Table 4). The resulting Y values for stations where we captured *B. musculus*, in general, were higher than those for where the species was not encountered. This is demonstrated in Fig. 3A, which depicts distributions of Y values for capture and noncapture sites as a percentage of the total of each. McFadden's ρ^2 was 0.186. Coefficients for environmental variables all were positive, indicating that locations where *B. musculus* was trapped tended to have higher values for these variables (Figs. 3B–3D are graphs of the first three variables individually), although for the last variable added to the equation — percentage of woody plants — the mean for capture sites is actually lower, albeit not significantly so (Table 2); percentage of woody plants was the last variable entered into the equation and is considered, in this context, in combination with the previously entered variables.

For the 1000 trap stations on grids in northern Colima (2006–2007), the logistic-regression equation was $Y = 0.139 - 0.064X_{13} - 0.033X_7 - 0.029X_{10} + 0.017X_6 - 0.046X_{12}$, where the independent variable X_{13} is maximum canopy height, X_7 is percent bare ground, X_{10} is slope, X_6 is percent rocks, and X_{12} is total hits high (Table 4). Thus, the resulting equation for northern Colima includes a different set of variables from that obtained for coastal Colima. McFadden's ρ^2 for northern Colima at 0.088 was relatively low, an indication that the resulting model is not particularly strong in separating trap stations where the species was caught and where it was not. This result is to some extent reflected in the compilation of projections on the logistic-

Table 4. Estimates, SEs, Z scores and P values for constant and coefficients of independent variables incorporated sequentially into logistic-regression equations when evaluating coastal, northern, and all grids in Colima, Mexico, to predict dependent variable (Y), indicating where southern pygmy mice (*Baiomys musculus*) were captured (1) and not captured (0).

Constant or independent variable	Coefficient ± SE	Z	P
2003–2005 (coastal Colima)			
Constant	–4.601±0.359	–12.807	<0.001
Percent forbs (X_2)	0.036±0.004	8.541	<0.001
Percent grasses (X_3)	0.031±0.004	8.155	<0.001
Mean hits at 1 m (X_8)	0.178±0.047	3.778	<0.001
Mean distance to nearest tree (m) (X_{14})	0.148±0.050	2.961	0.003
Percent woody plants (X_1)	0.020±0.009	2.207	0.027
2006–2007 (northern Colima)			
Constant	0.139±0.124	1.128	0.259
Maximum canopy height (m) (X_{13})	–0.064±0.013	–4.944	<0.001
Percent bare ground (X_7)	–0.033±0.009	–3.794	<0.001
Slope (°) (X_{10})	–0.029±0.012	–2.447	0.014
Percent rocks (X_6)	0.017±0.006	2.782	0.005
Total hits high (X_{12})	–0.046±0.017	–2.652	0.008
2003–2007 (all Colima grids)			
Constant	–2.925±0.336	–8.705	<0.001
Percent grasses (X_3)	0.027±0.004	7.428	<0.001
Percent rocks (X_6)	0.061±0.006	10.209	<0.001
Percent forbs (X_2)	0.034±0.004	7.735	<0.001
Percent litter (X_4)	0.025±0.004	6.577	<0.001
Percent canopy closed (X_9)	–0.008±0.002	–3.707	<0.001
Total hits low (X_{11})	0.038±0.014	2.724	0.006
Slope (°) (X_{10})	–0.022±0.010	–2.255	0.024
Total hits high (X_{12})	–0.034±0.013	–2.626	0.009
Maximum canopy height (m) (X_{13})	–0.030±0.012	–2.452	0.014
Percent woody plants (X_1)	0.015±0.007	2.123	0.034

regression equation (Fig. 4A); a higher percentage of sites where *B. musculus* was caught had relatively high projection values (i.e., –1.0 to 0.0), but at the same time a substantial percentage of sites where the species was not trapped had similar scores. The model indicates that in northern Colima, when considering variables in combination, a higher percentage of capture stations tended to have lower canopies (Fig. 4B), less bare ground (Fig. 4C), less slope (Fig. 4D), more rocks, and fewer hits high on a vertical pole.

When we considered all years combined (25 grids, 2500 trap stations), the resulting logistic-regression equation (Table 4) retained 10 of the 14 environmental variables. McFadden's ρ^2 was 0.147. Projection values for sites where *B. musculus* was trapped tended to be higher than for those where the species was not caught (Fig. 5A). Comparatively, stations where the species was caught had, in combination, more grass (Fig. 5B), more rocks (Fig. 5C), more forbs (Fig. 5D), more litter, a more open canopy, more hits low on a vertical pole, less slope, fewer hits high on a vertical pole, a lower canopy, and more woody plants. Note that for two variables — percentage of litter and percentage of woody plants — the results within the logistic regression, where variables are taken in combination, are in the opposite direction relative to when these were considered individually (Table 2).

In some cases it was evident that other features besides the ones we quantified had a considerable influence on the within-grid distributions of *B. musculus*. For example, on grid 1 in 2007 an unimproved road traversed the grid (Fig. 6B). While some of the 58 *B. musculus* were trapped at stations away from the road, it is clear that they were concentrated along the road (Fig. 6). Mean distance between the road and stations where *B. musculus* was caught was 14.5 m, compared with 26.8 m for stations where the species was not caught ($F_{[1,98]}$ = 13.33, P < 0.001). The product-moment correlation of number of individual animals caught at a station versus distance from road (m) was –0.337 (df = 98, P < 0.001); if one evaluates the data in another way, considering total number of captures per station relative to distance from the road, the result is similar (r = –0.308, df = 98, P < 0.01). One of our vegetation measures — mean distance to nearest tree (Fig. 6A) — exhibited a pattern that reflected directly the presence of the road, with stations along the road not surprisingly tending to have greater mean distances to the nearest tree. This variable showed a significant difference between capture and noncapture stations when we considered the 10 northern grids together (Table 2), although it was not sufficiently informative so as to be included in the logistic regression for the northern grids. On grid 1 in 2007, *B. musculus* was not captured in all areas where trees were relatively sparse (note upper-

Fig. 3. (A) Percentages of projections of trap stations in given class for logistic-regression model based on data from 15 grids for years 2003–2005 in coastal Colima (1500 trap stations; 135 where southern pygmy mouse (*Baiomys musculus*) was caught and 1365 where it was not caught). Variables in equation are percent forbs (X_2), percent grasses (X_3), mean number of hits at 1 m (X_8), mean distance to nearest tree (X_{14}), and percent woody plants (X_1). Subsequent panels indicate similar distributions for the first three variables, taken individually, that were in the logistic-regression model: (B) percent forbs; (C) percent grasses; and (D) mean number of hits at 1 m. Last two variables in logistic-regression equation are not shown individually.

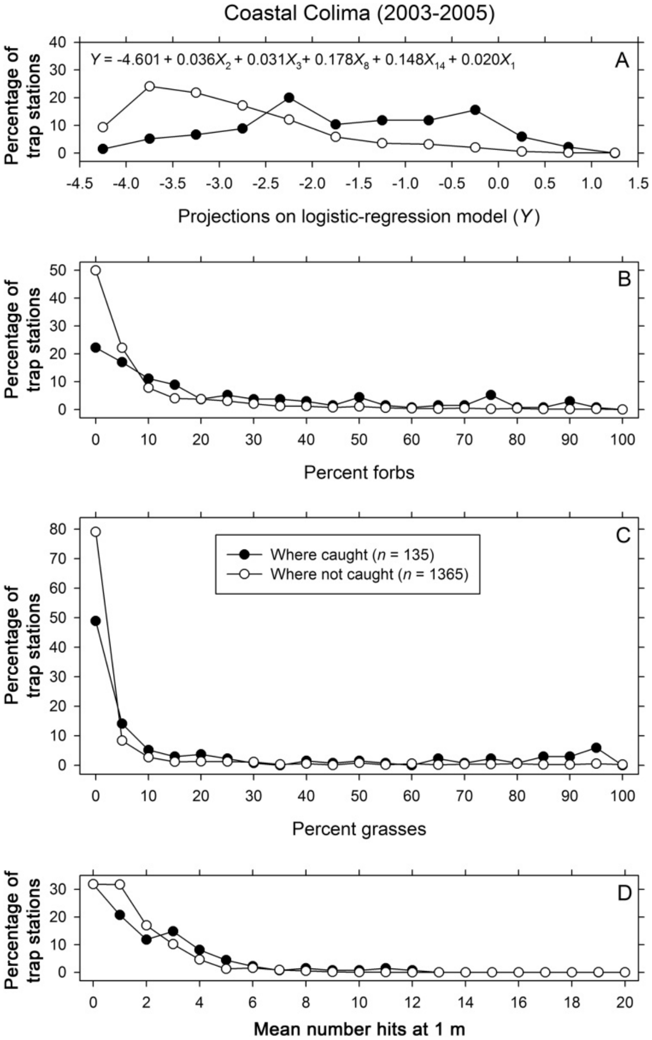
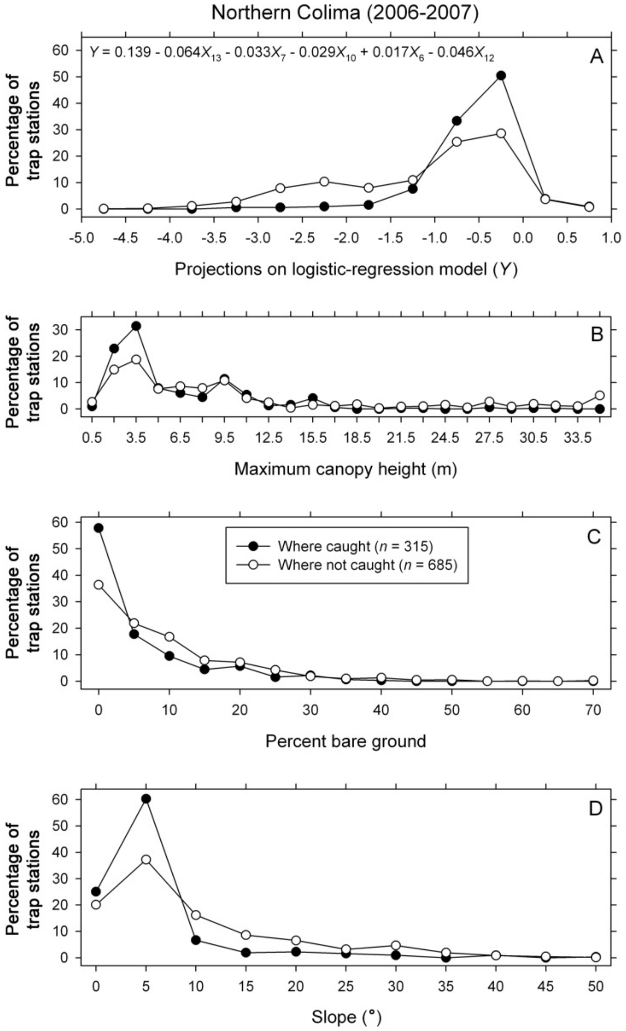


Fig. 4. (A) Percentages of projections of trap stations in given class for logistic-regression model based on data from 10 grids for years 2006–2007 in northern Colima (1000 trap stations; 315 where southern pygmy mouse (*Baiomys musculus*) was caught and 685 where it was not caught). Variables in equation are maximum canopy height (X_{13}), percent bare ground (X_7), slope (X_{10}), percent rocks (X_6), and total hits high (X_{12}). Subsequent panels indicate similar distributions on the first three variables, taken individually, that were in the logistic-regression model: (B) maximum canopy height; (C) percent bare ground; and (D) slope. Last two variables in logistic-regression equation are not shown individually.



right portion of grid, Fig. 6A); at the same time, it is clear that they were avoiding parts of the grid where trees were close together (as indicated by the mean distance to nearest tree being <2 m, Fig. 6A).

Discussion

Co-occurring species

The small mammals found in the same areas as *B. musculus* were varied in their habits. While some — like *Sigmodon mascotensis*, *S. alleni*, *Liomys pictus*, and *L. spectabilis* — were highly terrestrial as was *B. musculus*, our trapping that involved both ground and elevated traps indicated most were semiarboreal or highly arboreal. These included *Oryzomys couesi*, *Nyctomys sumichrasti*, *Osgoodomys banderanus*, *Oligoryzomys fulvescens*, *Peromyscus perfulvus*, *Reithrodontomys fulvescens*, *Tlacuatzin canescens*, *Xenomys nelsoni*, *P. aztecus*, *Hodomys alleni*, and *P. spicilegus*. Not unexpectedly, most eat seeds, but many also consume vegetative matter, insects, and other invertebrates (for general ecological characteristics of many of the encountered species see Ceballos and Miranda 2000).

The small mammals present on grids with *B. musculus* were reflective of associations reported in other studies. Ceballos Gonzalez (1989), studying small mammals in tropical deciduous and arroyo forests at the Chamela Biological Station in Jalisco, about 75 km northwest of our coastal grids,

Fig. 5. (A) Percentages of projections of trap stations in given class for logistic-regression model based on data from all 25 grids in Colima, Mexico, for years 2003–2007 (2500 trap stations; 450 where southern pygmy mouse (*Baiomys musculus*) was caught and 2050 where it was not caught). Variables in equation are percent grasses (X_3), percent rocks (X_6), percent forbs (X_2), percent litter (X_4), percent canopy closed (X_9), total hits low (X_{11}), slope (X_{10}), total hits high (X_{12}), maximum canopy height (X_{13}), and percent woody plants (X_1). Subsequent panels indicate similar distributions on the first three variables, taken individually, that were in the logistic-regression model: (B) percent grasses; (C) percent rocks; and (D) percent forbs. The remaining seven variables in logistic-regression equation are not shown individually.

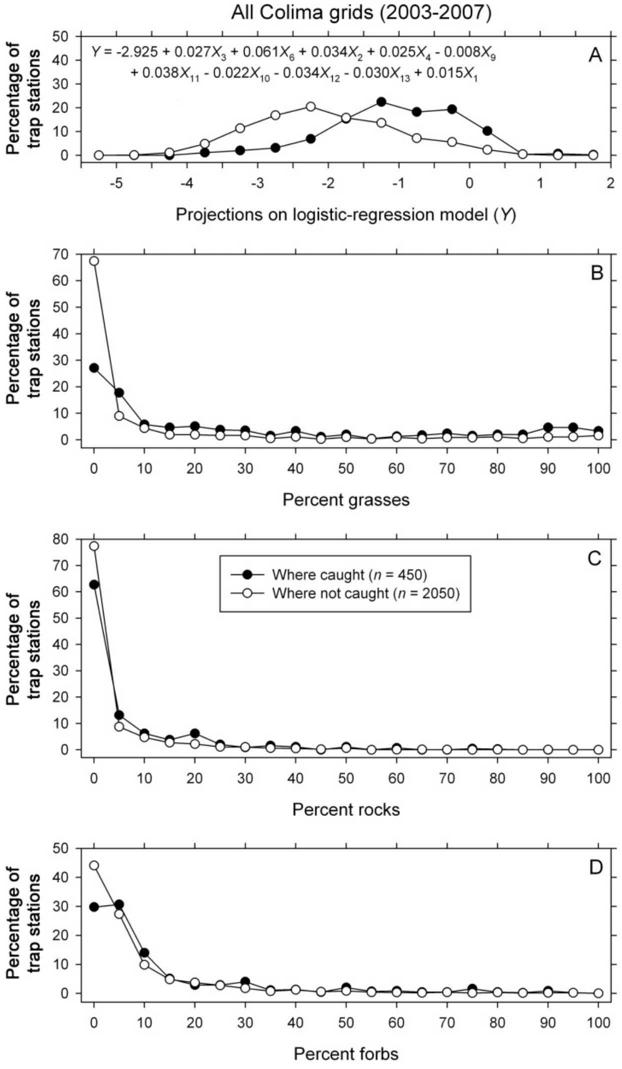
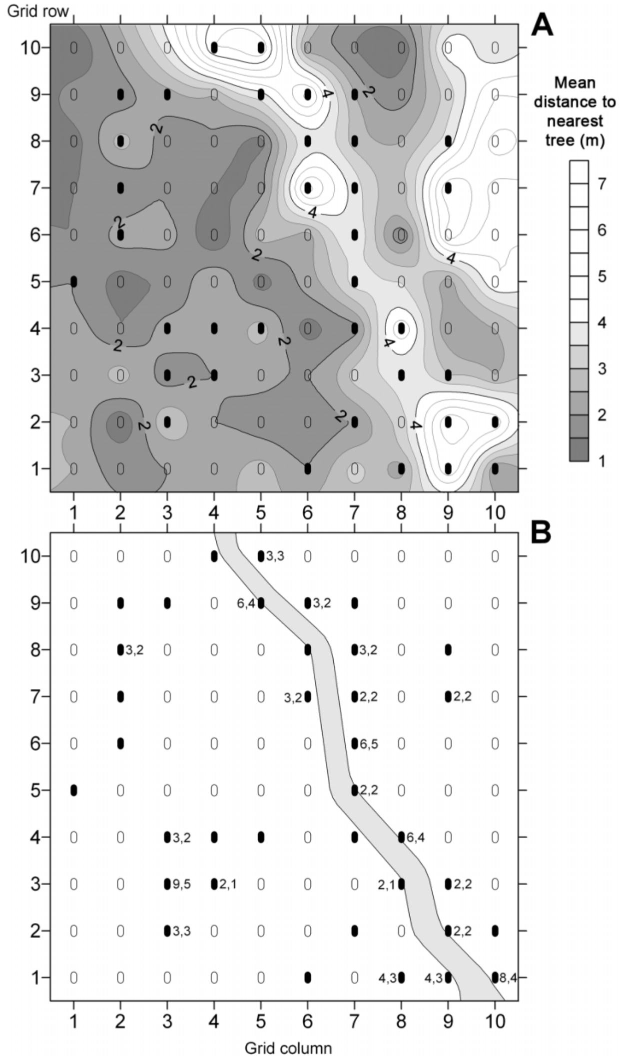


Fig. 6. Two depictions of grid 1 in 2007 showing stations where southern pygmy mouse (*Baiomys musculus*) was caught (solid ovals) and not caught (open ovals). (A) Contours signify estimated mean distance to nearest tree, with surface determined using kriging based on measurements taken at the 100 trap stations. (B) Shaded area indicates position of unimproved road that traversed the grid. Solid ovals without numbers represent stations where one *B. musculus* was caught once. For the others, the first value is total number of captures at that site over the 8-night trapping session, with the second indicating number of different individuals caught. Some animals were caught at more than one station.



considered *B. musculus* and *O. couesi* to be relatively similar in terms of habitat use. He captured 11 species of small mammals, including most of those we encountered (Ceballos Gonzalez 1989; Ceballos 1990), although at Chamela he found *B. musculus* restricted to banana plantations with a well-developed understory. In southeastern Morelos, the species was one of the most abundant of six species in a relatively undisturbed deciduous forest, the other often-encountered species being *Peromyscus levipes* Merriam, 1898, *Peromyscus melanophrys* (Coues, 1874), and *Liomys irroratus* (Gray, 1868) (García-Estrada et al. 2002); *Reithrodontomys megalotis* (Baird, 1857) and *H. alleni* were present but relatively rare. At a similar but disturbed site, *L. irroratus*, *P. melanophrys*, and *B. musculus* were most frequently encountered, with rare species being *P. levipes*, *R. megalotis*, and *Sigmodon hispidus* Say and Ord, 1825 (now *Sigmodon mascotensis* J.A. Allen, 1897; Musser and Carleton 2005). Individuals of *B. musculus* comprised 27.0% of captures at the undisturbed site and 16.7% at the disturbed site, percentages similar to those that we recorded. In earlier investigations in Morelos, *B. musculus* was associated with *L. irroratus*, *P. levipes*, *P. melanophyrs*, *S. hispidus* (now *S. mascotensis*), *R. megalotis*, and *R. fulvescens* (Sánchez Hernández and Romero Almaraz

1995); on one occasion, *B. musculus* was caught in the same trap with *R. megalotis*.

We found significant year-to-year differences in the percentages of small mammals caught that were *B. musculus*. The among-year differences were due in part to population size of *B. musculus* varying considerably from year to year (e.g., 71 caught in 2003 and only 13 in 2005), even when grids were in the same general area. In addition, the percentage differences also were influenced by other common species, particularly *O. couesi*, exhibiting notable interyear variation in numbers. The substantial differences in total number of small mammals caught probably were due in part to differences in habitat or vegetation on the grids being sampled in the different years. In addition, weather differences among years likely had a major effect on total numbers. For example, at coastal Playa de Oro the total number of small mammals captured in January 2004 (550 animals) was almost twice that for January 2003 (286) and more than twice that for January 2005 (206). Judging from weather records from Chamela (also along coast, 75 km to the northwest), precipitation was over 20% greater in the year prior to our January 2004 fieldwork than for January 2003 or 2005 (total 12-month Chamela precipitation; 681, 826, and 652 mm for 2002, 2003, and 2004, respectively). Furthermore, for northern Colima, we captured considerably fewer animals in January 2006 than 2007 (468 vs. 836), and precipitation was notably less prior to January 2006 than 2007 (precipitation for city of Colima; 689 and 1087 mm for June–December 2005 and 2006, respectively).

General demography

Over the 5 years of our study, 51.4% of adult females were pregnant or lactating, with the percentage varying from 42.4% in 2007 to 80.0% in 2004. Packard (1960) indicated that notations on specimen labels of females suggested that the species breeds in all months of the year. He had records of pregnant or lactating females for 8 of the 12 months, although none for January, April, May, or June. In southeastern Morelos, subadult and juvenile *B. musculus* were captured throughout the year, with the peak period being February and March (García-Estrada et al. 2002). Sánchez Hernández and Romero Almaraz (1995) reported for Morelos that 1 female had embryos in February and 11 were reproductively inactive; 1 female in March was inactive; 1 female in May was active and 3 inactive; and 4 of 10 females in July were active. None of 49 specimens (both males and females) collected by Hooper (1955) in Colima, Jalisco, and Michoacán in February "gave evidence of breeding", nor were any of 13 females pregnant that were collected in Michoacán in March (Hall and Villa R. 1949). In El Salvador, Felten (1958) did not find pregnant females in October through March, but Burt and Stirton (1961) collected four pregnant females there in December and early January. It has been reported that along the coast in Jalisco, and particularly in the vicinity of Chamela, breeding occurs in summer or primarily in summer (Ceballos and Miranda 1986, 2000), although specific data were not provided. For our study, although notable differences were found among years in the proportion of females that were pregnant or lactating, there was substantial reproductive activity in *B. musculus* in January of all years. Our coastal study site is within about 10 km of coastal Jalisco and 75 km of the Chamela Biological Station.

García-Estrada et al. (2002) reported the sex ratio for *B. musculus* caught at two sites in Morelos, the first site being relatively undisturbed and the second being highly disturbed. For the undisturbed site, they caught 86 *B. musculus*, with the ratio of males to females being 1:1.1. On the disturbed site, the 15 individuals captured exhibited a sex ratio of 1:1.3. Given the sample sizes, neither was statistically different from 1:1. Our data show a significant deviation, with fewer males than females overall (1:1.37).

Relatively few researchers have reported measurements of mass of *B. musculus*. Ceballos Gonzalez (1989) listed body mass for *B. musculus* as 9 g based on his studies in Chamela, but sample size was not indicated. Mass was indicated to be 7–8 g by Ceballos and Miranda (1986, 2000) for Chamela and coastal Jalisco, and 6–10 g by Chávez and Espinosa (2005) for the species as a whole. In Michoacán, Hall and Villa R. (1949) obtained masses of three males with worn teeth (8.3, 9.3, and 10.8 g), as well as for three nonpregnant females (8.1, 9.4, and 9.7 g). In Morelos, 16 males and 15 females averaged 8.9 and 9.8 g, with ranges from 8 to 10 and 8 to 13 g, respectively (Sánchez Hernández and Romero Almaraz 1995); thus, on average, females were >10% heavier. Packard (1960) did not include direct measurements of mass in his analyses; however, based on body and skull measurements, he was unable to detect secondary sexual differences for *B. musculus* from El Salvador. Conversely, our data suggest that sexual dimorphism occurs in this species, with females being, on average, about 7% heavier than males, although it is possible part of this difference may reflect the fact that some females were pregnant.

In general, mass values we obtained were greater than recorded by most previous investigators. Eight subspecies have been recognized (Packard 1960), with geographic variation in external size and some cranial dimensions; typically, southern subspecies are smaller and those at high elevations larger. Our findings within Colima, where only a single subspecies is recognized, show an opposite pattern for mass, with coastal animals being significantly heavier than those from northern Colima and higher elevation. Davis (1944) pointed out a similar pattern based on specimens taken in Guerrero; those from near Chilpancingo at 1300 m were notably lighter than those taken near Acapulco at about 300 m (10.8 vs. 14.2 g; $n = 10$ and 3, respectively), although he indicated that "external measurements were comparable". It would be of interest to conduct a detailed study of microgeographic variation for *B. musculus* within Colima, with adequate samples from numerous localities.

In addition to being somewhat larger, females tended to move notably farther than males at our study sites, with the mean of the mean distance from centroids of trapping sites being 9.10 and 5.86 m, respectively. In Morelos, García-Estrada et al. (2002) conducted a mark–recapture study, with 2-night trapping sessions conducted at 40 day intervals from February 1991 through March 1992. They calculated mean deviations from points of capture, using this as the radius of a circle and calculating the surface of a circle as an index to area of activity. At a highly disturbed site, they recorded movements of one male and one female, with the radius of the circle being considerably smaller for the female than the male (12.1 vs. 22.4 m), which is at variance to what we recorded. For a relatively undisturbed site, movements were considerably greater in the wet season than in the dry season (mean radius 18.8 vs. 13.2 m); sexes and numbers of individuals were not reported. Our January study was in the dry season, and their data suggest that movements in Colima would be greater in the wet season.

García-Estrada et al. (2002) also estimated population densities of *B. musculus* in Morelos based on minimum number known to be alive. At a relatively undisturbed site, density was 15 individuals/ha in February 1991 and declined slightly to 11 individuals/ha in April, prior to reaching a maximum of 30 individuals/ha in July, after which population density decreased through March 1992. At a highly disturbed site, density varied from 0 to 6 individuals/ha, with highest values being for March and July 1991. Most of our sites were relatively undisturbed. We had 8 trap grids where the species was not captured, with densities of 1.82–106.24 individuals/ha on the other 17 grids. Our estimating procedure produced values somewhat higher than would be the case using minimum number known to be alive (density using this method can be obtained for our data in Table 3 by dividing the number of animals captured by 1.098). Several of our grids along the coast supported higher densities of *B. musculus* than reported for February in Morelos, as was the case for 6 of 10 of the grids in northern Colima; other grids had densities in the range of those recorded in Morelos.

Probability of capture

For a number of small-mammal species, moonlight has been shown to affect activity patterns and habitat use, particularly for desert animals and others inhabiting open habitats (e.g., Blair 1943; Wolfe and Tan Summerlin 1989; Daly et al. 1992). Predator avoidance is purported to be an important factor driving such differences. In fact, in a study that did not measure wild-rodent activity, Lima Sábato et al. (2006) attributed the reduction in movements of a predator — wild maned wolves (*Chrysocyon brachyurus* (Illiger, 1815)) — during full-moon periods to "reduced rodent activity because in all tested rodent species to date the same response to a full moon was observed", although the quote is something of an overstatement. Kikkawa (1964) observed in the United Kingdom that *Apodemus sylvaticus* (L., 1758) were less active on clear nights with a full moon, presumably resulting in their being less trappable on those nights. In an 8-year study of rodents in Quebec, *Clethrionomys gapperi* (Vigors, 1830) and *Napaeozapus insignis* (Miller, 1891) had increased activity on moonless and cloudy nights (Vickery and Bider 1981). Moon phase affected activity of *Microtus pennsylvanicus* (Ord, 1815), with the species typically being more active under new- than full-moon conditions (Doucet and Bider 1969), and some combination of moon phase, nocturnal light intensity, and cloud cover had an effect on activity of the shrew *Sorex cinereus* Kerr, 1792 (Vickery and Bider 1978). Longland and Price (1991) analyzed simultaneously the influence of habitat and moonlight on activity and avian predator attacks on the heteromyids *Dipodomys merriami* Mearns, 1890, *Microdipodops megacephalus* Merriam, 1891, *Chaetodipus baileyi* (Merriam, 1894), and *Chaetodipus fallax* (Merriam, 1889) housed in a large flight cage. They found heteromyid activity to be lower under bright illumination ("full moon"), but illumination did not increase predation risk, possibly because the rodents changed activity patterns when exposed to full-moon conditions.

The effect on trap success also has been investigated. Paise and Vieira (2006) reported that nocturnal captures of the rodent *Oxymycterus nasutus* (Waterhouse, 1837) in southern Brazil were positively related to night brightness, which is probably not surprising, given that the species is largely diurnal. For desert rodents, Price et al. (1984) noted that they tended to capture fewer animals when nocturnal light levels were high, although the difference from dark or partial-dark periods was not significant statistically. Blair (1951), livetrapping beach-inhabiting *Peromyscus polionotus* (Wagner, 1843), had lower trap success on moonlit nights and considered moon illumination the most important factor influencing its activity on a given night. The South African rodent *Praomys verreauxii* (Smith, 1834) was less likely to be caught on moonlight nights, although other small mammals during the same study were not so affected (van Hensbergen and Martin 1993).

For *B. musculus*, we did not find an effect of moon illumination on capture probability, either when considered alone or in conjunction with trap-night (i.e., trap-nights 1–8). The reason for *B. musculus* being relatively insensitive to moonlight may relate to it typically being associated with heavy ground cover, which would provide considerable protection from visual predators. The species is cryptically colored in addition to being very small and easily able to move and hide in or below ground cover. Stokes et al. (2001) analyzed 15 years of trapping data on *Microtus ochrogaster* (Wagner, 1842) and *S. hispidus* in Kansas, assessing possible effects of a variety of environmental factors on trapping success. Nighttime illumination had little influence on capture probabilities. For *Apodemus sylvaticus*, Plesner Jensen and Honess (1995) also reported no effect of moonlight or cloud cover on trap success when tall vegetation was available. Likewise, Cook (1959) noted little effect of moonlight on small-mammal activity in central California, and activity of the marsupial *Antechinus stuartii* Macleay, 1841 in southeast Queensland was not influenced by moonlight (Wood 1970).

Relatively few investigators have reported on temporal variation in trap success or probability of capture within a trapping session. Over a 5-night trapping period with Sherman traps in Maryland, no temporal effect was evident in a field study of *M. pennsylvanicus* (Jett and Nichols 1987). However, in South Africa, using Sherman traps, van Hensbergen and Martin (1993) determined for an 8-night study period in February that the murid rodent *Rhabdomys pumilio* (Sparrman, 1784) exhibited a temporal pattern of capture probabilities relatively similar to what we observed for *B. musculus* on coastal grids, with probability of capture increasing steadily from trap-nights 1 to 4 and decreasing thereafter (capture probabilities were 0–0.42); *R. pumilio* was caught equally frequently during day and night. For a 12-year study involving 12 species of small mammals in Georgia, Golley et al. (1965) and Gentry et al. (1966) reported for 3-night trapping sessions that the number of captures on the third night was greater than expected; however, their results are not directly comparable with ours because they were using snap traps and, thus, removing animals from trapping sites. Patterson et al. (1989) reported in detail on temporal trap success within 6-night trapping sessions while studying small mammals along an elevational transect in Chilean rainforest. They detected a general tendency, when considering all species, for captures to decline throughout the sampling period. However, they were using both snap traps and Sherman traps in the same trap lines, with the latter making up only 18% of the total and proportionally catching fewer animals than expected by chance. For the most part they were steadily removing small mammals from transect areas and, thus, the resulting temporal decline is to be expected. We found a definite influence of trap-night for *B. musculus*, with the overall trend being a 1.66%/night increase in probability of capture or recapture. For coastal grids, there was a 1.25%/night increase to the fourth night and then a gradual decline. It is unclear as to why the pattern varied somewhat between coastal and northern sites. The overall pattern of increasing probability of capture with trap-night may result from adjustment of *B. musculus* to the disturbance associated with our initial placement of traps on the grid. Furthermore, the increasing probability of capture may reflect their having located a ready food source at the trap location.

Ecological characteristics

Baiomys musculus occurs in a variety of habitats (Davis 1944; Packard 1960). In Veracruz, it was common in weedy fields and abundant in uncleared corn fields (Allen and Chapman 1897) and, in Guatemala, it occurred along high cactus hedges where grass was protected from overgrazing by cattle (Goodwin 1934). The species also has been trapped in rocky areas, including along rock fences in Morelos (Davis and Russell 1954), in rocky areas of desert grasslands in Guerrero (Davis 1944), and rocky grazed areas near sugar-cane fields in Puebla (Packard 1960). Other situations where the species has been encountered were summarized by Packard (1960), such as a growth of cane grass, shrubs, and mesquites near an irrigation ditch (Hooper 1955), in scrubland and brushy areas (Goodwin 1934, 1942; Felten 1958), and in dense stands of ground vegetation comprised mostly of grasses (Davis 1944; Hall and Dalquest 1963).

At Chamela in Jalisco, Ceballos Gonzalez (1989) found the species only in banana plantations, which were humid and had a well-developed understory. The occurrence in understory fits well with our results. However, Ceballos Gonzalez (1989) considered *B. musculus* to be a habitat specialist, a supposition not supported by our results for Colima. Trapping data gathered by García-Estrada et al. (2002) in Morelos, while not reaching statistical significance, were suggestive that *B. musculus* exhibited differential use of habitat depending on the site-specific degree of disturbance, with preference for arboreal cover in a relatively undisturbed site, but for shrubby areas at a highly disturbed site.

In Colima, Hooper (1955) collected the species in open thorn forest with sparse grass on a rocky hillside bounding a stream, and in litter below shrubs in a palm forest — habitats similar to those represented by a number of our grids. Packard and Montgomery (1978) concluded that habitat of *B. musculus* "is primarily grassy areas where cover is provided by brush and shrubs, rocks, or dense vegetation". While our grids covered a range of habitats in Colima, most were in woodlands and, thus, did not encompass all habitat types in the state. However, within that context, *B. musculus* was present on grids with relatively little bare ground and little variation among trap stations in this variable. At the same time, grids where they occurred tended to be more open, with an inference that more grass was present. When considering individual trap stations for coastal Colima, sites where the species was present had more forbs, grasses, and vegetation hits at 1 m height while, at the same time, trees were relatively distant, but there was more woody ground cover; *B. musculus* was only in the more open areas that had the thicker low vegetation, including grasses. This tends to fit within Packard's (1960) general description in that he was looking at habitat use by *B. musculus* in a broad perspective, considering the full range of habitats available; our finding the species in more open areas for coastal Colima refers to those areas within the relatively dense woodland vegetation where the grids were placed. In northern Colima, the logistic-regression model was not particularly robust, but in this area the species tended to be caught at stations with lower canopies and less bare ground, as well as places that were flatter, had more rocks, and had fewer vegetation hits high on the vertical pole. When considering simultaneously trap stations on all grids, both coastal and northern, *B. musculus* was more often at locations with relatively thick vegetation near the ground and with ground cover including more grasses, rocks, forbs, litter, and woody plants. In addition, these sites were more open and had relatively low canopies. Our conclusion is that *B. musculus* prefers habitats that have relatively dense ground cover along with at least a partially open canopy — basic requirements that are met in several types of vegetation — with one result being that the species is widespread in the state of Colima.

Comparison with *Baiomys taylori*

Baiomys taylori, the congener of *B. musculus*, is smaller, with a mass of 6.0–9.5 g (Eshelman and Cameron 1987). Both species are known to breed year-round. Eshelman and Cameron (1987) noted that *B. taylori* shows considerable temporal and spatial variations in densities, with from 2 to 84 mice/ha being reported, similar to the range of values that we found for *B. musculus* in Colima in January. Raun and Wilks (1964) recorded a sex ratio of trapped *B. taylori* in southern Texas as being male-biased, with 100 females to 115 males, but could not demonstrate this to be different statistically from a 1:1 ratio. Their result differs from our finding for *B. musculus* in that the overall sex ratio was female-biased (males:females, 1:1.37). Stickel and Stickel (1949) in another Texas study of *B. taylori* trapped somewhat fewer males than females (males:females, 20:24).

Baiomys taylori, as *B. musculus*, occurs in a wide variety of habitats, and for the former "dense ground cover is a necessary component of optimal habitat", with disturbance that reduces ground cover resulting in a reduction in population density (Eshelman and Cameron 1987). For densities of *B. taylori*, burning was more detrimental than grazing, apparently because the former more completely removed mats of dense grass; few *B. taylori* were present in 1-year-old burns or where cattle grazing was intense (Baker 1940; Stickel and Stickel 1949). Densities of *B. taylori* were higher on ungrazed plots in Arizona (Jones et al. 2003). In southern Texas, *B. taylori* was in grassy environments and also in places where grass was relatively sparse but where other types of ground cover were available, such as rocks, cactus, and fallen logs (Raun and Wilks 1964). We found *B. musculus* to prefer habitats with relatively dense ground cover and at least a partially open canopy; cover often was grass, but other times it involved other types of vegetation or a combination of types. Cover — as with *B. taylori* — was the critical factor. Furthermore, the highest densities we encountered were in an area where no grazing had been allowed for three decades.

Investigators have suggested that competition exists between *S. hispidus* and *B. taylori* for favorable habitat, with changes in density of *B. taylori* being inversely related to those for *S. hispidus* (Raun and Wilks 1964). However, results from other studies (e.g., Grant et al. 1985) have not supported the notion of competition between *B. taylori* and *S. hispidus*. In east-central Texas, the presence of *S. hispidus* may have resulted in a reduction of *B. taylori* population size in winter, but did not influence its microhabitat use during winter or spring (Turner and Grant 1987). It would be of interest to evaluate whether there is a competitive relationship between *S. mascotensis* and *B. musculus*.

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Appendix A

Table A1. Gazetteer with localities in Colima, Mexico, where *Baiomys musculus* were captured.

Locality no.	Description
1	Comala; 1 km E Yerbabuena; 1470 m
2	Minatitlán; El Sauz; 8 km NE Minatitlán; 1200 m; 19°26′N, 103°60.00′W
3	Minatitlán; 8.5 km NE El Sauz; 1200 m; 19°26′N, 103°60.00′W
4	Minatitlán; Rastrojitos; 3 km NW Ranchitos; 1650 m
5	Minatitlán; 1 km NW Ranchitos; 1550 m
6	Minatitlán; El Salto; 4 km WSW Minatitlán; 630 m; 19°22′N, 104°05.06′W
7	Minatitlán; 29.5 km SW Minatitlán; 450 m; 19°17′N, 104°08.39′W
7*a*	Minatitlán; 30 km SW Minatitlán; 450 m; 19°17′N, 104°08.39′W
8	Cuauhtémoc; Rancho La Angostura; 761 m; 19°18.837′N, 103°39.997′W
9	Cuauhtémoc; 2 km E Palmillas; 950 m; 19°21′N, 103°31.58′W
10	Cuahutémoc; 2.5 km SE Palmillas; 950 m; 19°20′N, 103°32.22′W
11	Cuauhtémoc; 4.5 km SE Palmillas; 860 m; 19°19′N, 103°31.36′W
12	Cuauhtémoc; 5.5 km SE, 1 km SE Palmillas; 810 m; 19°19′N, 103°31.10′W
13	Cuauhtémoc; 4 km SE Palmillas; 860 m; 19°19′N, 103°31.36′W
13*a*	Cuauhtémoc; 5 km SE Palmillas; 860 m; 19°19′N, 103°31.40′W
13*b*	Cuauhtémoc; 5.5 km SE, 1.5 km E Palmillas; 810 m; 19°19′N, 103°31.10′W
13*c*	Cuauhtémoc; 5.5 km SE, 1 km SE Palmillas; 810 m; 19°19′N, 103°31.10′W
13*d*	Cuauhtémoc; 4.5 km SE, 0.5 km E Palmillas; 850 m; 19°19′N, 103°31.36′W
13*e*	Cuauhtémoc; 4.5 km SE, 0.5 km S Palmillas; 850 m; 19°19′N, 103°31.36′W
13*f*	Cuauhtémoc; 4.5 km SE, 1 km E Palmillas; 850 m; 19°19′N, 103°31.19′W
14	Cuauhtémoc; 2 km SE cerro Colorado; 920 m; 19°19.272′N, 103°32.732′W
15	Cuauhtémoc; 2.5 km SE cerro Colorado; 873 m; 19°18.864′N, 103°32.548′W
16	Cuauhtémoc; 6 km S Cuauhtémoc; 710 m; 19°16.083′N, 103°36.000′W
17	Cuauhtémoc; airport of Colima; 19°16′12.5″N, 103°35′33.4″W
18	Manzanillo; 4.5 km N Los Parajes; 19°15′N, 104°25.506′W
18*a*	Manzanillo; 4 km NW Los Parajes; 19°15′38″N, 104°25′40″W
19	Manzanillo; 0.5 km E Los Parajes; 250 m; 19°14′03″N, 104°24′32″W
20	Manzanillo; 1 km WNW Don Tomás; 265 m; 19°13′58″N, 104°23′56″W
21	Manzanillo; Don Tomás; 270 m; 19°13′43″N, 104°23′28″W
22	Manzanillo; La Tigrera; 2 km SW Don Tomás; 19°13′N, 104°24.35′W
23	Manzanillo; 4 km E Don Tomás; 19°12′51″N, 104°22′03″W
24	Manzanillo; 1.6 km SE La Huiscolotila; 250 m; 19°12′N, 104°21.93′W
25	Manzanillo; 2.4 km SE La Huiscolotila 220 m; 19°12′N, 104°21.67′W
26	Manzanillo; 2 km NW Los Parajes; 19°12′05″N, 104°22′04″W
27	Manzanillo; 2.5 km SW Chandiablo; 50 m; 19°10′N, 104°21.48′W
28	Manzanillo; 3 mi [4.8 km] N Santiago
29	Manzanillo; 0.6 km NE La Rosa; 700 m; 19°11.523′N, 104°06.225′W
29*a*	Manzanillo; 0.5 km NE La Rosa 893 m; 19°11.483′N, 104°06.146′W
29*b*	Manzanillo; río San José; 0.3 km NE La Rosa; 893 m; 19°11.483′N, 104°06.146′W
30	Manzanillo; 4 km S, 2 km W El Chavarín
31	Manzanillo; La Culebra; 2 m; 19°10.365′N, 104°38.855′W
32	Manzanillo; Playa de Oro; 3 m; 19°07.947′N, 104°30.802′W
32*a*	Manzanillo; Playa de Oro; 19°07.590′N, 104°28.784′W
32*b*	Manzanillo; Playa de Oro; 19°07′N, 104°28.7′W
32*c*	Manzanillo; Playa de Oro 19°07.601′N, 104°28.715′W
32*d*	Manzanillo; Playa de Oro; 19°08.054′N, 104°29.913′W
32*e*	Manzanillo; Playa de Oro; 19°08.057′N, 104°29.969′W
32*f*	Manzanillo; Playa de Oro 19°08.100′N, 104°29.957′W
32*g*	Manzanillo; Playa de Oro; 19°08.102′N, 104°29.917′W
33	Manzanillo; 2 km WSW La Central; 300 m; 19°08.312′N, 104°27.346′W
34	Manzanillo; 3 km E Santiago
35	Manzanillo; 5 mi [8.0 km] N Manzanillo
36	Manzanillo; 1 km W Paso Ancho; 80 m; 19°04.761′N, 104°08.908′W
37	Manzanillo; Agua Blanca; 141 m; 19°03.961′N, 104°03.152′W
38	Coquimatlán; 2.6 km NE Pueblo Juárez; 250 m; 19°10′N, 103°54.70′W

Table A1 (*concluded*).

Locality no.	Description
39	Coquimatlán; 3 km ESE Pueblo Juárez; 240 m; 19°09.867′N, 103°55.069′W
40	Coquimatlán; La Fundición; 19°08.498′N, 104°01.179′W
41	Coquimatlán; El Paraiso; 210 m; 19°08.960′N, 103°52.905′W
42	Colima; Colima
43	Colima; 4 mi [6.4 km] SW city of Colima
44	Colima; 2 km SE Puerta de Anzar; 460 m; 19°06.021′N, 103°32.301′W
45	Colima; 1 km NNW El Hervidero; 400 m; 19°05.130′N, 103°32.375′W
46	Colima; 1 km E El Hervidero; 5 km S Puerta de Anzar; 19°04.854′N, 103°32.153′W
46*a*	Colima; El Hervidero; 5 km S Puerta de Anzar; 244 m; 19°04′54″N, 103°32′18″W
47	Armería; Armería
48	Tecomán; 3 km E Tecomán; 10 m; 18°56′N, 103°49.84′W
49	Tecomán; 4 km E Tecomán; 10 m; 18°56′N, 103°49.84′W
50	Colima (no precise locality)

Note: Locality numbers refer to those in Fig. 1. Some geographically close localities are represented by a single symbol in the figure, but are so identified with lowercased italic letters to the locality numbers in this appendix table. Each locality listing first indicates the municipality (Colima has 10) before providing specific locality information.