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KANGAROO RAT BURROWS AT THE NEVADA TEST SITE[1]

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The chisel-toothed kangaroo rat, *Dipodomys microps occidentalis* Hall and Dale, inhabits most of the major plant communities at the Nevada nuclear test site. Because it is abundant and widely distributed at the test site it has been studied considerably with respect to its reaction to the effects of nuclear weapons testing.

This study, as part of a broad ecological study described in detail by Allred, Beck and Jorgensen (1963), was made to determine the nature of burrows made by this animal in different soil types and plant communities. Such information is important in evaluating the radiation dosage a rat may receive while in its burrow, and the effects of soil compaction from over-pressure of a nuclear detonation.

Procedure

Burrows were excavated in five plant communities during the spring and summer of 1961 as follows: ten burrows in *Salsola kali* and five each in *Atriplex confertifolia-Kochia americana*, *Lycium pallidum*, *Grayia spinosa-Lycium andersoni*, and *Coleogyne ramosissima.*

To locate occupied burrows for study, rats were live-trapped, released and their escape pattern noted. After release each rat quickly sought refuge in a burrow. Several minutes were spent observing the opening which the rat entered as well as the immediate vicinity to determine whether it emerged and entered another one. If no such movement were noted it was assumed that this was the principle burrow of the rat, and the burrow was marked for later excavation and study.

White (1962) used a grout mixture to make concrete molds of animal burrows, but the disadvantages of his system were prohibitive for its use for our studies. Consequently, a shovel, pick and small garden trowel were used to excavate the burrows. Care was taken to leave the sides and floor of each burrow intact.

Burrows were mapped as they were excavated. Two seven-foot pipes, joined to form a right angle, were marked at one-foot intervals. The horizontal pattern of each burrow was thus recorded on grid paper. Additional measurements were taken where necessary to insure greater accuracy. Measurements of depth were made at one-foot intervals. Average depth was determined from measurements taken (1) where the tunnels branched, (2) where the passages continued for a considerable distance at the same level, and (3) at the lowest point of the burrow. Although side passages and pockets were measured and mapped, those within three inches of the main

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passage were excluded from the depth profiles to facilitate clear diagrams.

Five to ten penetrometer measurements were taken to determine comparative rockniess of the soil and depth of the hardpan at each burrow site.

Results

Vegetative complexes of the communities were discussed by Allred, Beck and Jorgensen (1963). Johnson and Hibbard (1957) designated the geological formations and general soil types for the test site. Following are brief resumes of our study sites and the results of excavation and burrow examination (Table 1).

Atriplex-Kochia Habitat (Plate I). This site is located near the lowest part of the valley north of the playa in Yucca Flat. The soil is primarily hard clay several inches deep with two or three inches of loose sand around the base of the plants. Below the clay is a shallow layer of sandy clay, under which is a hardpan. The average penetrometer reading was 7.24 inches.

Table 1. Burrow depths, openings and number of dead-end side burrows.

Habitat	Depth in inches		No. openings		No. side-burrows	
	Greatest	Average	Greatest	Average	Range	Total in all burrows
Atriplex-Kochia	12	9.2	3	1.8	2-8	18
Coleogyne	24	15.7	3	2.2	3-5	22
Grayia-Lycium	24	15.3	6	3.2	6-18	56
Lycium	24	11.5	5	2.6	3-9	25
Salsola	24	12.8	4	2.7	2-9	26*

*Only five burrows used for comparison.

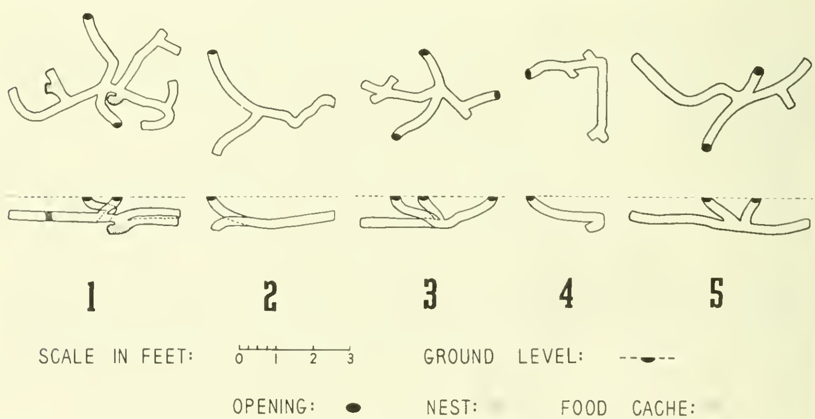

Plate I. Patterns of five burrows in the Atriplex-Kochia habitat. Upper figures: horizontal patterns; lower figures: corresponding vertical patterns.

The burrows were predominantly in the sandy clay soil immediately under the layer of clay. No burrow penetrated the hardpan. Openings were usually in the open spaces between plants. The burrow patterns were simple with relatively few side passageways. A nest constructed of plant materials was found in one burrow at a depth of one foot. A food cache containing hulls of seeds was located near the nest. All burrows had several camel crickets in them, and a harvestman and a centipede were seen near the nest of one burrow.

Coleogyne Habitat (Plate II). This site is located on the upper slope of the bajada in northeastern Yucca Flat. The soil is somewhat sandy with some clay and rocks of various sizes. A hardpan is usually present at a depth of about one foot. The average penetrometer reading was 9.13 inches.

The burrows in this area had no side passageways used as food caches. Evidence of one food cache in the main passageway consisted of small scatterings of seeds of annual plants. Three burrows each had one nest at a depth of 17, 18 and 21 inches, respectively.

Grayia-Lycium Habitat (Plate III). This study area is on the lower gentle slope of the bajada of northwestern Yucca Flat. The soil is sandy with some clay, but somewhat compact. Small pebbles are present, and a few rocks up to several inches in diameter are

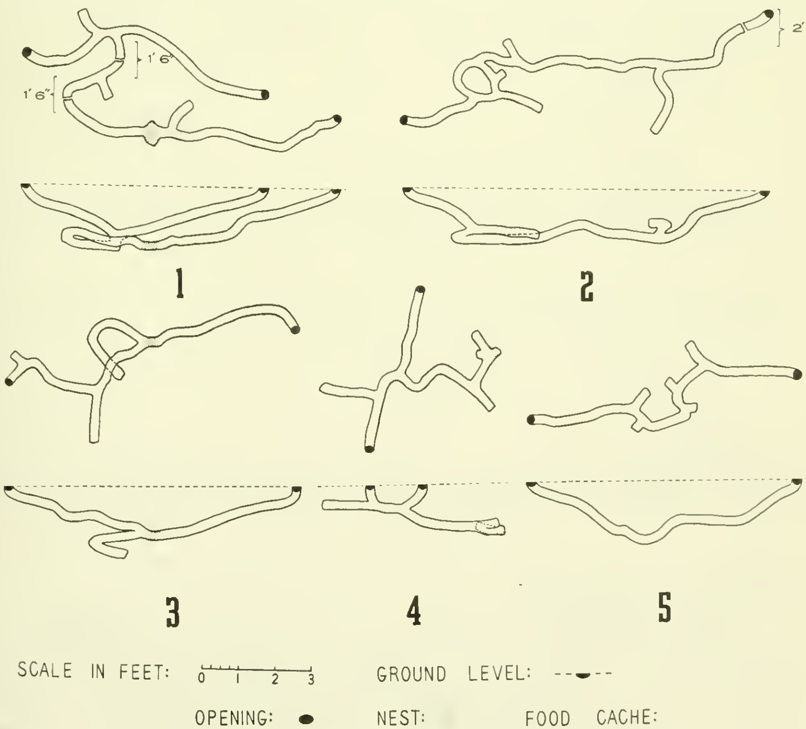

Plate II. Patterns of five burrows in the Coleogyne habitat. Top and third rows: horizontal patterns; second and fourth rows: corresponding vertical patterns.

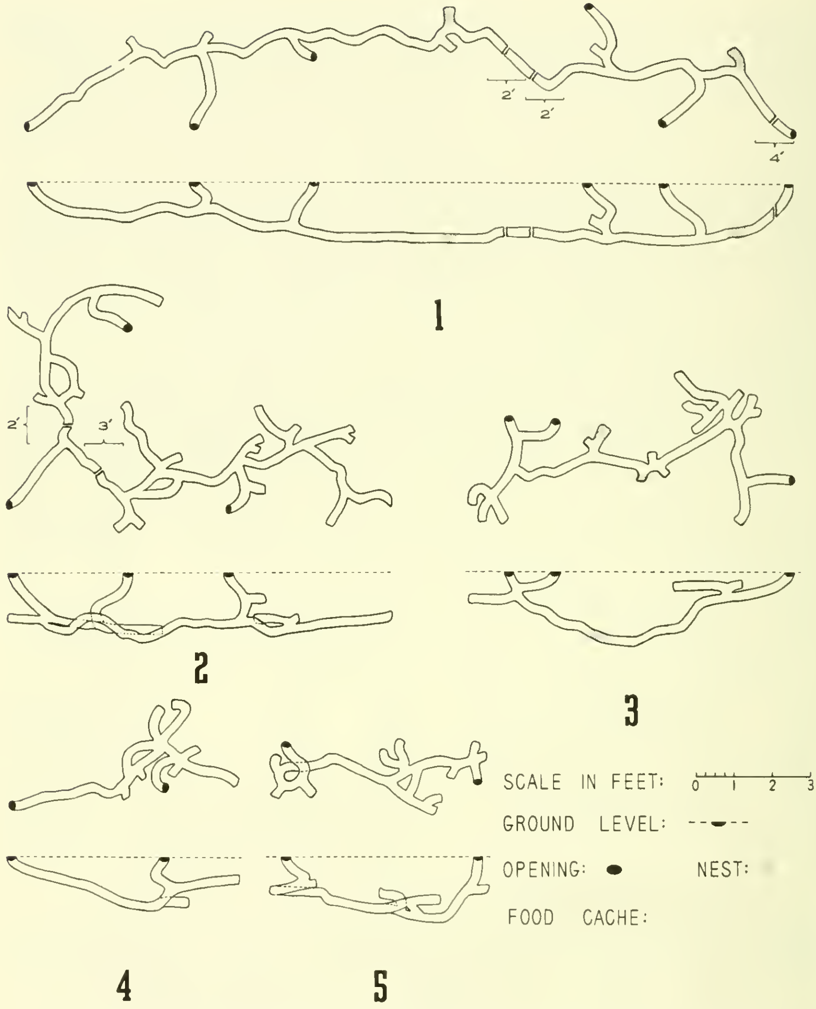

Plate III. Patterns of five burrows in the Grayia-Lycium habitat. Top, third and fifth rows: horizontal patterns; other rows: corresponding vertical patterns.

common on and near the surface. The average penetrometer reading was 14.49 inches.

Most of the burrow openings were in the open spaces between the plants. Two burrows contained nests, one burrow having two. These were at a depth of 22, 19 and 15 inches, respectively. Food caches of seeds, leaves and a few stems were found next to the nests. In one burrow lacking a nest a food cache of freshly cut green grass and seeds of a composite were found.

LYCIUM HABITAT (Plate IV). This site is in the lowest part of the valley southwest of the playa in Frenchman Flat. The surface soil is sandy with some clay and small rocks. Generally the soil is loose for a considerable depth. The average penetrometer reading was 20.32 inches.

Burrow openings in this area were usually concealed by the foliage of the plants. Even though there were frequently several openings, the one most commonly used was usually well concealed near the center of the area covered by the plant. No food caches or nests were found in these burrows.

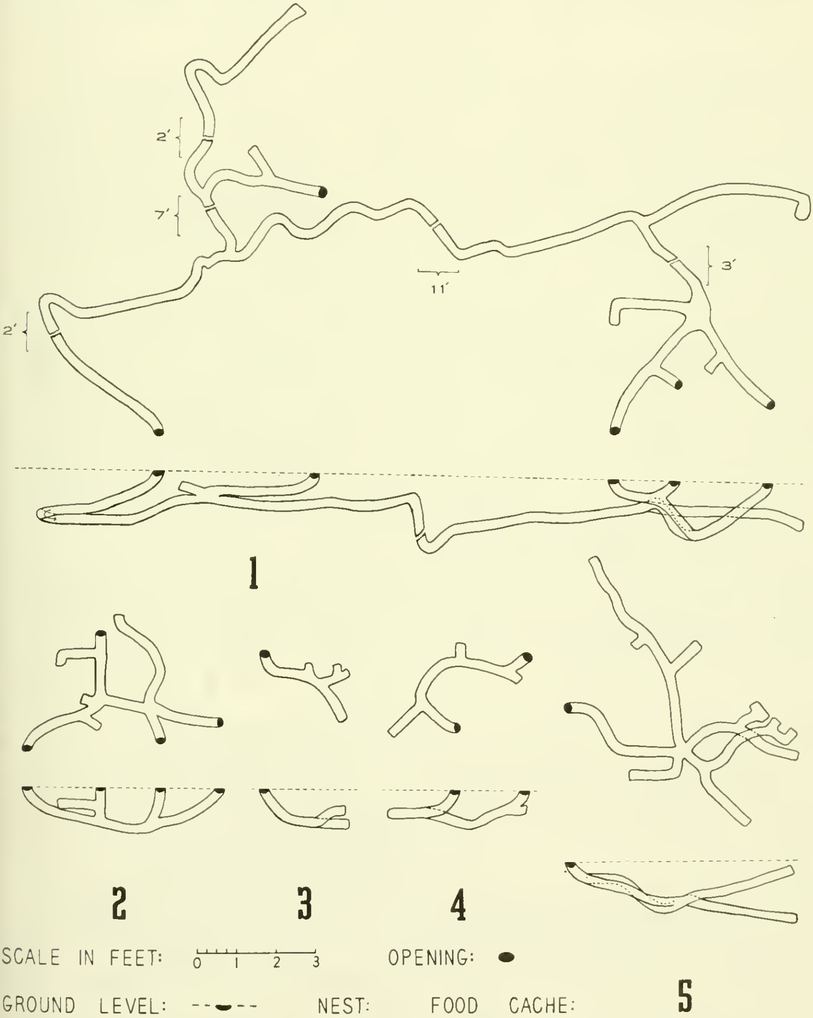

PLATE IV. Patterns of five burrows in the Lycium habitat. Top and third rows: horizontal patterns; other rows: corresponding vertical patterns.

Salsola Habitat (Plate V). This site is situated in a Grayia-Lycium area where nuclear detonations have destroyed the native vegetation and *Salsoli kali* has become established. The soil is similar

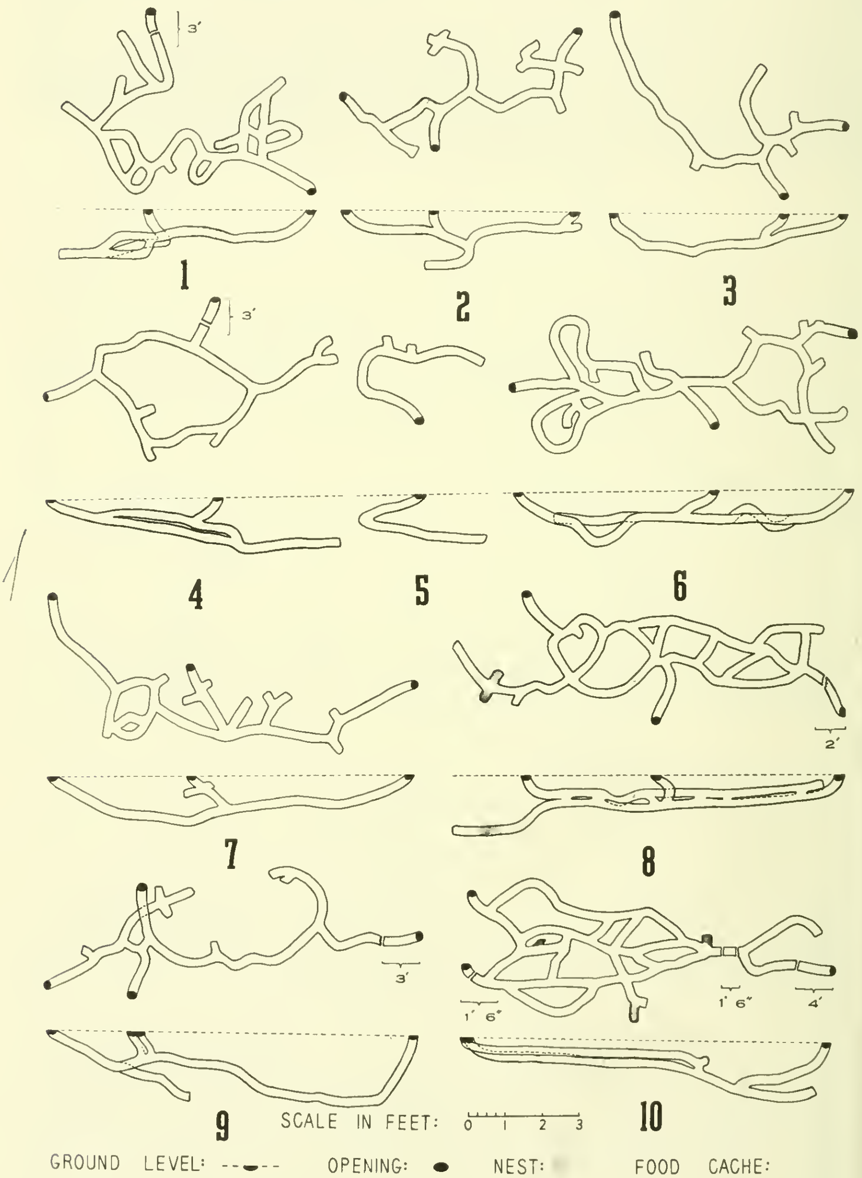

Plate V. Patterns of ten burrows in the Salsola habitat. Top, third, fifth and seventh rows: horizontal patterns; other rows: corresponding vertical patterns.

to that at the Grayia-Lycium site except that it is not as compacted. Rocks two inches or more in diameter are common, especially on the surface. The presence of more surface rocks in this area may be partly due to the effects of nuclear detonations. The average penetrometer reading was 15.75 inches.

Some of the burrows in this area were the most complex of any excavated. Many openings were plugged with soil three or four inches below ground surface. Only one nest was found, at a depth of 20 inches. Near the nest was a food cache principally of seeds of *Salsola*. Food caches found in four other burrows consisted principally of *Salsola* seeds, with small amounts of stems.

Discussion

The most complex burrows occurred in the Grayia-Lycium and Salsola habitats. Inasmuch as the predominent vegetation of the Salsola habitat originally was *Grayia* and *Lycium* before nuclear disturbance, it is assumed that the type of soil in the Grayia-Lycium community is more conducive to burrowing activities than the hard clay of the Atriplex-Kochia and rocky soil of the Coleogyne areas. This is substantiated by the larger number of side burrows present in the Grayia-Lycium—twice the number of any other habitat. Burrows in the hard clay of the Atriplex-Kochia habitat were shortest and least complex of all. Although the longest burrow excavated was in the Lycium area, this was an exception to the pattern of others in the same habitat. Soil texture likely influences the depth to which a rat will burrow, but even in the loose soils burrows did not exceed two feet. Tappe (1941) maintained that depth of burrow is determined by soil conditions. In 31 burrows of *D. heermanni* excavated, he found only one which exceeded 20 inches in depth. Hawbecker (1940) found *D. venustus* burrows 20 inches in depth, Grinnell (1932) found the greatest depth for *D. ingens* to be about 18 inches, and Culbertson (1946) and Fitch (1948) found the greatest depths for *D. nitratoides* and *D. heermanni*, respectively, to be 24 inches. Huey (1942, 1951) stated that *D. merriami* avoids rocky situations and cannot burrow into very hard soil. Hardy (1945) indicated that shallow loose soil above a hardpan was satisfactory for burrowing.

The number of burrow openings was greatest in the Grayia-Lycium area. Considering the variable numbers of openings in all habitats, two and three per burrow occurred with greatest and about equal frequency. Grinnell (1932) found 2-hole burrows most common for *D. ingens*, whereas Tappe (1941) found three or four the usual number for *D. heermanni*.

Nearly all the short, side passageways used for food storage were about two inches above the level of the main passageway floor. Other short, deadend passageways ended two or three inches above the floor level of the main passageway, although occasionally they were lower.

Seven of 30 burrows contained nests and eight had food caches. No reason for this low incidence is known. Fitch (1948) found old nests in only 11 of 150 burrows of *D. nitratoides*. Tappe (1941) found nine nests in 17 main burrows of *D. heermanni*. Hawbecker (1940) found that *D. venustus* had several supplementary burrows which always lacked nests and food caches. Apparently *D. microps* does not commonly build nests or perhaps dismantles them when no longer needed or the rat moves to another burrow. However, it is possible that many of our burrows were supplemental burrows.

The low incidence of food caches seems more easily explained. Food storage likely is correlated with season and food availability. Perhaps a rat is active above ground on succeeding nights only until a small store of food has been accumulated. Further activity above ground may then be suspended until the stored food is exhausted. Fitch (1948) maintained that storing of food in the burrows of *D. heermanni* is usually on a small scale to make available a constant supply during the majority of the hours that the animal is underground. Although Culbertson (1946) did not specifically study food storage habits of *D. nitratoides*, he did observe that food was occasionally stored in small pits in the burrow. Grinnell (1932) found no food caches in the burrows of *D. ingens*, although he found seed shells and hulls to be common. Tappe (1941) found food caches in many of the burrows of *D. heermanni*. Shaw (1934) found many underground food caches of considerable amounts, up to eight quarts each, in the burrows of *D. ingens*. Hardy (1945) found large food caches in the burrows of *D. microps* in southern Utah in September. Through our observation in the field, some evidence suggests that rats store seeds in small caches in shallow graves outside their burrows. Once a food source is located this likely facilitates emptying their cheek pouches of collected food without having to return relatively great distances to their burrows. Reynolds (1950, 1958) indicated that *D. merriami* stores excess seeds in surface caches. Such food is transported from 2 to 105 feet (average about 47 feet) before being cached. In fall, winter and spring many of the surface caches are opened by the rats. Shaw (1934) found surface food caches very numerous near the burrows of *D. ingens*. These caches were frequently transferred to the den. Hawbecker (1940) also found surface caches to be common for *D. venustus*.

Although it is assumed that the behavior of *D. microps* is similar to that of other species, further studies of their food and burrowing habits are needed.

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