HABITAT PREFERENCE OF THE ENDEMIC TAWNY DEERMOUSE (*PEROMYSCUS PERFULVUS*), A SPECIES OF CONSERVATION CONCERN

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ABSTRACT—The tawny deermouse (*Peromyscus perfulvus*), a semiarboreal endemic in western Mexico, exhibits attributes associated with extinction vulnerability. In January 2003 and 2004, we conducted mark-and-recapture studies at Playa de Oro, Colima, Mexico. Each year, five 100-station live-trap grids (each station with one ground and one arboreal trap; 10 by 10 configuration) were set up for 8 nights in areas with dense vegetation. Only one tawny deermouse was caught in 2003. In 2004, we trapped 16 individuals (12 males, 4 females) 47 times, with 91.4% of captures being in arboreal traps. Captures in 2004 were at 25 stations, all on the same grid, in habitat representing a mixture of thorn forest, mangrove, and palm trees (density 13.6 mice/ha). Considering all 500 trap stations in 2004, we used stepwise logistic regression to evaluate differences based on 13 structural-vegetation measures of the 25 stations where tawny deermice were found versus the 475 where it was not caught. Tawny deermice tended to inhabit locations with trees close-by, sparse low-level vegetation, little litter, and dense high-level vegetation. For the one grid where we caught tawny deermice (25 stations where present versus 75 absent), only distance to nearest tree was significantly predictive; mice avoided even small forest openings. Tawny deermice were trapped at only a small subset of sites within what heretofore has been considered its suitable habitat. Evidence of restricted spatial structure and other limiting demographic features indicate a need for increased concern in conservation of this endemic species.

RESUMEN—El ratón venado leonado (*Peromyscus perfulvus*) es una especie endémica y semiarborícola del oeste de México que presenta atributos asociados a especies vulnerables a la extinción. En enero de 2003 y 2004 se realizó un estudio de marcaje y recaptura en Playa de Oro, Colima, México. En cada año se trabajó con trampas para ratones vivos en cinco cuadrantes (cada cuadrante con 100 estaciones, con una trampa en el estrato terrestre y otra en el arbóreo, en una configuración de 10 × 10) durante 8 noches en áreas con vegetación densa. En 2003 se capturó sólo un individuo, mientras que en 2004 se capturaron 16 (12 machos, 4 hembras), 47 veces, con el 91.4% de las capturas en el estrato arbóreo. Capturas en 2004 fueron en 25 estaciones, todos en el mismo cuadrante, en un hábitat representado por una mezcla de bosque espinoso, manglar y palmas de coco (densidad 13.6 roedores/ha). Considerando las 500 estaciones de trampeo del 2004, se evaluaron 13 variables estructurales de la vegetación, por medio de una regresión logística paso a paso (25 estaciones donde los roedores estuvieron presentes vs. 475 ausentes). El ratón venado leonado tendió a habitar sitios con árboles cercanos, con vegetación del estrato inferior escasa, la del estrato superior densa y con poca hojarasca.

En el cuadrante donde se capturaron ratones venado leonado (25 estaciones presentes vs. 75 ausentes), sólo la distancia al árbol más cercano fue significativamente predictiva, la especie evitó incluso los claros más pequeños de la vegetación. El ratón venado leonado utilizó solamente un subconjunto reducido de los sitios que hasta ahora se han considerado como un hábitat adecuado. La evidencia de la estructura espacial restringida y otras características demográficas limitantes indican la necesidad de incrementar la categoría de conservación de esta especie endémica.

The tawny deermouse (*Peromyscus perfulvus*) is a solitary, nocturnal, semiarboreal species endemic to a small geographic area in western Mexico (Helm et al., 1974; Ceballos and Miranda, 2000). It occurs only in coastal lowlands of Jalisco and Colima to the interior of Michoacán, northernmost Guerrero, and the southwestern corner of the state of México (Álvarez and Hernández-Chávez, 1990; Musser and Carleton, 2005). Natural history of this species has not been studied in detail (see Helm et al., 1974; Collett et al., 1975; Ceballos, 1990). Given the small geographic distribution of the tawny deermouse and the fact that relevant habitats within this region have been highly altered in recent decades through outright loss, fragmentation, and degradation, the species seems to exhibit basic characteristics associated with increased risk of extinction.

Previous investigators (e.g., Wilson, 1985; Mares, 1986; Medellín, 1994) noted that many species face increased risk of extinction in tropical regions and developing countries due primarily to human activities. Janzen (1988) pointed out that Neotropical deciduous forests from Mexico to Panama have been highly fragmented and are threatened with complete destruction. Due to various political and economic factors, tropical dry forest in southern Mexico and Central America is being subjected to increased anthropogenic stresses, leading to severe disturbances and widespread clearing (Sánchez-Azofeifa et al., 2005). Habitat degradation and loss of species is projected by 2050 to be extensive in tropical and subtropical dry forests, as well as in grasslands, savannas, and shrublands in these same tropical and subtropical areas (Groom and Vynne, 2006). Habitats throughout Mexico have experienced high rates of modification and destruction due to activities associated with agriculture, cattle, and forestry (Ceballos and Navarro, 1991; Ceballos and García, 1995). Given its land area, a higher concentration of endemic mammals than expected occurs in Mexico (Ceballos and Brown, 1995), with endemism concentrated in particular biotic associations, including Pacific tropical dry forest (Ceballos and Rodríguez, 1993).

Frankel and Soulé (1981) noted that the most useful indicator of the status of a population is the number of individuals or, more precisely, effective population size. Recent research has reinforced the importance of these measures for conservation decision making (Reed and Frankham, 2003; Reed, 2005). Unfortunately, there is a paucity of data pertaining to population sizes for the tawny deermouse, with only a few attempts made to estimate densities of the species (e.g., Collett et al., 1975; Ceballos, 1990; Mendoza, 1997). Furthermore, habitat use by the tawny deermouse has been described only in general terms. There is a need for more detailed and quantitative ecological information on the tawny deermouse. Therefore, our purpose was to investigate details of habitat use by the species, as well as to obtain a robust estimate of population density at our study site. Additionally, we report selected demographic information, such as sex ratio, reproductive status, and age structure that could be useful in conservation planning for the tawny deermouse.

Materials and Methods—*Study Area and Trapping*—We conducted the study at Playa de Oro (19°08′N, 104°31′W), municipality of Manzanillo, in Colima, Mexico (Fig. 1). Study plots were within 1 km of the Pacific Ocean, with elevation slightly above sea level and topography generally flat. The habitat was primarily tropical dry deciduous forest, with thorn-forest and mangrove elements. Prominent trees and shrubs in the study area included: *Coccoloba barbadensis*; several species of *Acacia*, including *A. hindsii* and *A. farnesiana*; *Senna pallida* and *S. occidentalis*; *Pithecellobium lanceolatum* and *P. dulce*; *Hyperbaena ilicifolia*; *Crataeva tapia*; *Prosopis juliflora*; and *Guazuma ulmifolia*.

Livestock grazed in the area, although substantial portions of our study plots were not accessible to livestock due to density of the vegetation. Much of the area adjacent to our study plots was in agriculture, and parts had been cleared for plantations of coconut palm (*Cocos nucifera*).

Trapping sessions were in January 2003 and 2004 during the annual dry season. Ambient temperatures during January typically result in warm days and cool nights (January average for Manzanillo of 24.8°C; Instituto Nacional de Estadística, Geografía e Informá-

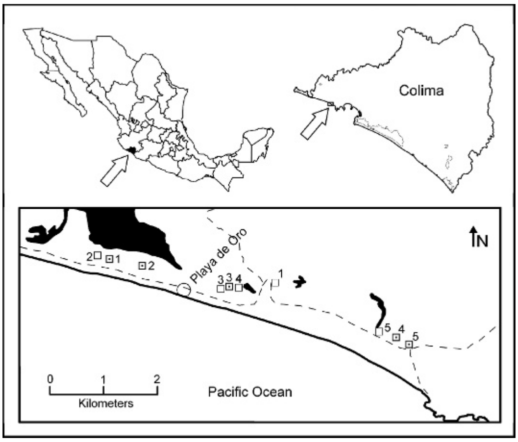

FIG. 1—Upper left panel shows location of state of Colima in Mexico. Upper right panel indicates location of Playa de Oro in Colima. Lower panel is an enlargement of study area at Playa de Oro. Darkened areas show extent of lagoons or marshes, and dashed lines represent roads and trails. Positions of trapping grids for tawny deermouse (*Peromyscus perfulvus*) in 2003 are indicated by open squares and those in 2004 by squares with central dots. Numbers associated with squares refer to specific grids.

tica, 1999). There was little day-to-day variation in temperature during our study, and it did not rain.

In both January 2003 and 2004, we established five 1-ha trap grids (10 total grids) on land with similar topography. Vegetation on each grid represented a mosaic of microhabitats, including thorn forest, coconut palm trees, mangrove forest, and open grassy areas. General descriptions of grids are as follows: 2003-1 and 2003-2, thorn forest with some palm trees within 25 m of mangrove; 2003-3 and 2003-4, thorn forest adjacent to a palm plantation; 2003-5, mixture of grassy areas and palm trees associated with an undergrowth of thorn forest; 2004-1 and 2004-2, mixture of thorn forest and mangrove with some palms; 2004-3, thorn forest next to a palm plantation; and 2004-4 and 2004-5, mixture of grassy plots, palm trees, and thorn forest adjacent to agricultural fields. None of the grids overlapped, and those in 2004 were interspersed among locations of grids used in 2003 (Fig. 1). All grids were close to lagoons, and several had portions grazed by livestock, mainly goats.

Each grid had 100 trap stations (10 by 10) located 10 m apart. Two Sherman live traps (7.5 by 9.0 by 23.0 cm; H. B. Sherman Traps, Tallahassee, Florida) were placed at each station, one on the ground and one 1–2 m above the ground on a thin plywood platform (12.5 by 34.5 cm) attached to a tree or a shrub (hereafter referred to as arboreal traps). Traps were baited with rolled oats.

In 2003, grids 1 and 2 were sampled during 2–5 January and 9–12 January, and grids 3, 4, and 5 during 3–5 January and 9–13 January. In 2004, grids 1 and 4 were sampled 3–5 January and 9–13 January. For grids 2 and 3 in 2004, we sampled 2–5 January and 9–12 January, while grid 5 was trapped 2–5 January and 9–13 January. Thus, four grids were sampled for 8 nights and one for 9 nights, resulting in 1,600 and 1,800 trap-nights/grid, respectively (1 trap-night = 1 trap set for 1 night), with an overall sampling effort of 16,200 trap-nights.

Traps were checked in the morning. For all tawny deermice captured, we recorded trap position (i.e., location in grid and ground versus arboreal), species, sex, reproductive status (i.e., judged reproductively active or not, depending on external condition of reproductive organs), and age (adult or young, based on pelage coloration; upperparts of adults have clear cinnamon rufous color in contrast to upperparts of juveniles, which are darker, being plumbeous and cinnamon; Hall and Villa, 1949; see also Kunz et al., 1996). Mice 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 within about an hour of when traps were checked in the morning.

Estimation of Density—Following Krebs (1966) and Slade and Blair (2000), we estimated population density of tawny deermice by direct count to determine minimum number of individuals known to be alive at time of sampling. Additionally, size of population was estimated using the jackknife estimator in the program CAPTURE (Otis et al., 1978; White et al., 1982). To account for animals whose movements extended beyond edges of the grid, an area of effect was added before calculating density by following Wilson and Anderson (1985). Therefore, a border strip equivalent to one-half the mean greatest distance traveled between points of capture was added to each side of the grid; we also added rounded corner areas with a radius set at one-half the mean greatest distance traveled. This expanded area was considered to be the area of effect.

Structure of Vegetation—In 2004, we quantified structure of vegetation by evaluating 13 characteristics (Table 1) at points adjacent (i.e., 1 m west) to each trap station (500 points total). Techniques were derived from Tazik et al. (1992); Pogue and Schnell (1994); Creighton et al. (1993), and Brower et al. (1998). At each station, we estimated percentage ground cover (to nearest 5%) for a 1-m square (first six variables in Table 1). Number of shrub stems hitting a 1-m bar at 1-m height was determined four times (once in each cardinal direction from central point) and the average calculated (variable 7). Canopy cover (i.e., percent closed, variable 8) was obtained using a spherical densitometer (model C, Forest Densitometers, Bartlesville, Oklahoma). Slope (variable 9) was determined using a clinometer. Employing a 7.5-m vertical pole marked at each decimeter, we determined the number of decimeter intervals within which vegetation touched the pole; resulting data were summed for 0–2.5 m (maximum of 25 hits; variable 10) and for 2.5–7.5 m (maximum of 50 hits; variable 11). We recorded maximum height of canopy at the trap location to the nearest 0.5 m (variable 12). Distance to nearest tree ≥10 cm diameter at breast height (dbh) was determined for each of four quadrants (with edges

TABLE 1—Mean ± *SD* of 13 independent variables measured to provide quantitative assessment of vegetation structure on trap grids used to study the tawny deermouse (*Peromyscus perfulvus*) in tropical dry forest at Playa de Oro, Colima, Mexico, January 2004.

	Independent variable[a]	Trap stations on grid 2 where: Captured (n = 25)	Trap stations on grid 2 where: Not captured (n = 75)	Trap stations on five grids where not captured[b] (n = 475)
1	Woody plants (%)*	2.4 ± 4.81	2.3 ± 5.77	7.8 ± 12.14
2	Forbs (%)	11.4 ± 14.25	8.8 ± 11.56	9.8 ± 19.25
3	Grasses (%)*	0.4 ± 1.38	2.5 ± 10.34	12.1 ± 25.77
4	Litter (%)	30.4 ± 23.40	31.1 ± 27.33	32.9 ± 26.59
5	Dead wood (%)*	22.6 ± 22.41	21.8 ± 21.16	14.2 ± 15.32
6	Bare ground (%)	32.8 ± 26.54	33.4 ± 22.45	23.2 ± 22.92
7	Average hits at 1 m[c]	0.56 ± 0.733	0.61 ± 1.099	0.79 ± 1.296
8	Percent of canopy closed*	87.1 ± 19.52	77.9 ± 33.79	72.0 ± 37.01
9	Slope (degrees)	2.2 ± 1.50	2.0 ± 1.24	3.5 ± 4.00
10	Total hits low[d]*	2.12 ± 3.333	2.99 ± 4.376	3.65 ± 3.539
11	Total hits high[d]**	6.00 ± 4.822	4.51 ± 5.262	3.19 ± 4.222
12	Maximum canopy height (m)	7.6 ± 2.96	7.4 ± 4.33	7.0 ± 4.20
13	Average distance to nearest tree (m)***	2.8 ± 0.98	4.0 ± 2.12	5.3 ± 2.62

[a] Asterisks identify seven variables, when considered individually, exhibiting statistically significant differences between the 25 trap stations where tawny deermice were captured and the 475 where not captured: *, $P < 0.05$; **, $P < 0.01$; ***, $P < 0.001$. For comparisons involving just grid 2, only variable 13 showed a similar statistical difference ($P < 0.01$).

[b] Includes 75 stations on grid 2 where tawny deermouse was not captured.

[c] Average of four determinations of number of shrub stems hitting a 1-m bar at 1-m height.

[d] Total number of decimeter intervals within which vegetation touched a vertical pole, summed for 0–2.5 m (total hits low) and for 2.5–7.5 m (total hits high).

of quadrants being the cardinal directions) and the average taken (variable 13); distances ≥10 m were tabulated as 10 m.

Statistical Analysis—For 2004, we analyzed the relationship between vegetation characteristics of trap stations where tawny deermice were caught and not caught by using stepwise logistic regression (Hosmer and Lemeshow, 2000; Systat Software, 2004*a*). The dependent variable was presence or absence (1 or 0) of the tawny deermouse, with the 13 structural-vegetation variables used as potential independent variables. The significance to include a variable was set at 0.05 and to remove at 0.10, with maximum number of steps limited to 10. McFadden's ρ^2-statistic, which can vary from 0 to 1, was used to evaluate resulting models as a whole. It is a transformation of the likelihood-ratio statistics intended to mimic R^2, with higher values indicating more significant results. Steinberg and Colla (2004) noted that ρ^2-values tend to be lower than R^2-values (0.20–0.40 have been considered to be satisfactory), but low values do not necessarily indicate poor fit of the model.

SigmaPlot 9 (Systat Software, 2004*b*) was used to summarize graphically associations of vegetation variables with whether or not the tawny deermouse was captured at given sites. In addition, for one of the vegetation characteristics and one of the grids, we used the computer program Surfer 8 (Golden Software, 2002) and kriging to map estimated levels for the variable across the complete grid area (i.e., the area included in the perimeter set at 5 m beyond the outermost traps on each side of the grid).

RESULTS—Sampling during 2003 resulted in capture of only one tawny deermouse for the 8,000 trap-nights of effort. The individual, an adult male, was taken in an arboreal trap on grid 2 (2003) and was not recaptured. It did not have descended testes and, therefore, was judged as reproductively inactive.

In 2004, we captured 16 tawny deermice (12 males, 4 females) a total of 47 times–43 captures (91.4%) were in arboreal traps and 4 (8.6%) in ground traps. All captures were at 25 of the 100 stations on grid 2 (Fig. 2). For males (all captured in arboreal traps initially), 10 were adults and 2 were subadults; three females were adults and one a subadult (three captured in arboreal traps and one at ground level initially). Of the four individuals initially captured in ground traps, two were males (one a subadult) and two were females. The adult tawny deermice caught were reproductively active. For the 10 adult males, nine were scrotal and one subscrotal, while for the three adult females, one was postlactating, one

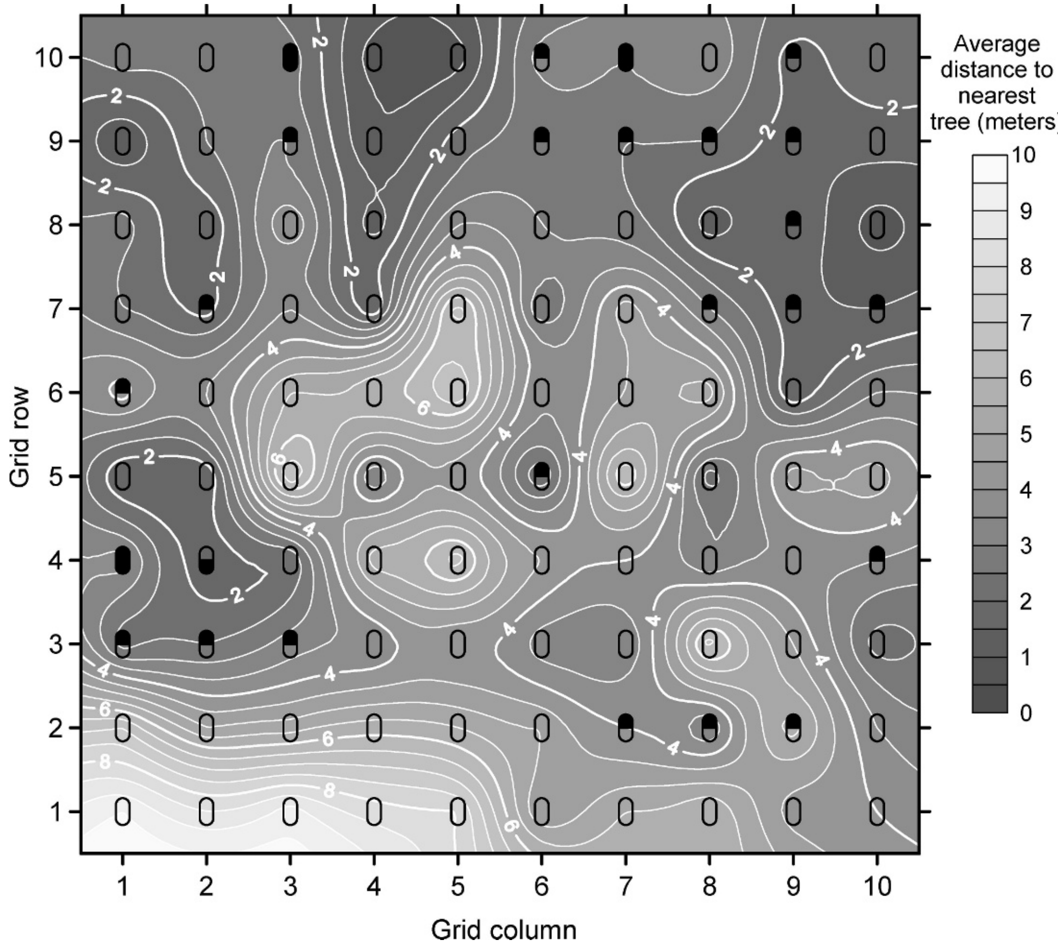

Fig. 2—Depiction of grid 2 in 2004 showing stations where tawny deermouse (*Peromyscus perfulvus*) was caught and not caught. Solid black ovals indicate where tawny deermouse was captured in both arboreal and ground traps. If only top half of oval is filled, tawny deermouse was caught only in arboreal trap; if only bottom of oval is filled, tawny deermouse was caught only in ground trap. Unfilled oval indicates species was not caught at station. Contours signify estimated average distance to nearest tree, with surface determined through use of kriging based on measurements taken at the 100 trap stations.

was lactating and pregnant. and one was lactating. Based on minimum number known alive at the time of the study, population abundance was 16 on grid 2, with no evidence of tawny deermice on the other four grids.

Using the program CAPTURE, we estimated that 18 tawny deermice (95% confidence interval 17–26 individuals) occurred on grid 2. Mean distance moved between points of capture (based on movements of 14 individuals) was 25.4 m, and the area of effect was estimated to be 1.32 ha. Thus, we determined that on grid 2 there was 1 tawny deermouse/0.07 ha or 13.6 individuals/ha. Taken across all five grids sampled in 2004, the density would reduce to 1 mouse/0.37 ha or 2.7 individuals/ha. Maximum distance between stations where a given individual was trapped was 67 m for one of the males and 36 m for one of the females.

Mean values and standard deviations for the 13 vegetation-structure variables for stations where tawny deermice were and were not caught are given in Table 1. For 7 of the 13 variables, when taken individually, there was a statistically significant difference between the 25 stations where tawny deermice were captured and the 475 stations where they were not caught (Table 1). Stations with mice had lower percentages

TABLE 2—Estimates for constant and coefficients of four independent variables resulting from logistic-regression analysis contrasting measures of 13 structural-vegetation variables at trap stations on the five grids in January 2004 where the tawny deermouse (*Peromyscus perfulvus*) was captured (coded 1; 25 stations) and not captured (coded 0; 475 stations). Similar values are provided that contrast stations on grid 2 where the species was captured (25 stations) and not captured (75 stations).

Constant or independent variable	Coefficient ± *SE*	*t*-ratio	*P*-value
Logistic-regression model for five grids			
Constant	0.347 ± 0.667	0.520	0.603
Average distance to nearest tree (X_{13})	−0.603 ± 0.139	−4.328	<0.001
Total hits low[a] (X_{10})	−0.256 ± 0.092	−2.776	0.006
Percent litter (X_4)	−0.025 ± 0.010	−2.523	0.012
Total hits high[a] (X_{11})	0.110 ± 0.041	2.686	0.007
Logistic-regression model for grid 2			
Constant	0.285 ± 0.536	0.531	0.595
Average distance to nearest tree (X_{13})	−0.417 ± 0.160	−2.602	0.009

[a] Total number of decimeter intervals within which vegetation touched a vertical pole, summed for 0–2.5 m (total hits low) and for 2.5–7.5 m (total hits high).

of woody plants and grasses, as well as more dead wood. The canopy was more closed, and there were fewer hits by vegetation low on a vertical pole and more hits high, as well as a shorter average distance to the nearest tree.

Stepwise logistic regression of the 500 trap stations, contrasting stations where tawny deermice were and were not caught, on the five grids resulted in the following equation:

$$Y = 0.347 - 0.603X_{13} - 0.256X_{10} - 0.025X_4 + 1.110X_{11},$$

where Y is the dependent variable (which initially we coded as 1 when species caught at station and 0 when not), X_{13} is average distance to nearest tree, X_{10} is total hits low, X_4 is percent litter, and X_{11} is total hits high (Table 2). McFadden's ρ^2 was 0.228. Taking the four independent variables in combination, the equation indicated that tawny deermice tended to be at locations where: (1) average distance to nearest trees was small; (2) low-level vegetation was relatively sparse; (3) there was little litter; and (4) vegetation was dense at higher levels. Resulting Y-values for stations where we captured tawny deermice, in general, were notably higher than for sites where we did not trap the species (Fig. 3a).

When considering independent variables in the equation separately, tawny deermice generally occurred at sites with trees close-by, whereas the distribution of the average distance to the nearest tree for the 475 other stations was essentially uniform for meter categories from 1 to 10 m (Fig. 3b). Also, for stations where tawny deermice were caught, there was little understory, as suggested by relatively fewer hits by vegetation low on a vertical pole (Fig. 3c) and

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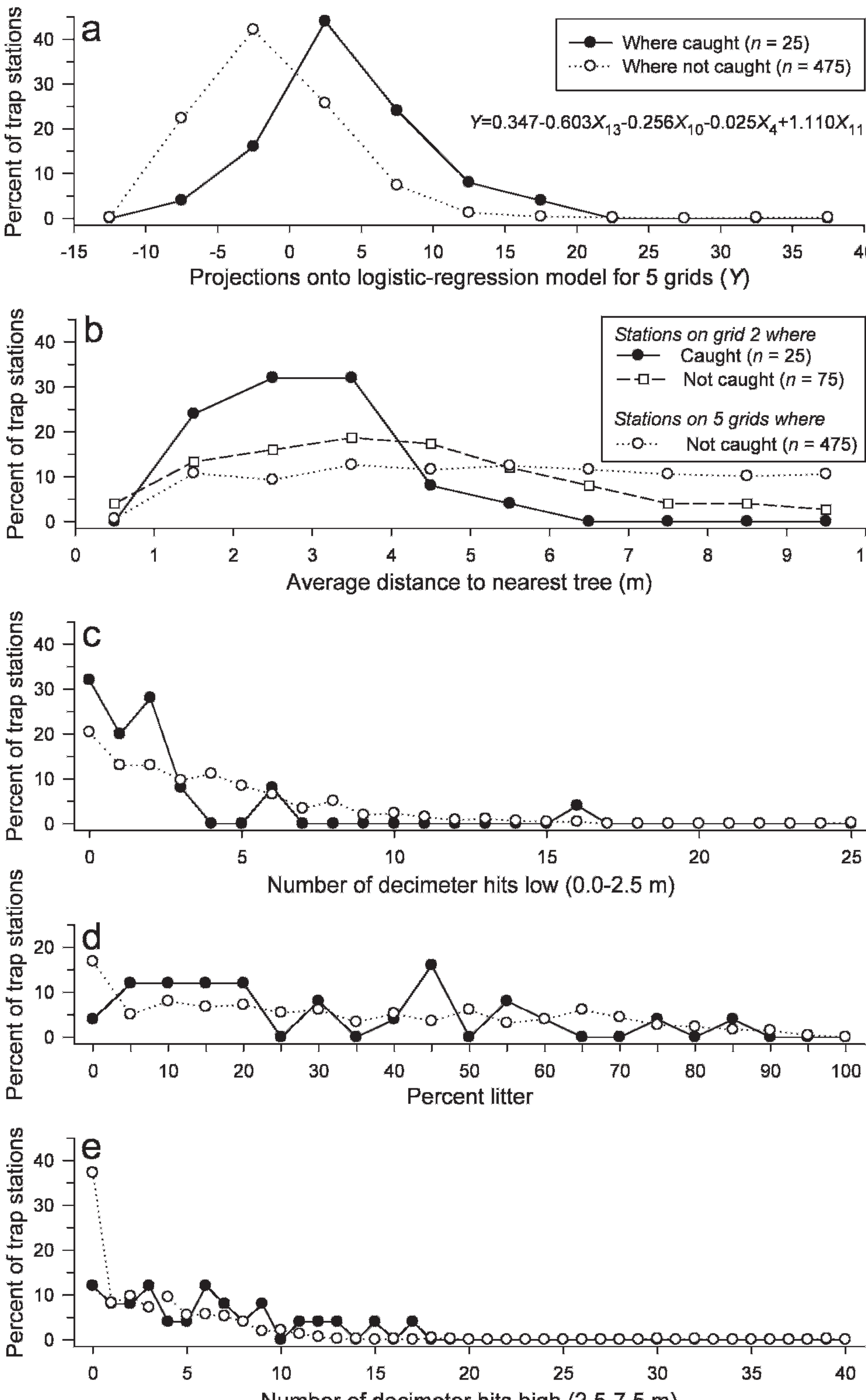
FIG. 3—(a) Percentages of projections of trap stations in 2004 in given projection classes for logistic-regression model based on data from all five grids, totaling 500 stations: 25 where tawny deermouse (*Peromyscus perfulvus*) was caught and 475 where not caught. Variables in equation are average distance to nearest tree (X_{13}), number of decimeter hits by vegetation low on pole (X_{10}), percent litter (X_4), and number of decimeter hits by vegetation high on pole (X_{11}). (b) Percentages of trap stations on grid 2 in distance classes for average distance to nearest tree for 25 trap stations where tawny deermice were captured and for 75 stations where it was not captured, as well as for all 475 stations on all five grids where it was not caught. Similarly, percentages of 25 stations where tawny deermice were captured and percentages of 475 stations where it was not captured for the following variables: (c) number of decimeter hits by vegetation low on pole; (d) percent litter; and (e) number of decimeter hits by vegetation high on pole.


a
Where caught (n = 25)
Where not caught (n = 475)
Y=0.347-0.603X13-0.256X10-0.025X4+1.110X11
Percent of trap stations
Projections onto logistic-regression model for 5 grids (Y)
b
Stations on grid 2 where
Caught (n = 25)
Not caught (n = 75)
Stations on 5 grids where
Not caught (n = 475)
Percent of trap stations
Average distance to nearest tree (m)
c
Percent of trap stations
Number of decimeter hits low (0.0-2.5 m)
d
Percent of trap stations
Percent litter
e
Percent of trap stations
Number of decimeter hits high (2.5-7.5 m)

relatively more hits by vegetation high on the pole (Fig. 3e) than for noncapture stations; capture sites also tended to have less litter. It is not surprising that the last two variables (number of vegetation hits high on the pole and percent litter), when taken individually, do not show markedly different patterns between stations where tawny deermice were caught or not caught. These variables were the last two added to the logistic-regression equation. In fact, percent litter was not statistically different when considered individually (Table 1); it was only helpful when simultaneously considered with the other variables in the equation.

When comparing only sites on grid 2, average distance to nearest tree (X_{13}) was the only variable that reached a significance level that allowed it to enter into the equation (Table 2):

$$Y = 0.285 - 0.417X_{13}.$$

McFadden's ρ^2 was 0.077. Although average distance to nearest tree generally was less for noncapture stations on grid 2 than for all five grids (Fig. 3b), stations where we captured tawny deermice had even lower values for this variable, suggesting that the species was avoiding sites where trees were not in close proximity, as illustrated in Fig. 2.

Discussion—The capture ratio of 3 males:1 female in our study was the same as reported by Collett et al. (1975) and similar to the 3.3:1.0 reported by Ceballos (1990) for the tawny deermouse. We cannot rule out a sex bias in terms of trapability and our sample size was small, but the similar results of these three studies suggest a possible male-biased sex ratio for the tawny deermouse. Drickamer et al. (2002) noted that populations of most species have about a 1:1 sex ratio at birth, but might deviate significantly from this ratio as adults. However, cases where females monopolize more than one male are rare in mammals (Feldhamer et al., 2004). Cockburn et al. (2002) noted that birds and mammals often do not meet predictions of sex bias from any single theory because sex allocation in these animals are subject to multiple influences, and Vaughan et al. (2000) indicated that much remains to be learned concerning occurrences and causes associated with biased sex ratios among mammals. If sex ratios, in fact, deviate substantially from 1:1 in the tawny deermouse, then effective population size would be notably lower than indicated simply by the total number of individuals in the population. This, in turn, would exacerbate loss of genetic variation due to drift-based mechanisms.

The semiarboreal nature of the tawny deermouse has been noted by several authors. Helm et al. (1974) trapped tawny deermice in trees but also on the ground in tropical dry forest with considerable secondary vegetation, coconut palms, tamarind (*Tamarindus indica*), lime trees (*Citrus aurantifolia*), and acacias (*Acacia*). All eight specimens collected by Collett et al. (1975) were on trees (1–3 m above ground) in tropical subdeciduous forest at Chamela. Núñez et al. (1981), using only ground traps, did capture the species in tropical subdeciduous forest with oaks, shrubs, and palms (*Brahea dulcis*) at El Tuito.

The most extensive previous study involving the tawny deermouse is that of Ceballos (1990), who trapped throughout the year and evaluated habitat use at arboreal and ground levels on the Chamela Biological Station. He had 21,600 trap-nights in habitats where tawny deermice were caught, with 85% (136 of 160) of captures being in traps above ground, although only 20% of his traps were in elevated positions. Had there been an equal number of elevated and ground traps, the adjusted, effective aboveground trapping rate would have 95.8%, even higher than our 91.4%. Both values corroborate the strong arboreal nature of the species. Such a heavy reliance on living in aboveground vegetation could make the species vulnerable to reductions in population size in regions subject to large-scale habitat modification, such as clearing for agriculture, which is the case throughout much of the range of the tawny deermouse. Few places within that range are afforded the protection from habitat disturbance provided by the Chamela Biological Station, where Ceballos (1990) and Helm et al. (1974) conducted their studies. Mendoza Durán (2002) noted that 75% of captures of tawny deermice on the ground were females, based on a multiyear compilation of trapping results. Our four ground captures were equally divided between males and females, but the total number of such captures was too small for us to draw any conclusions.

Reproductive activity has been reported to occur throughout the year for this species (Helm et al., 1974; Ceballos, 1990). Our data indicate that the tawny deermouse was reproductively active in Colima in January.

Ceballos (1990) documented tawny deermice primarily in wet habitats and reported them to be relatively abundant in palm and arroyo forest. He indicated that population densities fluctuated throughout the year from 2 to 14 individuals/ha, and he did not capture the species in mangrove, thorn forest, or grassland habitats. Our minimum number known alive of one individual on grid 2 in 2003 and the estimate of 13.6 individuals/ha on grid 2 in 2004 approximate the range of densities reported by Ceballos (1990). Mendoza Durán (2002), citing Mendoza (1997), indicated that maximum density of tawny deermice in tropical deciduous forest is about 3.7 individuals/ha, probably representing mostly dispersing individuals, while in tropical semideciduous forest, density of tawny deermice can be as high as 30 individuals/ha. Previously, maximum recorded distance between successive capture sites for the species was 70 m (Mendoza Durán, 2002), which is similar to the 67 m we recorded for one mouse.

We did not capture tawny deermice on sites consisting primarily of thorn forest or where a combination of grasses and thorn forest predominated. We did catch them on sites consisting of palm plantations overgrown with thorn forest and with some mangrove associations, but not on all sites represented by these habitats, suggesting that occurrence of tawny deermice might be patchy, even in what superficially seems to be suitable habitat. Our logistic-regression analyses also supported this conclusion; tawny deermice used those parts of habitats with dense trees, although other areas had habitat characteristics we might judge to be suitable. Furthermore, microhabitats used tended to be relatively open near the ground and denser at higher levels, with relatively little litter on the ground. Apparently, the tawny deermouse has a relatively narrow habitat tolerance.

Although coastal tropical forests in Colima do not have the same level of protection as similar habitats at the Chamela Biological Station in Jalisco, we originally selected our study plots so as to exclude areas strongly affected by grazing. Furthermore, on many of our study plots, vegetation was so dense as to preclude direct access by grazing animals. While relevant, parallel quantitative measures of habitat quality have not been made of suitable habitat on the Chamela Biological Station and our study plots, our qualitative impression is that habitat quality on our plots was not seriously degraded compared to that in Chamela. Nevertheless, our study plots were not buffered by officially protected lands, and much of the area immediately surrounding our plots was notably disturbed, which likely is the case for many of the places where the tawny deermouse occurs. Thus, while most of our plots did not exhibit major effects of habitat degradation, these areas are still vulnerable with even modest changes in land use. This probably is the situation throughout much of the range of the tawny deermouse.

The mark-recapture estimate we obtained was derived using a total area of effect, the first time this type of method has been used to estimate density of the tawny deermouse. Our finding of 13.6 individuals/ha (1 animal/0.07 ha) in occupied areas and 2.7/ha across a range of microhabitats are probably the most reliable estimates of population density for the species to date. Compared to densities of other species of *Peromyscus* in more temperate regions (Whitaker and Hamilton, 1998) or in tropical regions (Collett et al., 1975; García Estrada et al., 2002), these are not high densities and could be indicative of a small overall population size. Our multi-grid estimate of 2.7 tawny deermice/ha is at the low end of values (2.7–3.7 mice/ha) calculated from reports for a long-term study of similar design that examined the highly endangered Alabama beach mouse (*P. polionotus ammobates*; Swilling et al., 1998; Swilling and Wooten, 2002). Genetic consequences of such situations are well known (Reed and Frankham, 2003) and might already be an issue for the Playa de Oro population of the tawny deermouse. Nucleotide sequence analysis of the 1,500-bp segment of the mitochondrial DNA, which included the highly variable region with the control loop, revealed no variation (one haplotype) among eight tawny deermice sampled (M. C. Wooten; data not shown). This finding is similar to those for endangered populations of beach mice (*P. polionotus* ssp.; J. Van Zant, pers. comm.).

Information relevant to determining the conservation status of the tawny deermouse remains incomplete and, at present, it is not listed in the Norma Oficial Mexicana, NOM-059-ECOL-2001 (Secretaría de Medio Ambiente y Recuros Naturales, 2002). However, after analyzing data on current land uses and vegetation types from the Inventario Nacional Forestal 2000, Sánchez-Cordero et al. (2005) judged that the tawny deermouse faces a high risk of extirpation because >40% of habitats it frequents have been substantially transformed. Given the finding by Sánchez-Cordero et al. (2005) coupled with our results—that is, possible male-biased sex ratio, relatively low population density, highly arboreal habits in a region that is being heavily modified through human activities, and microhabitat preferences within an already restricted set of habitats that seem superficially suitable—there is reason for concern with regard to the future of the tawny deermouse. We recommend that the potential vulnerability of the species for extinction be recognized and stress the need for additional studies relating to demography of the tawny deermouse in other areas within its limited geographic range. Furthermore, even a superficial perusal of the literature indicates that we know little about the basics of ecology and overall demographics of many of the species of small mammals in this global hotspot for biodiversity. As posited by Lyons et al. (2005), it is critical that we gain a better understanding of rare species, such as the tawny deermouse, as they might contribute in significant ways to ecosystem stabilization.

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