RODENT MOVEMENTS IN SOUTH TEXAS AND THEIR RELATION TO DENSITY ESTIMATES[a, b]

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Abstract: The average distance moved between captures (d) in a 10 x 10 live trap grid with 15.2-m spacing was determined for eight species of rodents in South Texas during January-July 1975 and 1976. Large samples yielded fairly precise estimates of d for cotton rats (*Sigmodon hispidus*) (25.8 ± 0.58 m), deer mice (*Peromyscus leucopus* and *P. maniculatus*) (33.2 ± 2.50 m), fulvous harvest mice (*Reithrodontomys fulvescens*) (36.3 ± 1.92 m), and gray wood rats (*Neotoma micropus*) (20.7 ± 1.61 m). Generally, movements of adults were larger than those of juveniles and movements of males were larger than those of females. The data indicated a need to stratify the estimated area of trap grid influence by habitat for cotton rats and by yearly rainfall for gray wood rats for more accurate density estimates. The present data may be useful to other workers for determining the area of influence for lines or grids of traps.

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Data collected by establishing a live trap grid, capturing, marking, and recapturing rodents allow estimation of population size by several formulas (Overton and Davis 1969). The area of trap grid influence (A) must be determined to estimate density. This area is composed of the area encompassed by the grid itself (A) and an area peripheral to the grid that contributes animals to the mark-recapture data (A_p). Assuming valid estimation of population size, reliable determination of A_p becomes more critical to accurate density estimates as A decreases.

Procedures used to estimate A_p include (1) preclusion of the need to estimate A_p by using natural or artificial barriers to ingress, (2) establishing perimeter traps or trap lines to qualitatively (e.g. O'Farrel et al. 1975) or quantitatively (e.g. Swift and Steinhorst 1976) estimate the grid's sphere of influence, (3) adding one-half the width of a species' home range to the periphery of the grid (Blair 1941), and (4) adding the mean distance moved between captures (d) to the periphery of the grid (Brant 1962, Chew and Chew 1970). Brant reasoned that density estimates must take into account the average distance an animal moves into a trap.

Few published data are available for estimating A_p for rodents in South Texas. Stickel and Stickel (1949) reported that normal ranges of male cotton rats, female cotton rats, and pygmy mice (*Baiomys taylori*) were less than 30.5, 61.0, and 30.5 m, respectively, in an *Andropogon* community in central Texas. In southern Texas, Raun and Wilks (1964:35) recorded an "average daily radius of movement" of 13.8 and 12.2 m for male and female pygmy mice, respectively. Raun (1966) found that normal daily movements of female and male gray wood rats were 6.8 and 14.1 m, respectively, also in southern Texas. He reported average maximum movements of 15.4 and 38.9 m, respectively, for the wood rat.

The purpose of this paper is to present data on d for eight species of rodents in South Texas under carefully defined trapping and habitat conditions. The influence of sex, age, and habitat on d is evaluated. Lastly, implications and applications of the present results for density estimates are discussed.

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STUDY AREA AND METHODS

The study was conducted in northern Zavala County, Texas, in a regional vegetation type known as the South Texas Plains (Gould 1975), which has rolling topography and mild climate. Dense stands of mixed brush have invaded much of the region. Guthery (1977) and Guthery and Beasom (1977) described the study area in detail.

Four trapping grids were established, including two on upland sites (grids B1 and B2) and two on lowland sites (grids W1 and W2). Qualitative and quantitative vegetation analyses were conducted in each grid to define habitat so that its influence on d could be examined. The following attributes of vegetation within a 3-m radius of each grid point were recorded: (1) the dominant species of shrub grass, and forb, (2) the approximate canopy coverage of each plant category ($<$5, 5-25, 26-50, 51-75, and $>$ 75 percent), (3) the height class of shrubs ($<$1, 1-2, $>$2-3, and $>$ 3 m), (4) the height class of herbaceous vegetation ($<$ 15, 15-30, 31-45, 46-60, and $>$ 60 cm), and (5) soil type. Standing crop biomass of herbaceous vegetation was estimated by clipping 2 x 5 dm plots at ground level at 20 randomly selected points in each grid in June of 1975 and 1976. The clippings were placed in perforated paper bags, air dried at least 3 days, dried in a laboratory drier at 60 C at least 10 hours, and weighed to the nearest 0.1 g.

Each 10 x 10 grid contained 100 Sherman live traps spaced at 15.2-m intervals. Grid points were numbered as if they occurred in Quadrant II of a graph so that distance moved between captures could be determined by $d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$. Grids were trapped 5 days/month from January through July 1975 and 4 days/month from February through July 1976. The lowland sites were trapped concurrently during the first 10 days of a month; the upland sites were trapped concurrently within the remainder of the month. Trap bait was a mixture of sunflower seeds, sorghum, whole corn, and oats. The traps were checked and reset between 0600-1100 CST; they were operative for 24-hour periods.

Captured rodents were marked individually by clipping one or two toes (ears were notched also in grid W2 in 1975 because all unique toe-clip combinations were used). The species, sex, age, condition, trap row, and trap column were recorded at each capture. Smaller animals with finer pelage were classified as juveniles.

During the study, 23,600 trap nights were accumulated. This yielded 3,637 capture observations which were transferred to computer cards for analysis. Statistical tests, unless otherwise indicated, were pooled *t* tests using the estimated population variance as the error term. The significance level throughout this paper is 5 percent.

Nomenclature follows Davis (1974) for rodents and Gould (1975) for vegetation.

RESULTS AND DISCUSSION

Grid Vegetation

Canopy coverage of brush was high (range of about 40-70%) on each of the four grids (Table 1). Most brush was 1-3 m tall. Whitebrush (*Aloysia lycioides*) dominated the lowland grids and blackbrush acacia (*Acacia rigidula*) dominated the upland grids. Guajillo (*A. berlandieri*) was abundant on B2, probably because gravelly (cherty) soils occurred on about 30 percent of the site. Threeawns (*Aristida* spp.) dominated the herbaceous flora in upland grids whereas plains bristlegrass (*Setaria macrostachya*) and pink pappus (*Pappophorum bicolor*) dominated W1 and W2, respectively (Table 1). Height and coverage of grasses generally were lower in upland than in lowland grids. With the exception of W2, which supported dense stands of western ragweed (*Ambrosia psilostachya*), forbs were a minor component of the vegetation and were thus excluded from Table 1.

Analysis of variance indicated significant difference(s) existed in the standing crop biomass of grids. The means were 206, 199, 165, and 247 g dry weight/m^2 in June for B1, B2, W1, and W2, respectively.

Population d

Adequate sample sizes to obtain fairly precise estimates of d existed for cotton rats, deer mice, fulvous harvest mice, and gray wood rats (Table 2). Because samples were small for pygmy mice, short-tailed grasshopper mice (*Onychomys leucogaster*), Mexican ground squirrels (*Spermophilus mexicanus*) and hispid pocket mice (*Perognathus hispidus*), these species were excluded from further analysis.

The low d value for hispid pocket mice (Table 2) suggests that (1) the grid spacing of 15.2 m was beyond the normal range for this species or (2) individuals were attracted to traps ("trap happy"). For other species the spacing appeared acceptable.

Factors Affecting d

Table 1. Qualitative analysis of the composition and structure of vegetation on rodent grids in Zavala County, Texas. The numbers are percentage frequencies of occurrence of the characteristic.

	Upland Grids		*Lowland Grids*	
Characteristic	*B1*	*B2*	*W1*	*W2*
DOMINANT WOODY PLANT				
Whitebrush (*Aloysia lycioides*)	11	2	55	56
Blackbrush acacia (*Acacia rigidula*)	54	52	0	0
Guajillo (*A. berlandieri*)	1	36	0	1
Twisted acacia (*A. tortuosa*)	0	0	7	19
Mesquite (*Prosopis glandulosus*)	3	0	20	3
Granjeno (*Celtis pallida*)	12	0	6	2
Texas persimmon (*Diospyros texana*)	3	2	3	6
Shrubby blue sage (*Salvia ballotaeflora*)	7	5	0	0
Other species	2	3	9	13
WOODY PLANT HEIGHT CLASS (m)				
<1	32	10	14	7
1-2	27	45	44	45
>2-3	35	41	27	41
>3	6	4	15	7
WOODY PLANT COVERAGE CLASS (%)				
<5	21	5	20	5
5-25	27	14	14	14
26-50	32	27	21	29
51-75	20	27	19	27
>75	0	27	26	25
DOMINANT GRASS				
Threeawns (*Aristida* spp.)	67	57	15	23
Plains bristlegrass (*Setaria macrostachya*)	1	0	54	12
Curlymesquite (*Hilaria belangeri*)	18	0	15	22
Pink pappus (*Pappophorum bicolor*)	2	4	0	32
Red grama (*Bouteloua trifida*)	4	26	3	0
Tridens (*Tridens* sp.)	0	10	0	7
Other species	8	3	13	4
GRASS HEIGHT CLASS (cm)				
<15	10	7	7	0
15-30	14	37	15	19
31-45	55	47	35	35
46-60	19	9	36	30
>60	2	0	7	16
GRASS COVERAGE CLASS (%)				
<5	0	0	0	0
5-25	0	12	1	0
26-50	14	29	4	6
51-75	24	37	33	36
>75	62	22	62	58
SOIL TYPE				
Gravelly sandy loam	18	31	0	0
Sandy loam	82	69	0	0
Rocky clay loam	0	0	63	0
Clay loam	0	0	31	100

Table 2. Simple statistics for mean distance moved between captures (d) for rodents in Zavala County, Texas, January-July 1975 and 1976.

Species	*n*	*d* (*m*)	*sd*	*se*	*Maximum* (*m*)
Cotton rat	1,784	25.8	24.62	0.58	156.9
Deer mice[a]	197	33.2	35.04	2.50	173.8
Fulvous harvest mouse	220	36.3	28.53	1.92	143.8
Gray wood rat	217	20.7	23.65	1.61	140.5
Pygmy mouse	33	29.1	26.32	4.58	88.8
Short-tailed grasshopper mouse	5	32.9	31.13	13.92	68.2
Mexican ground squirrel	9	55.0	21.50	7.17	97.6
Hispid pocket mouse	23	4.0	11.44	2.29	43.1

[a]*Peromyscus leucopus* and *P. maniculatus.*

Sex and age. Generally, the average distance moved between captures was smaller for females than for males and smaller for juveniles than for adults (Table 3). Movement of adult female cotton rats were similar to those of juvenile females, but otherwise significant differences existed for the remaining five comparisons among cotton rats. The mean movement of juvenile female fulvous harvest mice was significantly smaller than that of adult males. Remaining comparisons within species by sex-age combination failed to show significance. Lack of significance in most tests, however, may reflect small sample size and highly variable data.

Table 3. Mean distance moved between captures (d) stratified by sex and age for rodents in Zavala County, Texas, January-July 1975 and 1976.

	Adult Female		*Juvenile Female*		*Adult Male*		*Juvenile Male*	
	n	*d* (*m*)	*n*	*d* (*m*)	*n*	*d* (*m*)	*n*	*d* (*m*)
Cotton rat	377	21.7	391	20.0	599	32.6	348	28.3
Deer mice[a]	69	35.4			107	34.0	2	10.8
Fulvous harvest mouse	71	35.5	14	24.9	96	39.2	3	36.0
Gray wood rat	94	18.3	19	15.4	55	24.3	32	20.2
Pygmy mouse	18	20.4			16	38.4		

[a]*Peromyscus leucopus* and *P. maniculatus.*

The suggested differences in movements between juveniles and adults and between males and females indicate that the area of grid influence is at least partially a function of the demographic structure of a popultion. Differences in movement by sex, when they exist, would be of little consequence in estimating A_t and density, providing no sex bias in probability of capture exists and the sex ratio is close to 1:1. A_p may decrease, however, as the percentage of juveniles in a population increases. This apparently occurred on grid W2 in 1975 where cotton rat density increased, due largely to reproduction, from about 10.3 to 42.5/ha from January to July (Guthery 1977); d decreased from 23.7 to 18.6 m during the same period.

Habitat. Substantial differences between rainfall patterns and totals during the study provided an opportunity to examine rodent movements under relatively favorable and relatively poor habitat conditions. Rainfall (91.4 cm) was well distributed and above average throughout August 1974 to July 1975. This resulted in comparatively lush stands of herbaceous vegetation. Rainfall was low (24.8 cm), however, during August 1975 to July 1976. Growth of herbaceous vegetation during October 1975 to April 1976, when about 4 cm of rain fell, was minimal or nonexistent and dead, standing vegetation deteriorated. Although analysis of variance could not detect a difference in June standing crop biomass of grids between years, a true difference apparently was masked by (1) a pulse in growth prior to clippings in 1976 due to heavy rains in April and May and (2) absence of cattle grazing on the experimental areas in 1976.

The average movements of cotton rats were similar in 1975 (24.5 m) and 1976 (25.0 m). For deer mice, fulvous harvest mice, and gray wood rats, d increased by 12.6, 8.7, and 7.2 m, respectively, during the inferior conditions of 1976. These differences were not significant except for gray wood rats (d = 17.3 and 24.5 m in 1975 and 1976, respectively). Sample sizes were small in 1976 for deer and fulvous harvest mice. These data suggest that, with the exception of cotton rats, there is a need to stratify A_p in South Texas by habitat conditions as affected by rainfall.

Comparison by individual grids (Table 4) allowed a more detailed examination of the effects of habitat on d. The mean movement of both cotton rats and fulvous harvest

Table 4. Mean distance moved between captures (d) stratified by individual grids for rodents in Zavala County, Texas, January-July 1975 and 1976.

	Upland Grids				*Lowland Grids*			
	B1		*B2*		*W1*		*W2*	
Species	*n*	*d* (*m*)	*n*	*d* (*m*)	*n*	*d* (*m*)	*n*	*d* (*m*)
Cotton rat	217	29.4	282	32.7	492	26.9	794	21.7
Deer mice[a]	43	34.5	15	24.7	111	36.5	28	23.1
Fulvous harvest mouse	35	32.9	68	37.9	94	32.3	23	53.0
Gray wood rat	31	22.8	78	24.4	76	15.1	32	22.8

[a]*Peromyscus leucopus* and *P. maniculatus.*

mice in W2 was significantly different from their movement in the other grids. Also, significant differences in d for cotton rats, deer mice, and gray wood rats existed between grids B2 and W1. These results suggest that d is, to a large degree, habitat specific for cotton rats. This finding seemingly contradicts the previous conclusion that broad environmental variation between 1975 and 1976 had little influence on cotton rat movement. Mean movements within grids during the two years were not significantly different, however, even though habitat quality varied. Thus refined estimates of cotton rat density apparently call for stratification of A_p by habitat type. The need for such stratification, though implied in some cases, was less clearcut for the other three species.

Application of Results

The implications of the present results can best be shown by a hypothetical example. Suppose that lines of 10 traps spaced at 10-m intervals were established in W2 and B2 and that 10 cotton rats were estimated to be in each line's sphere of influence. The area trapped can be estimated by $A_t = \pi d^2 + 2dl$ where l is the distance between end traps on the line. Using d's unique to the respective habitats (Table 4), A_t is estimated to be 0.54 and 0.92 ha in W2 and B2 respectively. Respective density estimates are 18.5 and 10.9/ha; density in B2 is thus 41 percent lower than that in W2 even though the estimated populations in the lines' spheres of influence are identical. Such differences would be less dramatic but still substantial in a larger grid. Under the specifications given above, but using a 10 x 10 grid with 15.2-m spacing, the areas trapped would be 3.2 and 4.1 ha for W2 and B2, respectively. With the line of traps, A_t for B2 is 70 percent greater than A_t for W2; with the grid the difference is 26 percent. These figures demonstrate numerically the relationship noted earlier, i.e., A_p becomes less critical to density estimates as A_t increases.

Results of this study could be applied by other workers, providing they were operating in similar habitat and their data were insufficient to estimate A_p. The population d's (Table 2) could be used to estimate A_t for lines or grids of traps. However, certain refinements in the population means appear warranted under some conditions. At a minimum, estimation of A_t for cotton rats should be stratified by upland and lowland sites. The grand means for these habitats were 31.3 and 23.7 m, respectively. Furthermore, d's of 17.3, 20.7, and 24.5 m apparently should be used for gray wood rats in "wet", "average", and "dry" years, respectively.

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