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NOTES ON THE MORRO BAY KANGAROO RAT

by

Glenn R. Stewart

California State Polytechnic College

San Luis Obispo

1958

Submitted: 26 March, 1958

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NOTES ON THE MORRO BAY KANGAROO RAT

By Glenn R. Stewart

SECTION I INTRODUCTION

History

Merriam (1907) provided the original description of the Morro Bay kangaroo rat, classifying the animal as Perodipus morroensis. In the years following, a taxonomic revision declared the genera Perodipus and Dipodomys to be indistinct and so placed all kangaroo rats in the genus Dipodomys. Grinnell (1922) described the Morro Bay kangaroo rat as Dipodomys morroensis and indicated the area of known habitat to be less than four square miles on the south side of the bay. Since then, the literature presents little additional information on this form except the paper by Boulware (1943) which relegates it to subspecific status as Dipodomys heermanni morroensis.

The Problem

The fact that this kangaroo rat is apparently confined to a very localized sea side habitat posed the problem with which this paper is concerned. First of all, a definition of the exact geographical range was to be attempted; and secondly, because of this form's unique environmental situation, information on its natural history would also be recorded.

SECTION II ACKNOWLEDGEMENTS

This manuscript is submitted as my thesis in partial satisfaction of the requirements for the degree Bachelor of Science in Biological Science at California State Polytechnic College, San Luis Obispo, California. The writer is indebted to Dr. A. I. Roest for advice and criticism offered in the research and preparation of the paper. Sincere gratitude is also expressed to the following: Dr. R. F. Hoover for aid in identifying plant species; Mr. C. F. Tolman, Jr., for helpful information on the fauna of the Morro Bay area; Mr. R. J. Lavery for graciously providing rainfall records; and Mr. R. A. Hays for the helping hand lent in actual field work.

SECTION III DESCRIPTION OF THE AREA

Location

The study area is located on the south side of Morro Bay (Fig. 1), about four miles south of the town of that name, in San Luis Obispo County (approximately 35° 18' north latitude, 120° 50' west longitude).

Climate and Topography

The study area is within California's fog belt where the mild climate provides a narrow range of extremes in temperature and relative humidity data (Table I), and an unusually high relative humidity compared to most environments harboring kangaroo rats. (Actual relative humidity at Morro Bay is probably somewhat higher than that recorded in the table for Santa Maria, which is thirty five miles to the south and twelve miles inland.)

Topographical features of the area are illustrated graphically in Figure 1 and pictorially in Figures 2, 3, and 4. (Figs. 2, 3, and 4 photographed from Black Hill in Morro Bay State Park.) The relief is notably uniform, being gently rolling in the northern and eastern portions, and generally flat while sloping to the hills in the south. Only in a small southwestern section, between the hills and ocean, is this pattern broken by a series of ravines.

Habitat

The soil is a medium textured, fairly loose sand, bounded on the east by Los Osos Creek and on the south by the San Luis Range. This sandy soil reaches an elevation of 1001 feet and abruptly ends at the top of the hill shown in Figures 1, 2, and 3.

Figure 1-----KEY

Geological Survey Map

Topography 1939; Culture Revision 1951

Vegetation

Coastal Strand

Chaparral

Eucalyptus

Oak & Chaparral

Cultivated or Grassland

Willows & Cottonwoods

Symbols

• Trap Site

✦ Quadrat

Overlay

Uninhabited

Fire

Concentrated Area

Uninhabited Favorable Habitat

Morro Rock
(STATE PARK)
Morro Bay
SAN BERNARDO
Black Hill
MORRO BAY
STATE PARK
MORRO BAY
MORRO BAY STATE PARK
Chorro
Park Ridge
Hollister Peak
Baywood Park
CANADA DE LOS OSOS
PECHO Y ISLAY
Hazard Canyon
SAN LUIS RANGE
Clark Valley
Islay
Valencia Peak
Point Buchon
Creek
(PORT SAN LUIS)
SCALE 1:62500
4 MILES
21000 FEET
5 KILOMETERS
ROAD CLA
Heavy-duty
Medium-duty
U.S. Route

Fig. 2. Range of D. h. morroensis looking southwest. Note relief; 1001 ft. hill topped with eucalyptus at extreme left; San Luis Range in background

Fig. 3. Range of D. h. morroensis looking south. Note relief; community of Baywood Park; hill topped with eucalyptus at extreme right

Fig. 4. Range of D. h. morroensis looking southeast. Note low range of hills forming extension area at left center

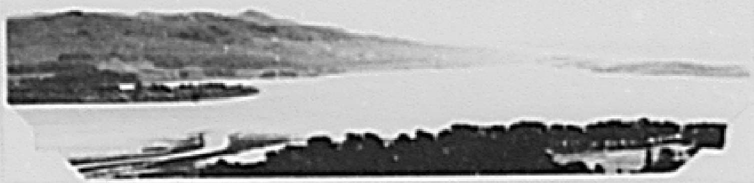

Fig. 2. Range of D. h. morroensis looking southwest. Note relief; 1001 ft. hill topped with eucalyptus at extreme left; San Luis Range in background

Fig. 3. Range of D. h. morroensis looking south. Note relief; community of Baywood Park; hill topped with eucalyptus at extreme right

Fig. 4. Range of D. h. morroensis looking southeast. Note low range of hills forming extension area at left center

Two distinct plant associations, characteristic of the area, may be recognized as described by Munz and Keck (1949). The most common association is a mixture of Coastal Strand and Coastal Sage Scrub. Although this association is not true Coastal Strand, it is labeled as such for convenience in this paper. Dominant species include Lupinus chamissonis, Eriogonum parvifolium, Ericameria ericoides, Lotus scoparius, Croton californicus, Salvia mellifera, and Artemisia californica. Numerous annuals are seasonally abundant (Table V), but grasses grow sparsely.

Chaparral forms the second plant community, a line of intergradation generally beginning at an elevation of 250 to 300 feet (Fig. 1). Dominant in this association are Arctostaphylos morroensis, Ceanothus cuneatus, and Adenostoma fasciculatum.

A few areas in the Coastal Strand are covered by a dense growth of oak (Quercus agrifolia) and/or chaparral. One damp spot supports a stand of willows and cottonwoods. These, together with eucalyptus groves, replace the dominant flora in some localities (Fig. 1).

Civilization

A considerable portion of the study area is developing as the community of Baywood Park, but very little of the land is farmed. During World War II, a two mile strip, lying between the ocean and hills at the southwest tip of the bay, was used for mortar practice.

SECTION IV MATERIALS AND METHODS

Traps

Spencer live traps were used exclusively throughout this study. The manufacturer is H. B. Sherman, P. O. Box 683, De Land, Florida. They are essentially an aluminum box measuring 3 X 3 X 10 inches (Figs. 5, 6). The trap door is worked by a spring, and a pan, supported by another spring, acts as the trigger. The back end clamps over the top and sides, and may be opened to remove the catch. These traps proved to be entirely satisfactory for taking kangaroo rats and other small rodents, rolled oats giving excellent results as bait.

Distribution Investigation

Exploration was carried out on foot between June 26, 1957 and August 1, 1957. A considerable area outside of the range boundaries shown in Figure 1 was covered, and in the writer's opinion, sufficient information was obtained for an accurate distribution analysis.

The two most obvious signs of *Dipodomys*' activity were their characteristic burrows and unmistakable tail tracks and foot prints (Figs. 13, 15, 16, 17, 24, 25). Since sign was generally abundant and easily recognized, trap sites were chosen with special effort to indicate the periphery of the range.

Thus, trapping was conducted with the objective of proving the presence or absence of *Dipodomys*. If one rat was caught the first night, the traps were removed with positive results; if no rats were caught in three nights, the traps were removed with negative results.

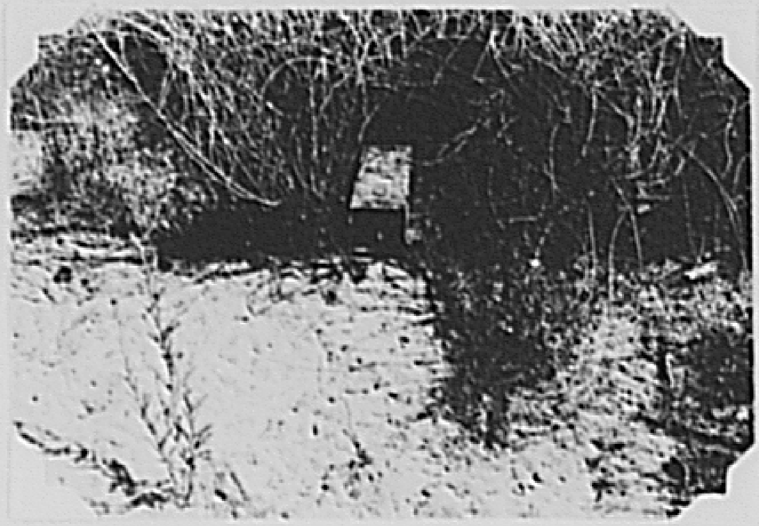

Fig. 5. Trap set in a likely spot. Note tracks

Fig. 6. Trap set at a burrow entrance. Note tracks

Ten traps spaced at thirty foot intervals were usually sufficient to cover the desired area, either in a single line, or two lines of five up to one hundred feet apart.

Only those traps set partly under cover at the edge of a bush or right at a burrow entrance would take specimens (Figs. 5, 6). Kangaroo rats showed little reluctance to enter correctly placed traps, and positive sign was usually confirmed in the first night.

Natural History Investigation

During the study, fifty four specimens were captured and brought into the laboratory for weighing, measuring, and detailed examination. Eight adults and two young were prepared as study skins. Six others, including two pregnant females (each of which gave birth to a litter), one normal female, one male, and two young, were kept for extended observation in captivity. The remaining forty rats were released near their points of capture.

Captives were kept in separate 12 X 12 X 10 inch plywood cages with glass fronts. They were supplied with sand and seemed to do well on a diet of oatmeal, walnuts, apple, and Friskies dog cubes.

In this study, specimens were classified as young if the pelage was not adult. No other criterion was used to distinguish age class.

Newly caught kangaroo rats were easily handled during the laboratory examination by wearing cloth garden gloves to protect against bites. Measurements of the total, tail, and hind foot lengths were recorded (Table VIII). For live specimens, the writer feels that they are accurate within 3 mm. in total length, 2 mm. in tail length, and ½ mm. for the foot.

To form the basis for a population estimate and obtain information as to the home range of D. heermanni morroensis, three quadrats were established in selected areas (Figs. 1, 10, 11, and 12). Two were located in areas harboring apparently normal populations of kangaroo rats, the third in a very concentrated area.

Each quadrat consisted of thirty six traps laid out in a grid system at thirty foot intervals. Such a quadrat trapped an area approximately equal to 0.75 acre.

Trapping was conducted for three successive nights in each of the quadrats during the period July 30, 1957, to August 8, 1957, and again between October 26, 1957, and November 11, 1957. All kangaroo rats captured during the first trapping period were marked individually and released on the spot. The movements of those retrapped during three successive nights in August and November were recorded relative to the original trap site of the respective periods (Table III). Movements over the three month period, August to November, were recorded relative to the original August and November trap sites, or what seemed to be the August and November loci of activity (Table IV). The movements of previously unmarked individuals trapped during the November period were not recorded.

In computing a population estimate, the Lincoln Index was used. It may be expressed as follows: $x/p = m/t$ where x is the known number of marked animals in the population; p is the total population; t is the total trapped in the second period; and m is the number of marked animals in t.

Additional data was recorded in field and laboratory observations throughout the course of this study.

SECTION V RESULTS OF THE DISTRIBUTION INVESTIGATION

Geographical Range

Grinnell (1922) estimated the range of morroensis to be less than four square miles. The present study indicates that this estimate was very nearly correct. As determined by field observations and trapping records, the range covers approximately 4.8 square miles (3,072 acres). Roughly speaking, it is bounded by the following topographical features: West, the Pacific Ocean and Morro Bay; north, Morro Bay and Los Osos Creek; east, Los Osos Creek, except where it touches the point of a small range of hills; south, the San Luis Range and Hazard Canyon, excepting a narrow strip lying between the hills and ocean which terminates at Islay Creek (Fig. 1).

The exact limits of distribution outlined in Figure 1 coincide almost exactly with the line of demarcation between sandy and hard soil on the southern and eastern periphery (except in the hills east of Los Osos Creek), the western periphery being determined by shifting dune sand or wet situations.

Limiting Factors

The main factors restricting the distribution of this kangaroo rat are soil, food, water, amount of cover, and broken terrain. Soil becomes limiting because of the rat's apparent inability to burrow satisfactorily in hard ground or extremely loose dune sand; food through its absence; water as a physical barrier; amount of cover because of the rat's decided preference for fairly open areas; and broken terrain as an impediment to normal bipedal locomotion.

Excepting the shifting dunes and a small ravine dissected area, the Coastal Strand association provides the ideal situation of fairly loose sand, abundant food (Table V), and adequate space for unrestricted activity.

Interesting Observations

The little range of hills east of Los Osos Creek is considered by the writer to be a definite range extension. It is partly grown to chaparral and/or oak, the rest being a grassland grazed by cattle. The soil is considerably harder than that of the Coastal Strand, but not as hard as that of Los Osos Valley and the San Luis Range. Three spots in the grassland are inhabited by small populations of kangaroo rats (Figs. 7, 8, and 9). *Lupinus arboreus* is present in each case. Possibly because of the comparatively hard, dirty soil, four out of the five specimens trapped here displayed a rough, scaly skin and poor pelage.

The overall pattern of distribution seems to be random throughout the Coastal Strand. However, an extremely concentrated population now exists in a previously cultivated area of 220 acres (Fig. 1, overlay). This land ceased to be cultivated about 1950 and kangaroo rats probably moved into the cleared spot as soon as food became available.

Grinnell (1922) observed the altitudinal range to be from sea level to 250 feet. The writer has found them at nearly 1000 feet in a small typical Coastal Strand habitat (Figs. 1, 2, and 3). A probable explanation is that the fire (Fig. 1, overlay) which burned off 100 acres of chaparral about 1949, enabled the rats to move up through

Fig. 7. Extension area. Rats inhabit the open grassland with *Lupinus arboreus*. Note chaparral in background

Fig. 8. Extension area. Rats inhabit small area at top left, just below chaparral and oak. Note *Lupinus arboreus* scattered below it

Fig. 9. Extension area. Same as Fig. 12, only taken from top. Note small burrow mounds in foreground and *Lupinus arboreus* farther down the hill

the burn as conditions became favorable. Positive evidence of kangaroo rats still in sections of the old burn support this hypothesis.

Within the 4.8 square mile geographical range, unsuitable habitat (Fig. 1, overlay), including the community of Baywood Park, constitutes about 1672 acres (2.6 sq. mi.). This leaves only 1400 acres (2.2 sq. mi.) of natural habitat. Strangely enough, approximately 40 acres of apparently favorable habitat is completely uninhabited by Dipodomys (Fig. 1, overlay).

Kangaroo rats were trapped less than 50 feet from dwellings and streets in the community of Baywood Park. This tends to indicate that they are relatively unaffected by the presence of human beings per se, but the predation of house cats and destruction of normal environment accompanying civilization definitely reduces their numbers.

Mr. C. F. Tolman, Jr., of Morro Bay reports seeing Dipodomys in Morro Bay State Park about 1947 or '48. He surmises that they had been released there, but failed to become established.

The minor disturbance created by a few head of cattle ranging in certain areas seems to have little effect upon the kangaroo rat population living there.

SECTION VI RESULTS OF THE NATURAL HISTORY INVESTIGATION

Description of Quadrats

The three quadrats used in this study are described as follows: Quadrat #1: In an area of extreme density with homogeneous cover; the dominant shrub is Lotus scoparius; preferred food (Table V) is very abundant (Figs. 1 and 10). Quadrat #2: In an area of normal density with heterogeneous cover; the dominant shrubs are Eriogonum parvifolium, Salvia mellifera, and Ericameria ericoides; preferred food is ample (Figs. 1 and 11). Quadrat #3: In an area of normal density with heterogeneous cover; the dominant shrubs are Lupinus chamissonis, Ericameria ericoides, Eriogonum parvifolium, and Salvia mellifera; preferred food is ample (Figs. 1 and 12). Some grasses grow in quadrats #1 and #3, but they are scarce in quadrat #2.

Population

Applying the Lincoln Index to data obtained from these quadrats, the estimated kangaroo rat populations are: Quadrat #1, 76.4 per acre; quadrat #2, 21.3 per acre; quadrat #3, 18.6 per acre. Table II seems to indicate that three nights of trapping were sufficient to capture most of the rats present in quadrats #2 and #3, but not in quadrat #1 which is probably supporting a maximum population.

The presumably high estimates derived may be partly due to the lengthy period separating the original and follow up trappings (Hayne, 1949). This would increase the chance of replacement of marked individuals because of dispersal or natural mortality, and result in an overestimation of the population. That such was the

Fig. 10. Quadrat #1 looking west. Note homogeneous cover

Fig. 11. Quadrat #2 looking north. Note heterogeneous cover

Fig. 12. Quadrat #3 looking west. Note heterogeneous cover; tip of bay and sand dunes in background

case in this study cannot be ascertained, but the turnover does not seem to have been excessive. Nevertheless, in order to allow for the possible overestimation, the writer feels that a 25% reduction of the calculated estimates is warranted (quadrat #1, 57.3 per acre; quadrat #2, 16 per acre; quadrat #3, 14 per acre). Thus normal populations would average 15 rats per acre and maximum populations about 60 rats per acre, the total population amounting to less than 30,000.

Home Range

Tables III and IV give some indication of the home range of this kangaroo rat. In general, their nightly foraging range is less than sixty feet, particularly in quadrat #1 where food is very plentiful and numerous contacts between individuals restrict the range even more. A large percentage of young in the population appears to cause the adults to forage greater distances, although the truth may be that the young are less cautious and enter traps first.

Over a three month period, retrapping of marked animals seems to indicate that the greatest percentage still moved less than ninety feet from the original trap site. Age probably did not influence the distance traveled.

Using the boundary strip method described by Stickel (1954), the maximum home range based on three successive trappings was as follows: Quadrat #1, 0.08 acre; quadrat #2, 0.08 acre; quadrat #3, 0.07 acre.

Food

The food species listed in Table V form the bulk of morroensis' diet. All of these plants were collected within its geographical range and offered to six captive specimens. The captives also ate ants and grasshoppers, particularly the heads, although they seemed reluctant to do so.

Quantities of food are stored in the burrows of this rat. Favorite places include pockets along main tunnels, at the junction of tunnels, in blind tunnels, or in the walls of rooms (Fig. 14). The occasional observation of little surface pockets near burrow entrances (Fig. 13) suggests that food may be stored in this manner for short periods, but no positive evidence confirmed such a habit in morroensis.

Competitors and Predators

Pocket mice (Perognathus californicus) and deer mice (Peromyscus maniculatus) are the common competitors found throughout the Coastal

Fig. 13. Burrow entrance with possible food pockets. Note tail tracks

Strand. Only very limited numbers of Perognathus seem able to live where kangaroo rats are most abundant (quadrat #1). Peromyscus appears where kangaroo rat populations are average (quadrats #2 and #3), and harvest mice (Reithrodontomys megalotus) find a favorable niche where some grasses are present in a heterogeneous situation (quadrat #3).

Rattlesnakes (Crotalus viridis), gopher snakes (Pituophis catenifer), and house cats were the only known predators directly observed. Badgers undoubtedly take a large toll, with owls and foxes accounting for a few.

Burrows

During the months of July and August, 1957, about fifteen apparently active burrows were excavated by spading directly through

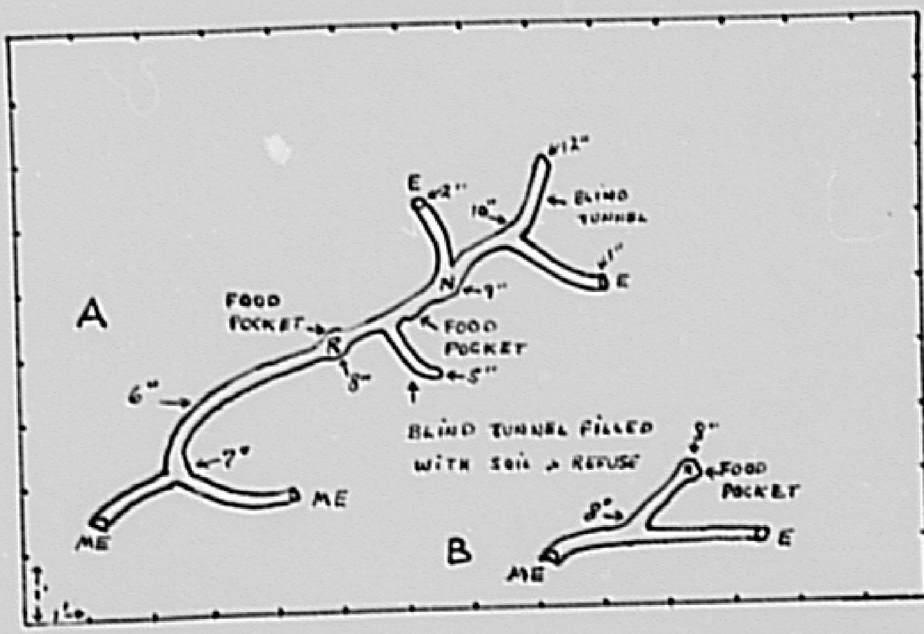

Fig. 14. Burrows of the Morro Bay Kangaroo Rat, vertical view. A. Main burrow. B. Subsidiary burrow. ME, main entrance; E, escape hole; R, room; N, nest. Measurements are from ground surface to floor of burrow. These are typical of the simplest burrows observed

the tunnels and tracing them as completely as possible. Soft sand complicated the operation and probably obscured some details that might have been observed. The data presented, however, is reasonably accurate.

Two different types of burrows, main burrows and subsidiary burrows, can be recognized, as described also for *D. heermanni tularensis* by Tappe (1941). Main burrows of *morroensis* are usually six to ten feet long with two or three rooms, one of which may be a nest, and numerous food pockets and blind tunnels filled with mixtures of soil, seeds, seed hulls, and other refuse (Fig. 14). In general, they do not seem to be as elaborate as those described for *tularensis*, and are usually equipped with only one of two main entrances (Fig. 15), although they may have two or three escapes. Some of them have blind tunnels descending to greater depths than the normal level.

Subsidiary burrows are very simple in construction, being from two to five feet long with no nests, although they may have a room or two and food pockets. They are generally equipped with one main entrance and at least one escape (Fig. 14). Tappe (op. cit.) suggests that these burrows serve as play grounds or hiding places.

Both main and subsidiary burrows lie six to ten inches under the surface as measured to the burrow floor. The greatest depth recorded was twenty six inches at the end of a blind tunnel. Tunnel diameters range from two to three inches, while rooms are usually four inches wide, three inches high, and up to six inches long.

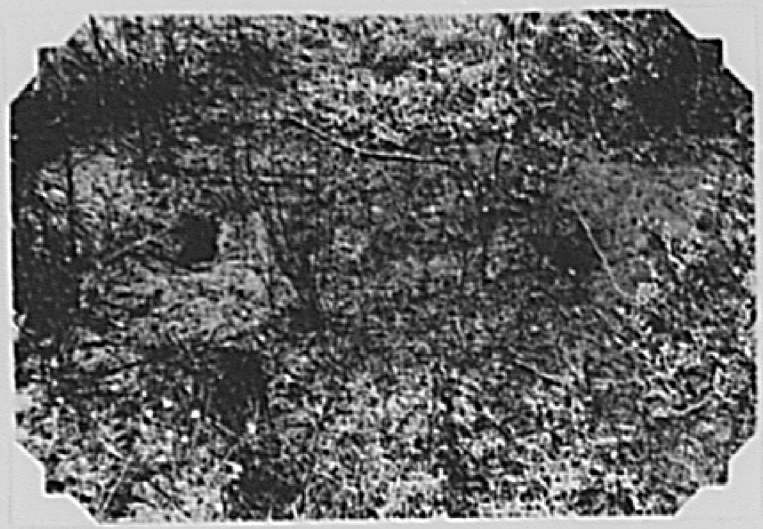

Fig. 15. Two entrances to a burrow

Main entrances almost always are characteristically arched with a flat runway (Fig. 16). A notable exception is encountered where the soil is hard as in the extension area. Here, burrow entrances are round (Fig. 17). Depending upon the length of use of the burrow and the looseness of the sand, main entrances may be as much as 4" X 4" in dimension.

Easy access to the burrow is always assured by locating its entrance in a clearing or near the edge of a bush, rather than under a tangle of branches or in thick cover. Thus the rat may dive in while running at full tilt. Escape holes may be under a bush or in an open area. Usually the escape hole ends one or two inches below the surface, and the rat must break through the thin crust to get away.

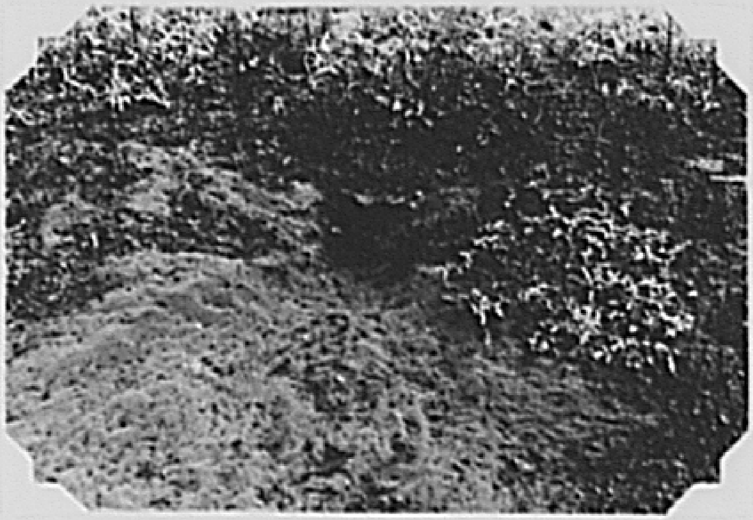

Fig. 16. Typical burrow entrance. Note arch and flat runway

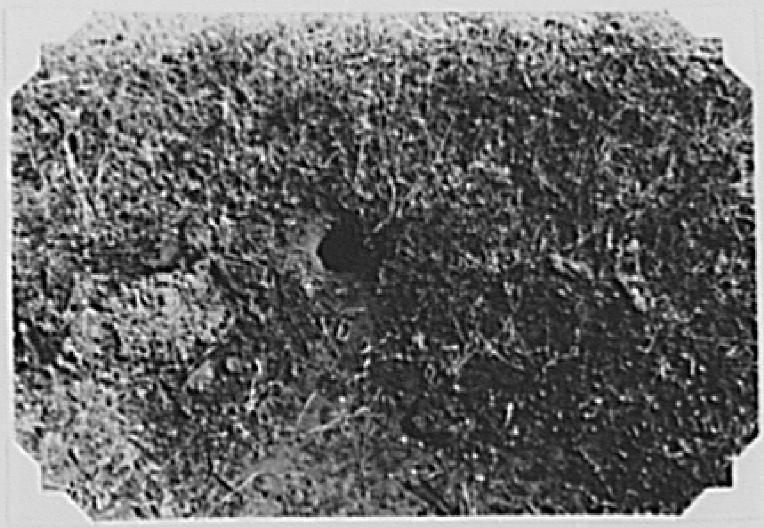

Fig. 17. Atypical burrow entrance in extension area. Note roundness rather than characteristic arch

No rats were found in any of the burrows excavated, a fact not too disturbing in view of the findings of Fitch (1948) in which only five of 118 excavated tularensis burrows produced rats.

Obvious nests were found in only three or four morroensis burrows. They may consist of a compact mass of seed hulls, seed "parachutes," grasses, bark, roots, and stems cut in short lengths, or merely a small amount of debris scattered on the floor.

None of the burrows were definitely found to be plugged.

Reproduction

Tappe (1941) found that tularensis breeds from February to August, the highest percentage of pregnancies occurring in April. Fitch (1948) believed that breeding in this form was not quite discontinued even during the winter months. Table VI indicates that breeding in morroensis may follow a similar pattern, and the mild Morro Bay climate (Table I) suggests the possibility of year round breeding activity.

Normal litter size is probably three. Two pregnant females examined each contained three embryos. Two others kept in the laboratory produced litters of three and four.

Young

Both of the litters raised in the laboratory were born the same night. Each family was kept in a 12 X 12 inch cage until the young were about ten weeks old. A wad of cotton furnished a nest for them until they no longer used it. One of the litter of four died the first day and apparently was eaten by the mother.

At birth the young are entirely pink and hairless, but after two or three days the back and head begin to darken. Tappe (op. cit.) noted this darkening in tularensis at twenty two hours. At eight days, the dorsal surfaces, particularly, and all areas that will grow pigmented hair, are black. Areas which will grow white hair are pink. The hip stripe is evident, being very broad posteriorly and narrow anteriorly (Fig. 18).

The young appeared to be hairless until the tenth day when fine hair was noticed on the back of the body and top of the head. Tappe (op. cit.) reports the first evidence of hair on tularensis at three days, but Doran (1952) noted the first appearance of hair on D. merriami merriami at six days.

The hair actually begins influencing coloration at about two weeks, and by about five weeks, the typical leaden hued juvenile pelage described by Grinnell (1922) is evident. The tail at this time is characterized by sparse hair, except for the distal one third which has relatively long hair and is very dark (Figs. 18 and 19). For the first three weeks or so the tail is crooked and practically useless (Fig. 18).

When eleven days old, the young from both litters were found wandering about the cages on all fours even though their eyes were still closed. On the thirteenth day the eyes of one of the litters began to open and the eyes of all were open by the seventeenth day. Comparable periods for tularensis and merriami are fourteen to fifteen days and twenty one days respectively (Tappe, op. cit., Doran, op. cit.).

Fig. 18. D. h. morroensis, 13 days. Note complete hip stripe; disproportionately large hind foot; crooked tail

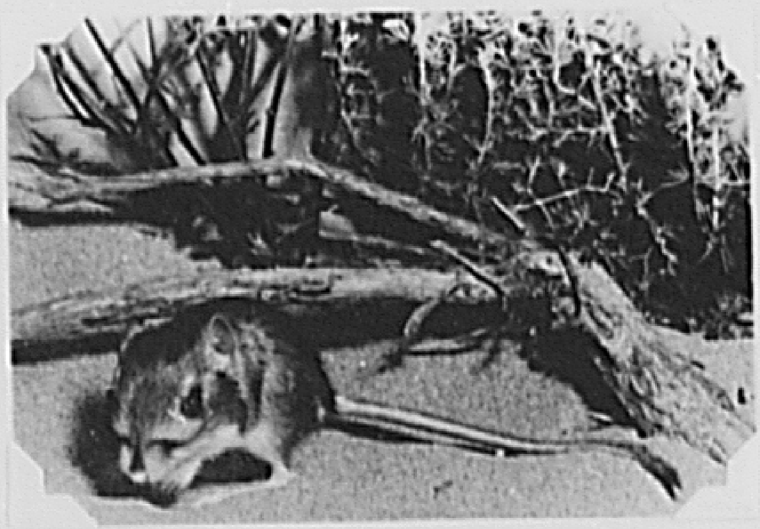

Fig. 19. D. h. morroensis, about 7 weeks. Note characteristic markings as in adult, but less sharply defined; distal 1/3 of tail with long, black hair

At fourteen days, one individual was observed in a bipedal stance nibbling on a flake of oatmeal. Most of them were awkwardly hopping about the cage by the eighteenth day, and by the twenty second day were quite nimble.

When seventeen days old, the young readily ate oatmeal, walnuts, and apple, and at nineteen days were seen filling their cheek pouches and attempting to bury food. They were completely weaned after twenty six days, although they occasionally tried to suckle for several more days. This weaning period is the same as that recorded for tularensis by Tappe (op. cit.).

The youngest specimens trapped in the field were estimated to be five or six weeks old. Maturity is apparently reached in about seventeen to twenty weeks as judged by the acquisition of complete adult pelage (see Grinnell, 1922) in eight laboratory specimens (litters and two young trapped in the field). Measurements and weights approach adult standards in fourteen to sixteen weeks. Sexual maturity is probably reached about this time. The testes of male rats enlarged noticeably at five or six weeks.

Table VII records the growth of a female from one of the litters. The individual was nearly mature at the last measuring and weighing, but below normal weight (Table VIII) maybe due to lack of exercise in the small confinement. Figures 18, 19, 20, 21, and 22, though not necessarily of the same individual, picture various stages in the development of morroensis.

Fig. 20. D. h. morroensis, about 11 weeks. Note tail almost completely haired with well developed crest; more clearly defined markings

Fig. 21. D. h. morroensis, about 16 weeks. Note conspicuous molt line with adult pelage anterior, juvenile posterior; spot of juvenile pelage between ears

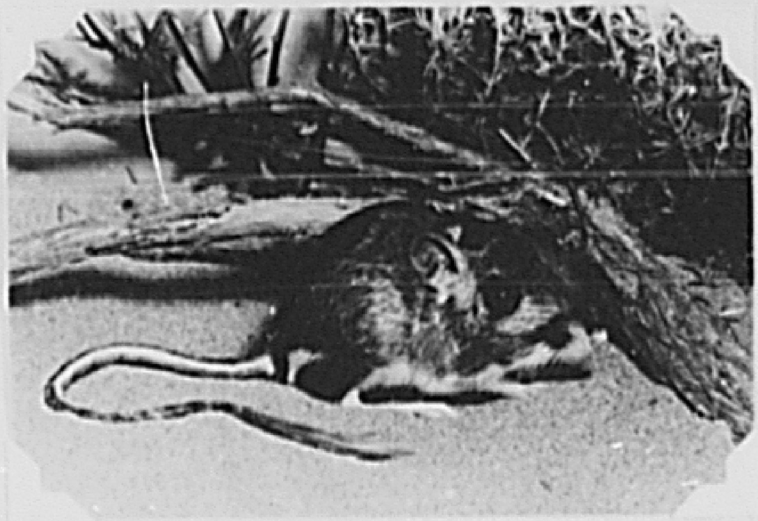

Fig. 22. D. h. morroensis (female), typical adult. Note incomplete hip stripe

Molting

None of the specimens trapped during July, August, or November were observed to be molting, although many species, including D. heermanni, are known to have an annual molt at this time of year (Quay, 1953). However, two adult specimens in the laboratory displayed a molt in January, 1958. A molt line was evident only upon close examination and could easily have gone undetected in the examination of ruffled, freshly caught specimens. Molting in the laboratory specimens may have been delayed because of their captive situation.

The transitional molt from juvenile to adult pelage was found to last six to eight weeks in captive specimens of morroensis. It progressed from front to rear, the first patches of adult pelage appearing on the forehead and neck. When well under way, the molt formed a conspicuous line (Fig. 21).

Social Behavior

D. h. morroensis appears to be a solitary animal. Strange individuals of like or opposite sex fight viciously the moment that two are confined in the same cage. It is interesting, however, that neither of the litters displayed much disharmony in their ten weeks of close contact. Also, one pair of litter mates has lived together in an 11 X 22 inch cage for three months without serious fighting. Another pair lived together in a 22 X 22 inch cage for two months before they had to be separated by a cardboard partition. Within a few days they gnawed two holes through the partition, and each passed from one side to the other at will. However, the hole was carefully plugged after a passage in either direction as though to keep the unwanted partner away. A status quo exists at the time of writing.

Neither of the above pairs have yet exhibited mating activity.

Vocal Ability

Adult individuals of morroensis were heard to produce two types of vocal sounds. Two fighting rats uttered a series of high pitched squeals on several occasions. Tappe (1941) mentions a "plaintive, low pitched, rattling squeak" produced by tularensis while struggling to get out of a person's grasp. Such a sound is also uttered by morroensis when disturbed. In addition, disturbed adults seemed to grind their teeth in a rattling manner without vocal action.

The young, while still in the nest, cried like new born puppies when the mother would move them or leave the nest for a time. They also cried almost continually if lost from the nest before they could see to get back into it.

Parasites

Fleas, lice, and ticks are easily observed parasites of this kangaroo rat. Of the fifty two individuals examined, 88.5% harbored at least one of these parasites, and 44.3% harbored two or more. In the breakdown, fleas parasitized 73%, lice 36.6%, and ticks 34.6%.

Nematodes were found in the gut of one of the five specimens checked for such parasites.

Taxonomic Characters

A comparison of the writer's specimens with those collected by Grinnell in 1918 and Tolman (Morro Bay) in 1955-56 is presented in Table VIII. It is not felt that any discrepancies in the methods of obtaining the data can fully account for the apparent decrease in size.

The characteristically incomplete hip stripe of morroensis was noted, under a previous heading, to be complete on all six laboratory young. However, there was considerable variation, the stripe being extremely narrow in some. Those with the widest stripe possessed a very narrow but complete white stripe when adults (Fig. 23). The others were obviously incomplete, although the stripe might be well indicated, as described by Grinnell (1922), with a "wash of pale tawny-olive across the middle of it." Still others showed scarcely any trace at all (Fig. 22).

Describing these conditions as noticeably complete, faintly complete, and incomplete, respectively, the examination of thirty

Fig. 23. D. h. morroensis, adult with complete hip stripe. Note bulging cheek pouches

two trapped adults found 6% noticeably complete, 22% faintly complete, and 72% incomplete.

Interesting Observations

Morro Bay kangaroo rats showed little reluctance to enter traps and may have tended to form a "trap habit" (Hayne, 1949) as indicated by the large percentage of individuals retrapped in the quadrats (Table IX). The percentages are lower for quadrat #1 probably because of the large number of animals competing for the traps.

The tracks of foraging rats are conspicuous signs of their presence (Figs. 24 and 25). Bartholomew and Caswell (1951) corroborate the writer's observation that morroensis leaves tail marks only when moving slowly for short distances in quadrupedal fashion. Foot prints left by rapidly moving individuals are rarely identifiable.

Fig. 24. Tail tracks and foot prints of D. h. morroensis

Fig. 25. Close-up of Fig. 24

Two attempts were made to observe *Dipodomys'* activity on moonlight nights (Aug. 8, 1957- 9 to 11 P.M. and Aug. 13, 1957- 2:30 to 3:30 A.M.). No rats were seen above ground in either case, but on the 13th fresh sign and a dead rat in the road provided definite evidence of their activity before the moon rose.

Adult rats were able to carry about 2/3 of a teaspoon of Quaker "Quick Oats" or ground chicken scratch in each pouch (Fig. 23).

SECTION VII SUMMARY

The range of Dipodomys heermanni morroensis encompasses approximately 4.8 square miles and is limited by relatively distinct boundaries. Hard soils prevent any significant range extension because of this form's inability to construct burrows in them. Some phases of morroensis' natural history closely parallel those of related forms, but differences exist, probably due to its peculiar environment. The population appears to be reproducing satisfactorily and readily moves into favorable situations. However, the Baywood Park area is rapidly being subdivided, and some of the most favorable habitat available to morroensis is being destroyed. The future will undoubtedly see considerable destruction of suitable habitat and a corresponding reduction in the numbers of this species.

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Table I

Month	Temperature, °F.			Rel. Humid., %			Rainfall
	Av. max.	Av. min.	Mean	Av. max.	Av. min.	Mean	Mean (in.)
Jan.	61	44	52	94	75	85	3.49
Feb.	61	45	53	88	58	75	2.93
Mar.	62	45	54	95	77	88	2.56
Apr.	64	46	55	98	83	91	1.22
May	65	48	56	91	64	80	.27
June	65	50	58	95	74	89	.04
July	66	52	59	94	81	89	.04
Aug.	66	52	59	98	86	93	.06
Sept.	68	52	60	96	83	91	.06
Oct.	69	50	60	87	62	75	.60
Nov.	67	48	57	94	65	82	1.44
Dec.	63	46	55	82	48	66	3.41
Annual	67	49	58	93	72	84	16.12

Morro Bay climate. Temperature and relative humidity data as presented by Nichter (1957); temp. from 20 yr. record obtained at Standard Oil Company Estro Terminal, Morro Bay, Calif.; rel. humid. from 1 yr. record taken nightly (8 PM through 8AM), Santa Maria, Calif. Rainfall data from 27 yr. record, courtesy of R. J. Lavery, Morro Bay, California

Table II

Trapping night	Number of new individuals trapped					
	Quadrat number 1		Quadrat number 2		Quadrat number 3	
	Aug.	Nov.	Aug.	Nov.	Aug.	Nov.
1	14	19	5	2	3	9
2	10	7	3	2	2	3
3	9	7	0	2	1	2
Total	33	33	8	6	6	14

Decrease in number of new individuals trapped during three successive nights

Table III

Quadrat number	Trapping period	No. re-trapped	Distance moved during 3 successive nights				
			0-30'	30'-60'	60'-90'	90'-120'	120'-150'
1	Aug.	13	92.3% (12Y)	---	7.7% (1A)	---	---
	Nov.	15	86.8% (13A)	6.6% (1A)	6.6% (1A)	---	---
2	Aug.	7	28.6% (2Y)	14.2% (1Y)	14.2% (1Y)	---	43% (2A,1Y)
	Nov.	3	67% (2A)	33% (1A)	---	---	---
3	Aug.	4	25% (1Y)	50% (2A)	25% (1A)	---	---
	Nov.	5	80% (4A)	20% (1A)	---	---	---

Range of activity during three successive nights; illustrated as per cent of rats retrapped one or more times at given distances relative to original trap site. A, adult; Y young

Table IV

Quadrat number	Trapping period	No. re-trapped	Distance moved during three month period				
			0-30'	30'-60'	60'-90'	90'-120'	120'-150'
1	Nov.	19	31.6% (6Y)	21.1% (3A,1Y)	26.3% (1A,4Y)	15.8% (2A,1Y)	5.2% (1A)
2	Nov.	3	---	33 1/3% (1Y)	33 1/3% (1A)	33 1/3% (1Y)	---
3	Nov.	6	33 1/3% (2A)	33 1/3% (1A,1Y)	---	---	33 1/3% (2A)

Distance traveled during a three month period (trappings about Aug. 1 and Nov. 1); illustrated as per cent of rats retrapped at given distances relative to original Aug. and Nov. trap sites, or apparent Aug. and Nov. loci of activity. A, adult; Y, young; indicates age class at Aug. trapping

Table V

Food species	Parts eaten	Acceptance
Corethrogyne sp.*	seeds	high
*Lotus scoparius**#	seeds, leaves, stems	high
*Cirsium occidentale**	seeds	high
*Ceanothus cuneatus**	seeds, leaves	low
*Eriophyllum confertiflorum**	seeds	medium
*Potentilla lindleyi**	seeds, pods, leaves	high
Hypochoeris glabra#	seeds	high
Erodium cicutarium#	seeds, leaves	high
Cryptantha clevelandei	seeds	high
Arctostaphylos morroensis	flesh of berries, seeds	low
*Diplacus aurantiacus**#	seeds	medium
Bromus sp.#	seeds, leaves, stems	high
Abronia sp.	seeds, pods	high
*Chorizanthe californica**	seeds	high
*Salvia mellifera**#	seeds	high

Continued on next page

Table V, continued

Food species	Parts eaten	Acceptance
*Ericameria ericoides**#	seeds	high
Eriastrum densifolium	seeds, pods	high
Stephanomeria virgata#	seeds	high
*Dudleya caespitosa**	seeds, leaves, stems	high
*Croton californicus**#	seeds	medium
*Eriogonum parvifolium**	seeds, flowers	medium
Hemizonia sp.#	seeds	medium
*Lupinus chamissonis**	seeds, leaves, stems	high
Lupinus arboreus#	seeds, leaves, stems	high

Food of the Morro Bay Kangaroo Rat. * indicates those found in 50% or more of the areas trapped. # indicates those found in the extension area. Acceptance is relative to the species most readily accepted

Table VI

Quadrat number	August			November		
	Sample size	No. of young	Per cent young	Sample size	No. of young	Per cent young
1	33	24	72.8	33	0	0
2	8	5	62.5	6	0	0
3	6	1	16.7	14	4	28.6

Per cent of young in population

Table VII

Age (days)	Total length (mm.)	Tail (mm.)	Hind foot (mm.)	Weight (gms.)
14	101	50	26	10
21	141	77	35	16.5
29	175	106	37	26.5
35	212	130	39	33.6
43	240	144	39	40
51	256	161	40	42
71	268	168	40	44.7
80	270	172	41	49.0
87	272	175	41	----
95	273	175	41	51.2
102	275	175	41	52.0
131	280	176	41	53.3

Growth of a young female kangaroo rat

Table VIII

	Live measurements		Study skins		Tolman		Grinnell*	
	Average	Extremes	Average	Extremes	Average	Extremes	Average	Extremes
Total length	282	267-295	284	269-294	286	280-295	296	275-308
Tail	170	158-181	171	163-181	177	172-180	176	164-185
Hind foot	41.8	39-45	42	41-45	42	41-43	42.6	42-44
Weight	62.4	57-76	64.8	59.5-71.0	---	---	68.0	60.6-81.0

Specimen measurements (mm.) and weights (gms.) compared. Data from live specimens obtained from twenty-five adult individuals (9 males, 16 females). Study skin data is from eight adult specimens (5 males, 3 females). Tolman's data is from 5 adult specimens (3 males, 2 females). Grinnell's data is from "ten selected adult specimens" (5 males, 5 females). *(Grinnell, 1922)

Table IX

	Quadrat No. 1		Quadrat No. 2		Quadrat No. 3	
	Aug.	Nov.	Aug.	Nov.	Aug.	Nov.
No. possible to retrap one or more times	24	19	8	3	5	6
No. retrapped one or more times	13 (54.2%)	15 (79%)	7 (87.5%)	3 (100%)	4 (80%)	5 (83.5%)
No. possible to retrap twice	14	19	5	2	3	4
No. retrapped twice	3 (21.4%)	8 (42%)	1 (20%)	2 (100%)	3 (100%)	4 (100%)

Per cent of animals recaptured