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Characteristics of the Burrows of Four Species of Rodents in Undisturbed Soils in Southeastern Idaho

TIMOTHY D. REYNOLDS[1] and WAYNE L. WAKKINEN[2]
Biology Department, Idaho State University, Pocatello, Idaho 83209

ABSTRACT: Dimensions of the burrow systems of four small mammals common to southeastern Idaho (*Spermophilus townsendii, Dipodomys ordii, Microtus montanus* and *Peromyscus maniculatus*) were determined in undisturbed soils. *Spermophilus* constructed two distinct burrow systems: over 120 cm deep and less than 60 cm deep. The deeper systems were significantly longer and had larger volume than the shallower burrows and the systems constructed by the other species. Burrow parameters for *Dipodomys* were bimodal, suggesting deep and shallow burrows, but this was not demonstrated statistically. All parameters for *Dipodomys* burrows were similar to shallow *Spermophilus* burrows. Volumes of both were significantly greater than volumes for *Peromyscus* and *Microtus*. A significant portion of the variability of all parameters for *Microtus* and shallow *Spermophilus* burrows was explained by the distribution of soil particle sizes, but equations based on these were only of limited value in predicting burrow parameters.

INTRODUCTION

Burrowing by fossorial and semifossorial rodents increases soil aeration, water percolation, soil mixing and recycling of insoluble and soluble chemicals to the soil surface (Abaturov, 1972; Chew, 1977; Green and Reynard, 1932; Hansen and Morris, 1968; Taylor, 1935; Ulehla *et al.*, 1974). Moreover, belowground food storage and excretion accelerate the accumulation of organic material in soil (Taylor, 1935; Thorpe, 1949).

The degree to which any species affects soil enrichment processes is a function of its burrow characteristics. Burrowing (and burrows) are well-documented for the family Geomyidae and various species of Heteromyid rodents. Little quantified information is available on the burrow systems of deer mice (*Peromyscus maniculatus*) (Scheffer, 1924; Kritzman, 1974), montane voles (*Microtus montanus*) (Lyons, 1979), or Townsend's ground squirrels (*Spermophilus townsendii*) (Alcorn, 1940), although anecdotal accounts of the latter are common (*e.g.*, Davis, 1939; Linsdale, 1938; Scheffer, 1941). Quantified information on burrow parameters of Ord's kangaroo rat (*Dipodomys ordii*) is lacking.

The objectives of this study were to examine the geometry and characteristics of the burrows of these four species in undisturbed soils in southeastern Idaho, and to relate burrow parameters to soil texture characteristics.

METHODS

Burrows were examined at the Idaho National Engineering Laboratory (INEL) on the sagebrush- (*Artemisia* spp.) dominated Snake River Plain approximately 48 km W of Idaho Falls, Bonneville Co., Idaho. The topography is flat to gently rolling, with frequent lava outcrops typical of the Columbia Plateau Province (Atwood, 1970). The average elevation is ca. 1500 m. Soils, derived mostly from silicic volcanics and Paleozoic rocks from the mountains N and W of the site, are primarily aeolian sandy loams and loess underlain by undifferentiated basalt over a rhyolite foundation (Nace *et al.*, 1975).

All burrows examined were in generally undisturbed soils. Data were collected from May through July 1982. Before a burrow system was examined, the species occupying the burrow was determined by snap-trapping at the burrow opening(s). If the occupant

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[1]Radiological and Environmental Sciences Laboratory, U.S. Department of Energy, 785 DOE Place, Idaho Falls, Idaho 83402.

[2]Present address: Department of Forestry, Wildlife, and Range Science, University of Idaho, Moscow 83843.

was not collected, hair found in the burrow was used to identify the species (Moore *et al.*, 1974). Occasionally, scats were compared with reference material for identification. If hair and/or scat identification indicated habitation by > 1 species, data for that burrow were omitted from analyses.

The characteristics of burrow systems were determined by injecting them with polyurethane foam (Felthauser and McInroy, 1983) and mapping the system. Hand tools and a back-hoe were used to expose the hardened foam casting. Measurements of burrow systems were made *in situ*. A 1 x 2 m tubular-aluminum frame, divided into 100-cm^2 grid cells by wire strung at 10-cm intervals, was placed at the surface above each casting. Burrow depth was measured by suspending a ruler through the center of each grid cell directly above the casting. Distances were recorded on graph paper, with each grid on the paper corresponding to a grid cell on the frame. The result was a top-view schematic of each burrow system, with data within each grid representing depth. Later, the diameter of each burrow was added to provide the maximum depth for subsequent statistical analyses. The volume of soil excavated by the burrowing animal was determined by measuring water displacement (to the nearest 0.1 liter) of each polyurethane burrow casting. Significant differences ($P < 0.05$) for burrow parameters among species were determined by one-way ANOVA (Zar, 1974). Each species was initially assumed to construct only one type of burrow system. Hence, at first all data for each parameter for each species were combined during statistical comparisons. Later, when it appeared that *Spermophilus* and *Dipodomys* each constructed more than one type of burrow, data for each burrow type were separated and parameters were compared within and among species.

Soil samples were collected immediately adjacent to most burrow systems. Soil particle size was determined by standard sedimentation processes (American Society for Testing and Materials, 1972). Soil particles (sand, silt and clay) were defined by sizes of > 0.06 mm, 0.002-0.06 mm and < 0.002 mm, respectively (Dunn *et al.*, 1980). Equations describing the relationships between the proportion of different soil particle sizes and burrow length, depth and volume for each species were developed by multiple linear regression analyses (Neter and Wasserman, 1974). Because the sum of the proportions of the three soil separates in any sample totaled 100%, it was necessary to examine all combinations of two separates (*i.e.*, silt and sand, sand and clay, and clay and silt), as well as each separate individually, to determine which had the greatest effect on each burrow parameter. Significance ($P < 0.05$) was assessed with an F-test (Neter and Wasserman, 1974).

The predictive value of the equations was examined by determining the 95% confidence intervals around a predicted parameter value ($\hat{y}_{new}$). These calculations were based on "new observations" of the soil fractions, which were simply the averages of the percentages of the distribution of soil particle sizes from burrows for each species.

RESULTS

Seventy-nine burrow systems were examined (Table 1). All of the occupants, and presumably constructors, of *Peromyscus* and *Microtus* burrows were determined by snap-trapping. *Spermophilus* (three adults and four juveniles) were trapped at the mouth of seven burrows, and adult-sized (> 50 g) *Dipodomys* were collected from 11 burrows. No juvenile *Dipodomys* were captured. Occupants of 21 burrow systems were determined by scat and/or hair analysis.

A *Spermophilus* burrow was the deepest (138 cm), longest (930 cm) and largest (29.9 L) recorded. The averages of these parameters for all *Spermophilus* burrows were 46 ± 38 cm, 404 ± 349 cm, and 11.2 ± 14.8 L, respectively. These did not differ significantly from average values for Dipodomys burrow systems. The average volumes of *Microtus* and *Peromyscus* systems were significantly less than the average *Spermophilus* and *Dipodomys* systems ($F_{3,72} = 4.93$; $P < 0.01$; Table 1). Seventeen (85%) *Spermophilus* systems were less than 60 cm deep; three (15%) were deeper than 120 cm. The average depth, length

and volume of the deeper systems were significantly greater than the averages for the shallower *Spermophilus* burrows and the other three species examined (Table 1). The three deep burrows accounted for over 35% of the total volume of soil excavated by *Spermophilus*. The mean depth, length and volume of *Dipodomys* burrows was not significantly different from that of shallow *Spermophilus* systems. Burrow systems of both of these species had significantly greater mean volumes than either *Microtus* or *Peromyscus* systems. No other comparisons among the four species were statistically significant.

The particle size distribution for the soils containing the burrows was uniform (Table 2). Soils were classified as sandy loam, loamy sand or loam (Dunn *et al.*, 1980). No significant relationships were found among soil separate fractions and any burrow parameter for either *Peromyscus* or *Dipodomys*. Significant regression relationships existed among the particle size fractions and all burrow parameters for *Spermophilus* and *Microtus*. With one exception, the lower and upper 95% confidence values for the significant regression equations were < 0.5 and > 2.0 times the predicted value ($\hat{y}_{new}$), respectively. The exception was the equation describing the depth of *Microtus* burrows (D = 1.9[Sa]-61.8; where D = depth in cm and Sa = percent sand in the soil) which had a 95% confidence interval of $0.6(\hat{y}_{new}) \leq \hat{y}_{new} \leq 1.4(\hat{y}_{new})$.

There was a significant positive correlation between average body size (mass) for each species and mean burrow depth ($r = 0.32$, $t = 2.14$, $P < 0.05$) and volume ($r = 0.49$, $t = 3.56$, $P < 0.01$). Total burrow length was independent of body size ($r = 0.06$, $t = 0.38$, $P > 0.6$), but, as expected, significantly correlated with burrow volume ($r = 0.84$, $t = 9.79$, $P < 0.001$).

TABLE 1. — Mean ± SD and (range) of burrow parameters of four species of rodents at the Idaho National Engineering Laboratory. Within a column, means bearing different superscripts are significantly different (ANOVA, P < 0.05)

Species	N	Depth (cm)	Length[1] (cm)	Volume (L)
Peromyscus maniculatus	26	24 ± 11[a] (13-50)	132 ± 107[a] (30-470)	1.7 ± 1.8[a] (0.3-7.7)
Microtus montanus	14	23 ± 10[a] (15-55)	133 ± 82[a] (20-220)	1.1 ± 1.2[a] (0.1-4.0)
Dipodomys ordii	19	34 ± 12[a] (20-69)	253 ± 233[a] (50-890)	7.2 ± 7.7[b] (1.0-26.3)
Spermophilus townsendii				
"Shallow"	17	29 ± 12[a] (14-55)	222 ± 284[a] (30-890)	8.2 ± 9.7[b] (1.2-16.4)
"Deep"	3	128 ± 9[b] (121-138)	813 ± 43[b] (770-860)	27.9 ± 1.8[c] (22.8-29.9)

[1]Represents the sum of the total length of all main and side tunnels for each burrow system

TABLE 2. — Ranges of the soil separates (sand, silt and clay) from which burrows of four species of small mammals were excavated

Species	Sand (%)	Silt (%)	Clay (%)
Peromyscus maniculatus	40.0-53.0	34.8-46.6	11.5-15.6
Dipodomys ordii	31.7-52.4	34.5-46.6	11.4-13.4
Spermophilus townsendii	37.9-59.1	29.5-53.9	8.2-14.3
Microtus montanus	40.3-45.9	41.4-46.6	13.4-16.5

DISCUSSION

The only significant differences among burrow parameters were the greater volumes of soil excavated from *Spermophilus* and *Dipodomys* burrows. The extreme variability of the *Spermophilus* and *Dipodomys* data (Table 1) likely contributed to the lack of significance between other parameters among species.

Length was especially variable for *Dipodomys* burrows (Table 1), with 16 (84%) of the burrows <450 cm and three (16%) >550 cm. But, although other *Dipodomys* species are reported to have more than one type of burrow (Hawbecker, 1940; Anderson and Allred, 1964; Bienek and Grundmann, 1971), neither our length, depth or volume data clearly indicated more than one type for *D. ordii*.

Parameters for *Spermophilus* burrows were also quite variable (Table 1). Depths of *Spermophilus* burrows had a bimodal distribution, suggesting two distinct burrow types. Others (Bartholomew and Hudson, 1961; Davis, 1939) credited *Spermophilus* spp. with two or more (Alcorn, 1940; Shaw, 1924) types of burrow systems. We classified *Spermophilus* burrows systems as shallow (≤ 60 cm) and deep (≥ 120 cm). All parameters for deep systems were significantly different from shallow *Spermophilus* systems and burrows of the other three species (Table 1). Our deep systems were similar in size to the average (N = 5) 698.7 ± 560.3 cm length and 96.7 ± 35.9 cm depth Alcorn (1940) measured and reported as "home burrows of adults." The average shallow *Spermophilus* burrow was no different than the average *Dipodomys* burrow. The average length of our shallow systems was comparable to the 309.3 ± 96.0 cm average (N = 4) length of Alcorn's (1940) "home burrows of juveniles." The average depth was most similar to the 38.5 ± 6.0 cm (N = 4) depth of his "auxiliary burrows at feeding places." We captured adult and juvenile (young of the year) *Spermophilus* at the entrance of both deep and shallow burrow systems. We do not know if juvenile animals actually excavated any burrows prior to our study or if they were still using natal burrow systems. Because our trapping at the entrances to *Spermophilus* burrows occurred well after the reproductive season, we were unable to distinguish yearling from older animals (Smith and Johnson, 1985). Fitch (1948), Grinnell and Dixon (1918) and Linsdale (1938) reported that *S. beecheyi* burrows that had been occupied longer, either by the initial tenant or a series of consecutive occupants, were larger than younger systems. We can only speculate whether or not yearling *S. townsendii* excavated shallow systems and older animals were responsible for deep systems.

More soil was removed from *Spermophilus* and *Dipodomys* burrows than from *Peromyscus* and *Microtus* burrows. Not unexpectedly, bigger species excavated larger holes. The burrow parameters for *Microtus* and *Peromyscus maniculatus* were similar (Table 1). The *Microtus* burrows we described were slightly shallower ($\bar{x} = 23 \pm 6$ cm vs. 32 cm) and considerably shorter ($\bar{x} = 133 \pm 82$ cm vs. nearly 1100 cm) than the two burrows excavated by Lyons (1979). These differences are most likely due to different sampling techniques in different study areas, habitats and soil types. Neither *Microtus* nor *Peromyscus* burrows in this study were deeper than 55 cm; most were less than 20 cm. Scheffer (1941) reported *Peromyscus* burrows always were shallower than 60 cm. Our data from undisturbed soils do not refute this. Burrow depths for these two cricetids were relatively uniform, although range of depths was greater for *Peromyscus* (Table 1). Lengths of *Microtus* burrows had a bimodal distribution. Six burrows (43%) were longer than 150 cm; the remainder were less than 100 cm. These were significantly different. Length of *Peromyscus* burrows were distributed similarly, but due to the extreme range of lengths beyond 150 cm differences were not significant. It is interesting, and perhaps more than coincidental, that for each of the four species a few burrow systems were considerably longer. The more common shorter burrows may result from new cohorts entering the population and digging new burrows, while older animals occupying and enlarging burrows for relatively long periods, or some animals colonizing and enlarging unoccupied burrow systems, may account for longer systems. Similar reasoning may explain the bimodality of the depth data for *Spermophilus* and *Dipodomys* burrow systems. Five (26%) and

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nine (47%) *Dipodomys* burrows were deeper than the deepest *Peromyscus* and *Microtus* systems, respectively. This indicates that, at least for our study sites, the two hibernating species (*Dipodomys* and *Spermophilus*) often burrowed deeper than the nonhibernating cricetids. Deep systems likely insulate the occupant from environmental stresses during aestivation and hibernation, and may reflect the burrowing habits of older, experienced animals.

The predictive utility of the regression equations describing the relationships between the soil characteristics and burrow parameters were limited. For each species, these equations were valid only for distributions of soil separates within the narrow ranges in Table 2. Second, except for the regression equation describing the volume of *Microtus* burrows, the 95% confidence intervals around parameters predicted by regression equations were far too wide to provide an accurate and useful estimate of actual burrow parameters for any species. Small sample size, coupled with variations in the data within a particular suite of soil separate percentages, likely accounted for this.

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Analyses of Ann
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Department of Biolo

Department of Ecology, Ethol

ABSTRACT: Annual Octob
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