CHARACTERISTICS OF KANGAROO RAT BURROWS IN FALLOW FIELDS OF THE SOUTHERN SAN JOAQUIN VALLEY

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ABSTRACT: The architecture of burrow systems of kangaroo rats (*Dipodomys* spp.) vary among species and knowing how these systems are constructed could be useful in the management and conservation of kangaroo rats. We excavated burrow systems of the two kangaroo rat species that occur on the valley floor of the southern San Joaquin Valley in California. Systems of both species were located in fields that had been fallow for about eight years. We excavated 15 burrow systems of Tipton kangaroo rats (*D. nitratoides nitratoides*) and 10 burrow systems of Heermann's kangaroo rats (*D. heermanni tularensis*) in areas west of Bakersfield in Kern County. In general, both species constructed shallow systems that are < 25 cm under the surface. Both species also constructed systems that included multiple openings to the surface, although of the systems we excavated, more openings were found in Tipton kangaroo rats systems (mean = 2.5) than in burrows of Heermann's kangaroo rats (mean = 2.0). Some tunnels were unbranched, but often systems included multiple interconnecting tunnels. Mean greatest length of burrows were similar between Tipton (1.82 m) and Heermann's kangaroo rats (1.61 m) and lengths varied between 0.75 - 3.5 m and 0.5 - 2.8 m, respectively.

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Burrow systems, such as those constructed by kangaroo rats (*Dipodomys* spp.), provide the occupant with shelter from temperature extremes and inclement weather, aid in the conservation of body moisture, provide protection from predators, and are used to store food reserves (Meadows 1991). In almost all instances, burrows of kangaroo rats are occupied by a single individual and are vigorously defended (Jones 1993), but occasionally two adults have been found in burrows (Monson and Kessler 1940, Monson 1943). The architecture of burrow systems vary among species and knowing how these systems are constructed could be useful in the management and conservation of kangaroo rats. We excavated burrow systems of the two kangaroo rat species that occur on the valley floor of the southern San Joaquin Valley. We excavated burrow systems of Tipton kangaroo rats (*D. nitratoides nitratoides*), a federally and state-listed endangered species, and burrows of Heermann's kangaroo rats (*D. heermanni tularensis*), a non-listed species. No other species of kangaroo rats inhabit the valley floor in the southern end of the San Joaquin Valley, however, short-nosed kangaroo rats (*D. n. brevinasus*) and giant kangaroo rats (*D. ingens*) occur on the sloping plains surrounding the valley floor.

METHODS

We excavated 15 burrow systems of Tipton kangaroo rats, which were located in the Ten Section Oil Field (Sec. 33, T30S, R26E), approximately 15 miles west of Bakersfield, Kern County, California. All burrow systems of Tipton kangaroo rats were within an enclosure approximately 0.5 ha in size that was fenced with woven-plastic erosion cloth. The site was level and covered with introduced grasses, mainly *Bromus madritensis* ssp. *rubens*. Saltbush (*Atriplex* sp.) shrubs were scattered throughout the enclosure. Excavation of the burrow systems occurred 23 November 1994 and followed four nights of trapping 11-18 November. No rodents were trapped during this session (Germano and Rhodehamel, California State University, Bakersfield and Quad Consultants, unpubl. report), and we were asked by personnel of Region 4 of the California Department of Fish and Game to excavate the burrow systems to ensure that no rodents were present.

We excavated ten burrow systems of Heermann's kangaroo rats in the Coles Levee Ecosystem Preserve (Sec. 35, T30S, R25E, approximately 20 miles southwest of Bakersfield). These burrow systems were within 20 m of concrete pads of active and abandoned oil wells. This area also was relatively flat and the ground cover was dominated by nonnative grasses. Saltbush shrubs were also scattered throughout at these sites. Traps were set 19-22 November and burrows were excavated 9 December 1994 on the preserve. Only Heermann's kangaroo rats were captured at these sites (Germano, California State University, Bakersfield, unpubl. report).

Both sites were in oil fields that had a low to moderate number of oil wells. Both sites were fallow fields that had been cultivated in the past but had not been plowed for approximately eight years (Marcia Wolfe, M. H. Wolfe and Associates, and John Shelton, California Department of Water Resources, pers. comm.). We also excavated 11 Tipton kangaroo rat burrows in January 1995 located in natural habitat surrounding the Shafter-Wasco Landfill (Sec. 8, T28S, R24E). We excavated these burrows in the same manner as the other burrows and used these systems as a comparison to systems constructed in fallow fields.

At all three sites, we excavated burrow systems using shovels, hand trowels, and our hands. A set of burrow openings were judged to be part of a burrow system before excavation based on the closeness of burrow openings to one another and their distance from other burrow openings. Excavation involved carefully shaving successive layers of earth from atop the tunnels until we could determine their depth and direction. We excavated all tunnels beginning at a burrow entrance until the tunnel stopped, met with another tunnel, or became another opening to the surface. We measured the greatest length and maximum depth of the burrow system with a meter stick. We measured burrow openings with a 10-cm rule. We also made a drawing of each burrow system showing the relative orientation and geometry of the tunnels.

RESULTS

Burrow systems of Tipton kangaroo rats in fallow fields were relatively simple and were either unbranched or branched into several interconnecting tunnels (Fig. 1). In all cases but one, burrows were oriented in a single plane (non-overlapping). In one system (#10), an unconnected tunnel ran deep (42 cm) under an overlaying tunnel system (Fig. 1). Depth of tunnels below the soil surface ranged from 10 - 42 cm and the mean depth was 20.2 cm (Table 1). The mean number of openings to the surface was 2.5, and the range of openings was 1 - 6 (Table 1). The greatest length of burrows ranged from 0.75 m to about 3.5 m (Table 1). No kangaroo rats were found during burrow excavation.

Burrows of Heermann's kangaroo rats were similar to those of Tipton kangaroo rats. Most burrows were simple systems with few interconnecting tunnels that were relatively shallow, but two (#3 and #10) had a tunnel that descended to a depth of 65 cm (Fig. 2). Unlike burrows of Tipton kangaroo rats, tunnels in several burrows of Heermann's kangaroo rats had enlarged areas. Also, one burrow (#5) contained loose dirt mixed with seed hulls of grass in a tunnel with a plugged opening (Fig. 2). Average depth of burrows of Heermann's kangaroo rats were slightly deeper than those of Tipton kangaroo rats, but were shorter in greatest length (Table 1). Burrows of Heermann's kangaroo rats also contained slightly fewer openings (mean = 2.0) than burrows of Tipton kangaroo rats (Table 1). Although several burrow systems had fresh dirt and tracks at some entrances, no kangaroo rats were found when these systems were excavated.

Of 11 burrow systems of Tipton kangaroo rats excavated in natural habitat, the mean depth and length of tunnels were greater than that found for Tipton or Heermann's kangaroo rat systems in fallow fields (Table 1). In addition, there were almost twice as many burrow openings as either species in fallow fields (Table 1).

Soils at both sites are classified as Kimberlina fine sandy loam (U.S. Soil Conservation Service 1988). These

Table 1. Summary statistics (mean ± standard deviation, range in parentheses) of characteristics of Tipton kangaroo rats and Heermann's kangaroo rat burrows in the southern San Joaquin Valley. Sample size (*n*) of depth, length, and number of openings of burrows of Tipton kangaroo rat in fallow fields are greater than 15 because two systems contained unconnected tunnels (see Fig. 1).

Burrow	Tipton Kangaroo Rat					
Characteristic	Fallow	*n*	Natural	*n*	Heermann's Kangaroo Rat	*n*
Depth in cm (greatest)	20.2 ± 8.69 (10 - 42)	18	38.6 ± 33.1 (13 - 120)	11	24.7 ± 21.30 (12 - 65)	10
Length in m (greatest)	1.82 ± 0.81 (0.75 - 3.5)	18	2.88 + 1.32 (1.1 - 6.0)	11	1.61 ± 0.77 (0.5 - 2.8)	10
Number of Openings	2.5 ± 1.47 (1 - 6)	18	3.9 + 1.97 (2 - 8)	11	2.0 + 0.67 (1 - 3)	10
Width of Openings (mm)	42.1 ± 7.75 (34 - 65)	17	39.0 ± 7.29 (20 - 55)	42	54.7 ± 13.4 (35 - 90)	19
Height of Openings (mm)	39.5 ± 6.02 (30 - 55)	17	38.7 ± 6.39 (22 - 55)	43	56.1 ± 11.8 (36 - 80)	19

are deep, well drained soils derived from granitic and sedimentary rock. This soil type has a slope of 0 to 2%. The surface layer generally is composed of brown fine sandy loam about 23 cm thick. The upper 91 cm of the underlaying material is also brown fine sandy loam, but the lower part to 180 cm is composed of pale brown silt loam (U.S. Soil Conservation Service 1988).

DISCUSSION

The structure of kangaroo rat burrows were relatively simple in fallow fields in the southern San Joaquin Valley. Burrow systems of both Tipton kangaroo rats and Heermann's kangaroo rats had few interconnected tunnels and were not dug deep below the surface. The structure of burrows of Tipton kangaroo rats in old fallow fields is similar to the structure of burrows of Tipton kangaroo rats that we excavated in natural habitat, although, on average, they were shallower and not as long.

The shallow depth of construction of burrows of Tipton and Heermann's kangaroo rats is similar to what had been found previously. In a study of the conspecific Fresno kangaroo rat (*Dipodomys nitratoides exilis*), Culbertson (1946) found that burrow systems often were only 20 - 25 cm below the ground surface, although occasionally a tunnel would be dug to a depth of 76 cm. Heermann's kangaroo rats on the northwest side of the Valley usually dig tunnels 15 - 50 cm below the surface, but one tunnel was found to extend 104 cm below the ground (Tappe 1941). We found a similar situation with two burrow systems of Heermann's kangaroo rats, each of which had one tunnel descending to a depth of 65 cm. These tunnels were much deeper than the rest of the tunnels in that system, as well as deeper than the mean tunnel depth. Tappe (1941) hypothesized that these deep tunnels may function to drain excess water out of the rest of the system during rainy periods.

No stored seeds were seen in the burrow systems that we excavated. The one deposit of seed hulls mixed in loose dirt that we found in a burrow of a Heermann's kangaroo rat did not contain intact seeds. Stored seeds have been found in burrows of Heermann's kangaroo rats on the northwest side of the San Joaquin Valley in hilly areas (Tappe 1941). Only small pockets of stored seeds were found in some burrows of Fresno kangaroo rats (Culbertson 1946) and no stored seeds were found in burrows of Tipton kangaroo rats

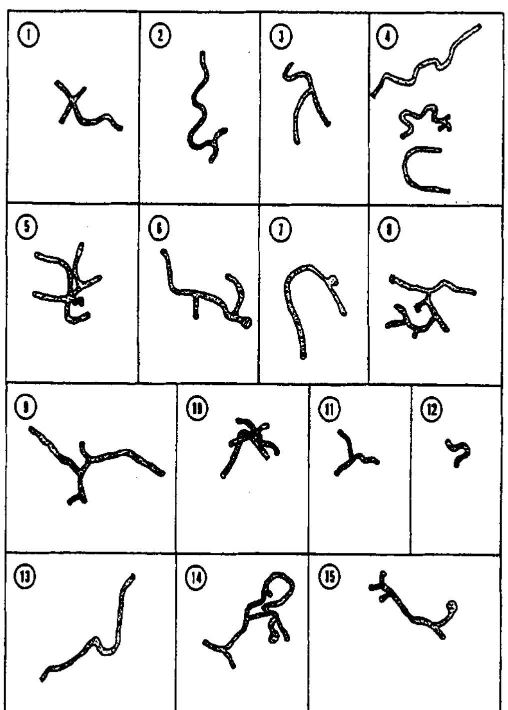

Fig. 1. Relative geometry and orientation of burrow systems of Tipton kangaroo rats from fallow fields in the southern San Joaquin Valley. Clear ellipses at the end of tunnels represent open burrow entrances. Dark ellipses at the end of tunnels represent plugged burrows. Lines drawn through a portion of a tunnel or an entrance represents a collapsed section of the system.

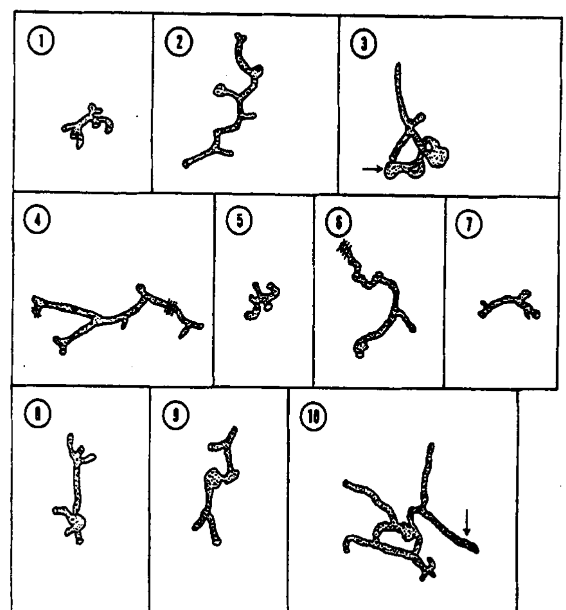

Fig. 2. Relative geometry and orientation of burrow systems of Heermann's kangaroo rats from the southern San Joaquin Valley. Markings in the drawings are the same as in Fig. 1. The arrows in system #3 and #10 are tunnels that descended 65 cm below ground level.

that we excavated in natural vegetation at the landfill site. Culbertson (1946) notes that generally Fresno kangaroo rats do not store seeds. This is in sharp contrast to giant kangaroo rats (*D. ingens*) that store large amounts of seed (Shaw 1934). However, giant kangaroo rats do not inhabit the valley floor (Williams and Kilburn 1991). Also, the difference in storage of seeds between Heermann's kangaroo rats on the valley floor and on hillsides may relate to the likelihood of seed spoilage in low lying valley habitats. Conditions in burrows of all species of kangaroo rats on the valley floor are likely too wet during the winter to avert seeds spoiling (Culbertson 1946).

We did not find any kangaroo rats in the burrows we excavated. We are confident, however, that the burrows that we designated as belonging to each species is correct. The burrows we designated as being made by Tipton kangaroo rats were in an area in which we trapped numerous Tipton kangaroo rats previously, and burrow entrances were similar in size to horizontal burrows measured for this species (mean width = 34.7 mm, mean height = 42.6, n = 126, Daniel Williams, in litt.). The burrows we excavated and designated as belonging to Heermann's kangaroo rats were in an area where only Heermann's kangaroo rats had been caught several weeks earlier, and burrow entrances were similar in size to horizontal burrows measured for this species (mean width = 51.3 mm, mean height = 54.6, n = 70, Daniel Williams, in litt.). Kangaroo rats may conceal themselves in side tunnels in which they plug the entrance and therefore could go undetected during excavation (Daniel Williams, California State University, Stanislaus, pers. comm.). In one study, burrow systems of giant kangaroo rats were gassed with poison and then excavated, and sometimes no kangaroo rat was found (Shaw 1934). We do not believe that concealed occupants is a likely explanation for our results. In many instances, we felt the tunnel sides throughout the system with our hands to detect all tunnels. Also, the systems we excavated were very simple compared to the multi-layered and multi-branched systems of giant kangaroo rats. We are convinced that no kangaroo rats occupied the systems we excavated, even those that showed activity at entrances.

Our results have conservation and management implications. The Tipton kangaroo rat is listed as an endangered species and destruction of its burrow could directly or indirectly kill individuals. Plowing, even relatively shallow plowing (25 cm), of native or fallow lands that contain Tipton kangaroo rats will probably destroy many, if not all, of the burrow systems of this species. Also, any actions (such as livestock grazing) that destroy most of the seed source on the ground surface will directly harm both Tipton and Heermann's kangaroo rats (on the valley floor) because these species do not store seeds in large quantities in their burrows, and may not store any in winter. We are not suggesting that all livestock grazing is harmful, unless stocking rates are high and duration of grazing is prolonged to the point of significantly lowering seed production of grasses and forbes. Fire in these habitats could be detrimental if the burn is slow and hot enough to consume seeds on the ground. Preliminary data suggest, however, that many fires in these habitats may not have severe consequences (Germano and Saslaw, California State University, Bakersfield, Bureau of Land Management, unpubl. data).

We suggest that biologists use caution when using burrow numbers to estimate relative density of these kangaroo rats. No individuals were found in any of the burrows that we excavated. The 15 burrow systems of Tipton kangaroo rats excavated in fallow fields likely were constructed only about a month before we dug them up because we surveyed this area about six weeks before trapping and no burrows were found. These systems did not show any activity of kangaroo rats at burrow entrances, but rain had fallen during the month and occupied burrows of Tipton kangaroo rats often don't have fresh dirt at entrances (Best 1991). In contrast, several of the entrances of burrows of Heermann's kangaroo rats that we excavated had fresh dirt and tracks, but no rats were found. Also, two of the eleven burrow systems of Tipton kangaroo rats in natural habitat also had fresh dirt and tracks at burrow entrances but no individuals were found. Because of this, we believe that one kangaroo rat may use more than one burrow system during its nightly activity. At this point, we do not know how many systems are used, and the number may vary monthly, seasonally, or yearly. In addition, the number of entrances to burrows of both species is variable, and it is not obvious from an intact burrow how many entrances one system contains. These uncertainties make estimates of kangaroo rat abundance from burrow counts tenuous for these species.

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