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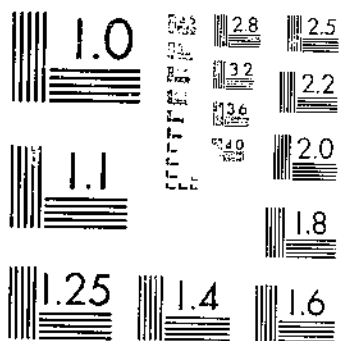
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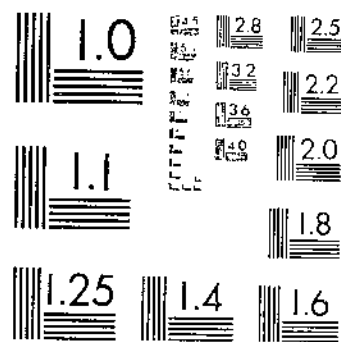
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UNITED STATES DEPARTMENT OF AGRICULTURE
WASHINGTON, D. C.

POCKET MICE OF WASHINGTON AND
OREGON IN RELATION TO AGRICULTURE¹

By THEO. H. SCHEFFER, formerly associate biologist, Section of Food Habits Division of Wildlife Research, Bureau of Biological Survey

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INTRODUCTION

When a site in a particular woodland, prairie, or desert region has been selected for adaptation to agricultural uses, the question naturally arises as to how the native mammal and bird life will affect new agricultural interests. Will it embarrass efforts or add to the joy of living? Even such apparently insignificant creatures as wild mice play their part in the economy of agricultural production. Certain species, it has been learned at considerable cost, at times become veritable plagues, whereas others—the grasshopper mice (*Onychomys*), for instance—because of their food habits, affect agricultural interests beneficially.

An intelligent approach to a solution of the faunal problems must include first of all a life-history study of the group or groups whose activities it may be necessary to control or whose existence it may be desirable to perpetuate. Otherwise a mistake may occur at the outset that will cause regrets when it is perhaps too late either to prevent losses or to benefit by the presence of the species. Inasmuch as man has arrogated to himself the right to conserve or to control other forms of life, he is under obligation to exercise that right wisely.

To gain a knowledge of the life history of a rodent it is necessary to make close observations of it in its natural environment at intervals

¹ Submitted for publication August 26, 1937.

of 3 or 4 weeks, or less, depending on the season, and for more than 1 year in order to fill in any gaps discovered in the first year and to make allowances for variations in seasons. Knowledge thus obtained should be supplemented by that acquired from observations of the animal in captivity.

Warrant for the study of the life histories of the two species of pocket mice (*Perognathus lordi* and *P. parvus*) considered in this bulletin was found in persistent reports that these mice had been increasing in numbers and were beginning to damage the grain crops seriously in some sections of eastern Washington. The information presented is the result of research work on the group for 15 consecutive months and of seasonal investigations in 2 other years.

DISTRIBUTION AND HABITAT

Pocket mice (*Perognathus*) are confined to North America and are restricted to the region west of the Mississippi River (fig. 1). They

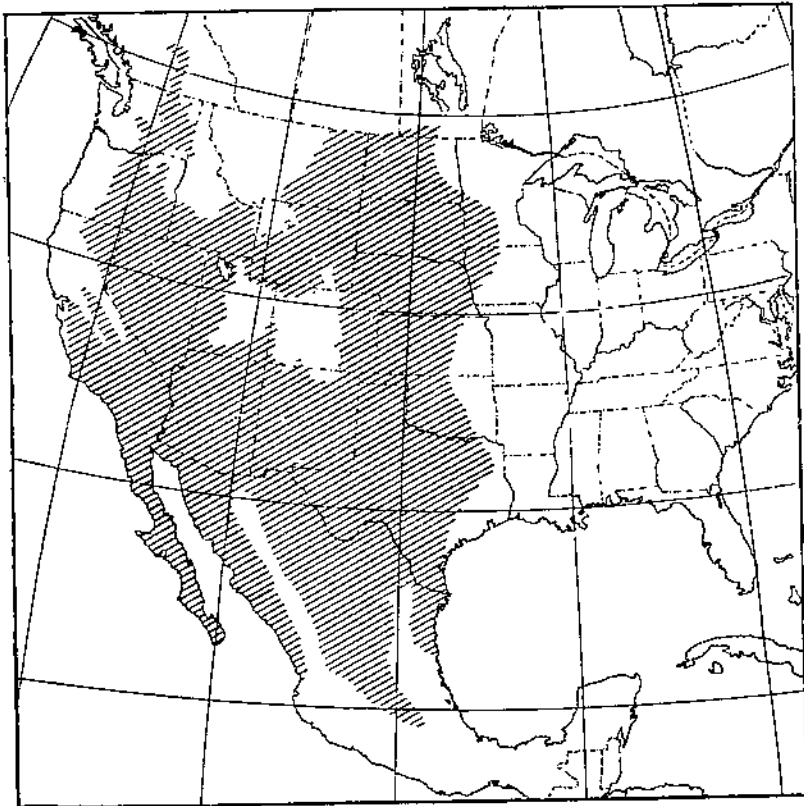


FIGURE 1. - Distribution of pocket mice (*Perognathus*).

are distributed generally over the territory of the United States west of the 100th meridian, except in the higher altitudes and the Pacific humid coastal belt of Washington, Oregon, and northern California, and occur in some numbers east of the 100th meridian in all the

States that are crossed by that meridian. Their northern limit is reached in British Columbia, where they are found in a restricted area; and their southern limit, in Mexico, where they occur over a wide territory. They are most at home on the plains and in the semiarid and desert lands and do not as a rule inhabit mountainous districts unless the prevailing climatic conditions are arid.

The investigations discussed in this bulletin were confined to the two species of *Perognathus* that occur in the Northwest, *P. lordi* and *P. parvus*. In general, *P. lordi* is found in eastern Washington—east of the Columbia River—and north into British Columbia; *P. parvus*, in the Yakima Valley and Horse Heaven country, in Washington, and down through eastern Oregon.

ASSOCIATES

Of interest always are the relations between the animal one is studying and certain others in its habitat. In the same district and fields with *Perognathus lordi* are to be found a species of white-footed, or deer, mouse (*Peromyscus maniculatus gambelii*), a species of grasshopper mouse (*Onychomys leucogaster fuscogriseus*) (pl. 1, A), and a species of harvest mouse (*Reithrodontomys megalotis nigrescens*). In fact, all four genera may sometimes be taken within a radius of a dozen yards.

As to relative numbers, the pocket mouse is much the most abundant of the four and has been increasing its lead since the natural environment has been changed by the growing of grain crops. The total number of mice of each group taken by widespread trapping in 19 field trips is shown in table 1.

TABLE 1.—Number and species of mice taken by trapping in 19 field trips

Species	Field trips	Mice trapped
	Number	Number
<i>Perognathus</i>	17	1,993
<i>Peromyscus</i>	18	783
<i>Onychomys</i>	12	36
<i>Reithrodontomys</i>	3	25

Reithrodontomys was taken in one locality only, but the other three groups were very generally distributed. Deducting the numbers taken during the 4 winter months, when very few pocket mice are abroad, the totals remaining for the two larger groups are: *Perognathus*, 1,550; *Peromyscus*, 416. In two experimental poisoning operations in wheatfields and along their borders 1,993 *Perognathus* and 337 *Peromyscus* were destroyed.

DESCRIPTION

Pocket mice (*Perog. mus*) are so named from their external fur-lined cheek pockets, used principally for carrying food stores, in the possession of which they resemble the pocket gophers (*Thomomys*) and the kangaroo rats (*Dipodomys*), which occur in some parts of their range.

They are approximately the size of the common house mouse (*Mus musculus musculus*), but they have proportionately longer tails and smaller ears. The hind legs and feet are considerably longer and

stouter than the front ones, but the disproportion in this respect is not so great as in the jumping mice (*Zapus*) and kangaroo rats. The handlike front feet, provided with strong claws, are used in feeding, in filling and emptying the cheek pockets, and in digging.

The measurements of 22 adult specimens of each sex of *Perognathus lordi*, taken near Lind, Wash., September 15, averaged as follows: Males, total length 180.8 mm; tail, 98.3; hind foot, 22.2; females, total length, 171.3 mm; tail, 90.5; hind foot, 22.0. The average weights of 10 specimens of each sex, taken May 10, were: Males, 19.7 g; females, 14.4 g.

The average measurements and weights of 10 specimens of each sex of *Perognathus parvus*, taken near Kennewick, Wash., April 25, were: Males, total length, 169.4 mm; tail, 89.5, hind foot, 22.8; weight, 17.25 g; females, total length, 161.5 mm; tail, 85.7; hind foot, 22.6; weight, 14.3 g.

The color pattern throughout the group is much the same—some shade of buff with an admixture of black hairs on the upper parts and lighter shades or white on the under parts.

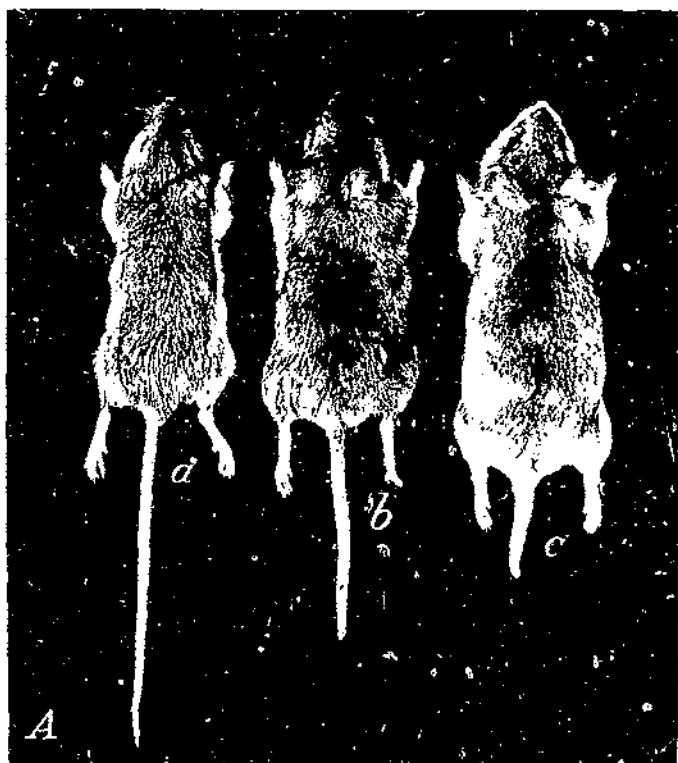
Molting occurs in midsummer, after the breeding season is over (pl. 1, B). In general, the males go through the process first while a few females are still pregnant or suckling young. By the last week of August, 65 percent of the males observed in this investigation were found to be in various stages of the pelage change, but only an occasional female. Three or four weeks later, a considerable number of the females were found in the molt, some of them being almost bare in patches.

DISPOSITION

Perognathus is milder than its associates in most other groups, which may be accounted for by the fact that it is strictly vegetarian and not predatory on any other form of life. When unable to escape it falls easy prey to the white-footed or the grasshopper mouse, either of which will quickly kill and greedily eat it. It shows less fear of men than do the other mice, and one may handle it without danger of being bitten if careful not to grasp it tightly.

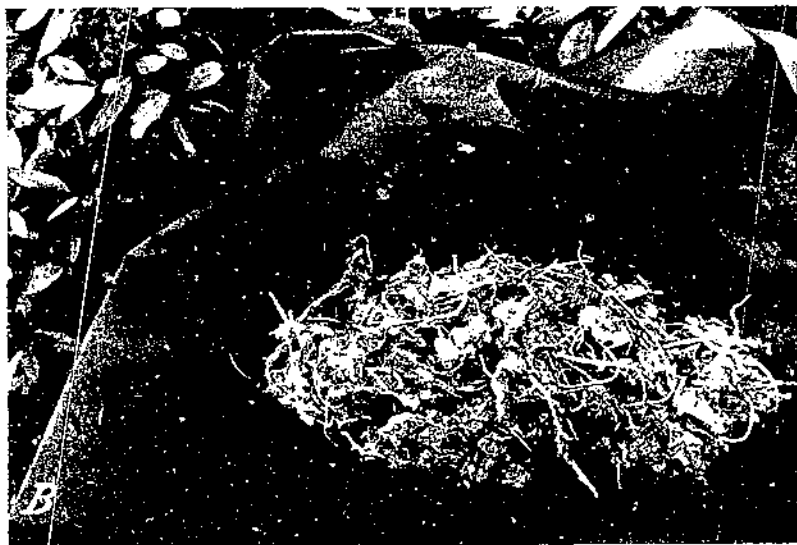
Among themselves, pocket mice quarrel to some extent. A person passing quietly along the weed drift on fence lines after nightfall early in summer may note what seems to be some evidence of discord among them, as indicated by notes of complaint or anger, although males taken at this season bear no marks of hostile encounter. When two or more of these mice are put into the same cage, they usually fight for a long time, but without serious results, after which they huddle together, seemingly forgetting their animosities, even if there are a dozen in the cage. The method of fighting is not of the rough-and-tumble sort, but rather a furiously rapid sparring with the front feet, accompanied by squeals, the antagonists standing partly erect on their hind legs. The sparring seems to be executed to prevent the opponent from biting. The peculiar squeak of the pocket mouse is quite different from the note of any other small rodent and seems always the same in character.

Strictly considered, *Perognathus* is not a social animal, as each individual apparently looks out for itself after the period of early youth. Experiments in trapping under cages placed over the burrow entrances to exclude mice that might be foraging about indicated



16627, 16628

A, a, *Perognathus*; b, *Peromyscus*; c, *Onychomys*. (About half natural size.) Land, Wash., April 7, 1923.
B, Molding in nodes of *Perognathus forbesi*. Land, Wash., August 30, 1923.



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A. Trapping under cages for occupants of single-burrow system of *Perognathus*. Lind, Wash., May 19, 1923.
B. Remains of 220 mice (205 *Perognathus*, 15 *Peromyscus*), tail count, taken late in May and in June, from mound and throat of burrow at entrance to nest of burrowing owls (*Spodopteryx*). Othello, Wash., June 29, 1923.

no residence in family groups except while the young were quite small (pl. 2, A). The writer has never found more than a single mouse in a winter nest, but in captivity several individuals will den together even when a separate nesting box is provided for each.

When released from a trap or cage into an enclosure on the ground, pocket mice proceed forthwith to find a dust bath, in which they fluff and preen themselves like birds or domestic fowls. Without this dusting, which probably helps also to keep the mice free from parasitic fleas and mites, the pelage becomes matted and unkempt.

NATURAL ENEMIES

The pocket mouse is the natural prey of almost any predaceous bird or mammal in its habitat, particularly of the species that hunt in the twilight and at night. Unfortunately, the numbers of such enemies of harmful rodents have been greatly reduced in recent years through the thoughtlessness of the very persons who should have been the most interested in their conservation.

BIRDS

Among the avian victims of wanton sport or misguided zeal for the destruction of supposed pests are the shrike (*Lanius ludovicianus*), the marsh hawk (*Circus hudsonius*), the red-tailed hawk (*Buteo borealis*), and the ferruginous roughleg (*B. regalis*), all of which hunt in daylight and with their keen sight spy out from their aerial vantage points small rodents that would ordinarily escape human observation. The hawks mentioned are all large and need not be mistaken for the so-called chicken hawks, which are of medium or small size; and the marsh hawk has a broad white band on the rump that is easily recognizable in flight.

During the hours of evening and dawn the burrowing owl (*Speotyto cunicularia*) and the short-eared owl (*Asio flammeus*) do valiant service in ridding the country of rodents that are abroad chiefly at such times. The burrowing owl nests in abandoned burrows of the badger or in similar situations, around which are littered the remains of the rodents that it has fed to its young (pl. 2, B). The short-eared owl usually conceals itself in the daytime among the bushes and vines along the edges of coulees, but on cloudy days it may be observed flying low on the hunt at any hour.

MAMMALS

Among the mammals predatory on pocket mice and other rodents are the badger (*Taxidea*), skunk (*Mephitis*), weasel (*Mustela*), and coyote (*Canis*); and as stated, the grasshopper and white-footed mice greedily prey upon *Perognathus*. Indeed, in trapping districts where these three mice abound, it is sometimes difficult to get specimens of *Perognathus* that are not mangled or half eaten. In a poisoning test in which a large number of pocket and white-footed mice were picked up, 170 of the former were mangled and partly eaten but not one of the latter was torn. In spring and summer the patient badger spends much time digging in the stubble or waste lands, its nose presumably having given it reliable information as to the location of the prey it seeks, but its clumsy methods are better adapted for pro-

curing a meal of white-footed mice than of pocket mice, because the former do not burrow nearly so deep as the latter. The skunk and the coyote are both good diggers, although apparently they depend largely on direct capture of rodents. The weasel will enter any rodent burrow that is large enough to admit its lithe, slender body, but in obtaining mice it must depend entirely on stalking and rushing.

PERIODS OF ACTIVITY

DAILY MOVEMENTS

The pocket mice of the species and area under discussion are mainly crepuscular and nocturnal in their movements abroad. Rarely is one trapped in the daytime, but within the hour following sunset the traps usually fill rapidly and may be reset and filled repeatedly. At dawn, fewer pocket mice are found abroad than in the evening. It is at these hours of twilight and dawn that the predaceous birds are the more frequently observed hunting awing. Trapping records show that on rainy nights, infrequent in summer, pocket mice do not venture forth much.

Rather infrequently one will find them during daylight hours in the stubble or weeds at harvesttime, although when early summer fallowing of stubble fields compels numbers of them to make short migrations to new homes within reach of food supplies they are seen a little more often. At that time they find temporary shelter in short burrows, under the larger clods, and in accumulations of trash.

SEASONAL MOVEMENTS

In contrast to the other groups of mice of the area, which are usually abroad in normal numbers in midwinter, the pocket mice are busily active abroad during only 8 or 9 months, depending on the season, and keep within their burrows during cold weather, where periods and duration of dormancy apparently vary with individuals (table 2). Burrow entrances at that time become obstructed by the action of rain, wind, and frost and usually are not opened up again until spring. From late in November until early in March, an occasional straggler may be trapped, but only in a sheltered situation. This midwinter seclusion may be further visualized by a review of the trapping records in table 3. It is correlated with the food-storing habits of these mice and is not, as has been supposed, an indication of true hibernation.

Pocket mice are easily chilled to the point of torpor by temperatures considerably above freezing, when *Peromyscus* and *Onychomys* in the same situations are not in the least affected. When pitfalls a foot deep and covered with a tilting lid were used to trap pocket mice alive, it was found necessary in frosty weather to place chaff or fluff of some sort in the bottom of the pits to serve as shelter.

By reference to table 3 it will be noted that in the case of *Perognathus lordi* the males appear earlier in spring than the females. In 1923, the trapping records for the first week in April show that 76 out of the 80 specimens taken were males. In the middle of March 1924, under more advanced spring conditions, 46 males and only 4 females were trapped.

TABLE 2.—Data on dormancy of 10 pocket mice (*Perognathus lordi*), December to March, inclusive

[First temperature is that of cave cellar; second, of unheated basement. A indicates mouse active when observed; D, mouse dormant; figure after D, rate of respiration; +, food supply intact; —, part of food transferred or eaten; O, all food taken]

Place mouse was confined and mouse No.	Dec. 5; 41°, 40° F.		Dec. 8; 41°, 34° F.		Dec. 11; 38°, 38° F.		Dec. 20; 38°, 36° F.		Dec. 27; 36°, 36° F.		Jan. 1; 28°, 20° F.		Jan. 7; 26°, 24° F.		Jan. 15; 30° 33° F.	
	Mouse	Food	Mouse	Food	Mouse	Food	Mouse	Food	Mouse	Food	Mouse	Food	Mouse	Food	Mouse	Food
Cave cellar:																
1.....	A	—	D	—	D26	—	D14	?	D24	—	¹ D80	—	A	—	D12	—
2.....	A	—	A	—	A	—	A	—	A	—	A	—	A	—	A	—
3.....	A	—	A	—	A	—	A	—	D46	—	¹ D80	—	D40	—	D20	—
4.....	A	—	A	—	A	—	A	—	A	—	¹ D	—	A	—	D24	—
5.....	A	—	A	—	A	—	D16	O	A	—	D44	O	A	—	A	—
Unheated basement:																
6.....	A	—	A	—	A	—	D	O	A	—	A	—	¹ D	—	A	—
7.....	A	—	A	—	A	—	A	—	A	—	A	—	A	—	A	—
8.....	A	—	D	—	D30	—	A	—	A	—	A	—	A	—	A	—
9.....	A	—	A	—	A	—	A	—	A	—	A	—	A	—	A	—
10.....	A	—	A	—	A	—	A	—	A	—	A	—	A	—	A	—

Place mouse was confined and mouse No.	Jan. 23; 30°, 34° F.		Jan. 30; 35°, 39° F.		Feb. 4; 36°, 40° F.		Feb. 13; 41°, 47° F.		Feb. 21; 40°, 43° F.		Mar. 10; 40°, 42° F.		Mar. 17; 38° F. ?		Mar. 31; 42° F. ?	
	Mouse	Food	Mouse	Food	Mouse	Food	Mouse	Food	Mouse	Food	Mouse	Food	Mouse	Food	Mouse	Food
Cave cellar:																
1.....	D18	—	D16	—	D20	—	D16	—	D	—	D	—	A	—	D30	—
2.....	A	—	A	—	A	—	A	—	A	—	A	—	A	—	A	—
3.....	D22	+	D20	—	D20	—	¹ D	—	A	—	¹ D	—	A	—	A	—
4.....	D28	—	D24	—	D30	—	A	—	D	—	D	—	D28	—	D40	—
5.....	A	—	(²)	—	—	—	—	—	—	—	—	—	—	—	—	—
Unheated basement:																
6.....	D12	—	D12	—	D18	—	D44	—	(²)	—	D	O	A	—	A	—
7.....	A	—	A	—	A	—	A	—	A	—	D	—	A	—	A	—
8.....	D16	O	A	—	A	—	D56	—	D44	—	D	—	D30	O	D28	—
9.....	A	—	D48	—	D20	—	(²)	—	(²)	—	—	—	—	—	—	—
10.....	A	—	A	—	A	—	¹ D70	—	A	—	D	—	A	—	D30	—

¹ Partly dormant.

² Dead.

³ Escaped.

IRREGULAR DORMANCY

Detailed information on irregular dormancy, obtained by keeping 10 pocket mice under observation from December to March, inclusive, is given in table 2. One lot, Nos. 1 to 5, was kept in a cave cellar ordinarily used for storing canned fruit; the other lot, Nos. 6 to 10, in an unheated basement, walled with bricks and boards. A reliable thermograph was used in each situation. Each mouse was caged separately and at every observation was supplied with a fresh ration of wheat in a small ointment box.

Data from table 2 may be summarized as follows: (1) Periods and duration of dormancy varied considerably with individuals. One mouse (No. 2) was active at every observation; one (No. 7) was found dormant only once, and two (Nos. 5 and 9), twice; two (Nos. 6 and 8) were found dormant and active an equal number of times; and three (Nos. 1, 3, and 4) were found dormant more often than awake. (2) With one possible exception (No. 3), each mouse was active at some time during each interval between observations, as shown by diminution of the food supply freshly placed at each observation. (3) The degree of the lethargy was in some measure indicated by the rate of respiration recorded. Normal breathing appeared to be about 80 respirations a minute, although mice Nos. 1 and 3 did not seem to be wide awake when breathing at this rate.

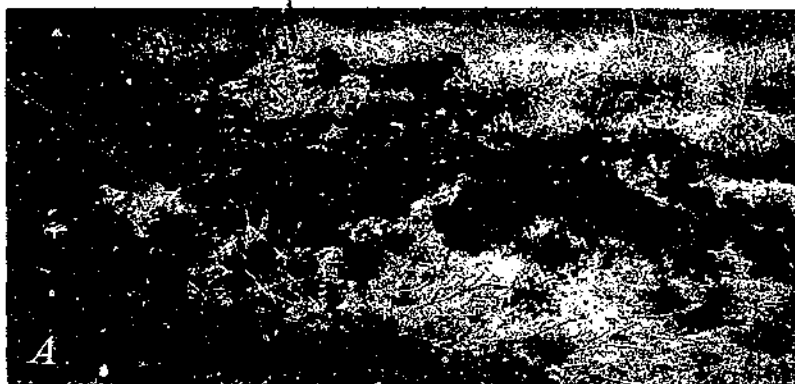
In digging about in the field in winter months, the writer found only one dormant pocket mouse, a *Perognathus lordi*. When wrapped in the folds of an old coat, it revived and became quite active within the course of an hour. Mice of this species kept in various situations, both in their natural habitat and in the coast county of Washington, were dormant at times but seldom for a whole week.

SHELTER AND BURROWS

On wild lands, the activities of pocket mice are more or less screened by the sage, bunch grass, and rabbitbrush of the semiarid country. In cultivated tracts or abandoned fields, the mice seek the shelter of the stubble, the rank growth of introduced plants, and the drift of soil and tumbleweeds along fence lines and other obstructions (pl. 3, A). In such situations they harbor in the greater numbers, but their burrows are also common on the bare, wind-swept parts of fields if food is available within their normal daily foraging range.

Signs of the presence of *Perognathus* are the burrow entrances, which can ordinarily be distinguished from those of other mice, the mounds of finely pulverized soil near some of the entrances in midsummer and later, and tracks in the sand and dust when associated with marks of the tail, which trails at times. Also, when the young begin to roam about in midsummer, there is a marked increase in the signs of fresh digging and of search for food.

Burrow openings, which appear circular in outline when the irregularities of the surface soil are sheared away, are slightly less than an inch in diameter and are a little smaller in cross section than those of the white-footed mouse.



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A. Typical fence-line condition in the dry-farming region—soil drifts and tumbleweed cover infested with *Pteropanthus*, *Pennisetum*, and *Gnaphalium*. Lind, Wash., September 11, 1922. B. Tufts of volunteer wheat from shallow cache of grain carried by pocket mice from adjoining fields. Lind, Wash., November 6, 1921.



Dust mound of *Paragonathus lardi*, open burrow. Cunningham, Wash., June 21, 1924.

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In spring and early summer there are no soil dumps on the surface to mark the locations of the pocket mouse burrows, but by midsummer characteristic dust mounds begin to appear (pl. 4). These resemble the earth heaps made by the pocket gopher but are usually smaller. Sometimes, too, the exits of the branch burrows are plugged with loose earth as are those of the pocket gopher. These loose-earth heaps are not always formed of soil excavated from the deep burrows; more often they are composed of soil from just beneath the surface crust, where the mice have been digging temporary runways or storage chambers.

The burrows themselves are difficult to explore because of their depth and the peculiar condition of the stratum of soil in which they usually terminate. Practically all the dozen or more burrows that were examined in the Lind-Ritzville country of eastern Washington reached this layer at a depth of $3\frac{1}{2}$ to 5 feet, depending on the slope of the land, the cover, and the surface tillage. There the soil is of the loess type, and at the greatest depth to which moisture from the scant rainfall (7 to 10 inches annually) penetrates, a harder, mineralized layer has been formed by capillary evaporation. Immediately beneath this is a loose, ashy layer that does not everywhere make contact with the crust above. When, as is commonly the case, the burrow of the pocket mouse goes beneath this crust, it is useless to try to follow it more than a short distance, as there is no tunnel course to guide the investigator. Occasionally, however, the nest may be found by chance near the point where one breaks through the layer.

To illustrate the general location of the nests that terminate the burrows, it may be noted that in five excavations they were found at depths of 34, 36, 40, 48, and 76 inches. In four other excavations, the burrows were followed to depths of 46, 48, 60, and 62 inches without finding any nests.

In order that the mice may reach these depths by fairly easy grades, the burrow runs somewhat spirally or has in its course two or three hairpin loops, all within a comparatively short horizontal radius. There is but one main tunnel in the deeper part of the system, but nearer the surface there are usually two, three, or four branches that terminate in as many exits.

The nest sites are globular cavities, each about the size of a baseball. The nests are made of finely broken weed twigs, perianths of Russian-thistles, and seed husks or bits of dried grass. These materials are found also in the cheek pockets of some of the mice that are trapped.

In the firm soil underneath the drift along fence lines some of the burrows do not run so deep as those described.

BREEDING

Field studies on the breeding habits of *Perognathus lordi* were conducted through one entire breeding season and parts of two others. The data obtained are given in table 3.

TABLE 3.—Data on breeding habits of *Perognathus lordi*

Collection dates	Days between collections	Specimens taken				Pregnancies					Pregnancies ¹ having—						
		Total	Male	Female	Immature	Early	Medium	Advanced	Total		2 fetuses	3 fetuses	4 fetuses	5 fetuses	6 fetuses	7 fetuses	8 fetuses
	Number	Number	Number	Number	Number	Number	Number	Number	Number	Percent	Number	Number	Number	Number	Number	Number	Number
<i>1921</i>																	
Apr. 26-28	95	67	28	0	0	0	0	0	0	.....	.....	.....	.....	.....	.....	.....
July 13-14	90	28	35	27	10	6	2	18	51	0	1	3	7	3	3	1
<i>1922</i>																	
Sept. 11-16	¹ 103	.....	.....	.....	0	0	0	0	0	.....	.....	.....	.....	.....	.....	.....
Oct. 16-21	² 112	.....	.....	.....	0	0	0	0	0	.....	.....	.....	.....	.....	.....	.....
Nov. 21-24	30	53	35	18	0	0	0	0	0	.....	.....	.....	.....	.....	.....	.....
<i>1923</i>																	
Jan. 9-11	0	0	0	0	0	0	0	0	0	.....	.....	.....	.....	.....	.....	.....
Feb. 25-Mar. 3	44	0	0	0	0	0	0	0	0	.....	.....	.....	.....	.....	.....	.....
Apr. 2-9	29	80	76	4	0	0	0	0	0	.....	.....	.....	.....	.....	.....	.....
May 7-12	27	133	75	58	0	3	0	0	3	5	0	0	2	1	0	0
May 23-June 2	15	116	65	51	0	2	7	0	9	18	1	2	6	0	0	0
June 25-30	22	146	77	67	2	11	11	3	25	37	0	0	10	9	3	2
July 23-30	22	194	85	81	28	15	13	4	32	40	0	0	2	16	8	3
Aug. 23-30	28	224	35	61	128	5	3	0	8	13	0	0	4	3	1	0
Sept. 23-28	23	130	27	29	74	0	0	0	0	0	.....	.....	.....	.....	.....	.....
Nov. 2-10	34	40	30	10	0	0	0	0	0	0	.....	.....	.....	.....	.....	.....
Dec. 10-14	29	³ 5	.....	4	0	0	0	0	0	.....	.....	.....	.....	.....	.....	.....
<i>1924</i>																	
Feb. 12-14	4	4	0	0	0	0	0	0	0	.....	.....	.....	.....	.....	.....	.....
Mar. 11-14	27	44	40	4	0	0	0	0	0	.....	.....	.....	.....	.....	.....	.....
June 6	34	9	25	0	4	3	2	9	36	1	0	3	3	2	0	0
June 23-25	16	70	0	61	9	9	18	1	28	46	0	1	4	7	10	6
Total	⁴ 1,673	653	536	268	59	61	12	132	.....	2	4	34	46	27	14	5

¹ Average number of fetuses, 5.16.² Sex undetermined.³ Sex of 1 specimen undetermined.⁴ Sex of 216 specimens undetermined.

For comparison with the breeding data for *Perognathus lordi* (table 3), two collections of *P. parvus* were made from a district a few miles south of Kennewick, Wash. The first, collected from April 23 to 28, contained 74 specimens, 37 of each sex. There were no cases of pregnancy. The second, collected from June 2 to 8, contained 10 males, 32 females, and 11 immature specimens. The stages of pregnancy were: Early, 12; medium, 8; advanced, 2; and, in addition, 7 females had recently borne young. As only 34 days elapsed between the two collections it is probable that the specimens classed as immature in April were young of the previous season. No young of *P. lordi* were trapped until late in June, and they were but a small proportion of the total catch.

It is not practicable to determine in the field the exact period of gestation in *Perognathus lordi*, and although numbers of both sexes were kept in captivity during the summer, they did not breed. From much indirect evidence, however, it is concluded that the term of uterine development is certainly between 21 and 28 days. Assuming this, it is evident that many females raise a second litter during the breeding season. This conclusion is fully warranted by the percentages of pregnancy and by the intervals between collecting periods given in table 3, and it would be further strengthened if these percentages were raised one-fourth or one-third to account for the females in advanced stages of pregnancy that evidently remain in seclusion near their nests and food stores at this time. Only enough of these could be trapped to determine a basis for classifying this stage in gestation. More than two litters can scarcely be accounted for in the brief midsummer breeding season.

Duration of the breeding period can be determined about as readily from a study of seasonal development of the sex organs of the male as from examination of the female. In the breeding season, the testes in *Perognathus lordi* average 4 by 6 mm and the secondary sexual organs also are well developed. Out of season, these structures are inconspicuous and sometimes barely distinguishable. The female has three pairs of mammae—two abdominal and one pectoral.

FOOD AND FOOD HABITS

SEEDS AND GRAIN

Perognathus is strictly vegetarian. Its natural food consists chiefly of the seeds and grains that it can harvest from native plants, supplemented by the green stuff available in the semiarid country at certain seasons.

The introduction of some of the more noxious weeds into the country, particularly the Russian-thistle (*Salsola pestifer*), a species of wild mustard (*Sisymbrium altissimum*), and pigweed (*Amaranthus* and *Chenopodium*), has greatly increased its food supply. Most of these plants are tumbleweeds, which generously distribute their loads of seed from burrow to burrow.

The breaking up of large tracts of the original sage, bunch grass, and rabbitbrush, followed by the growing of light crops of grain on these lands under dry-farming conditions, has also contributed abundantly to the food supply of the smaller rodents. In addition, rye is now commonly sown on the roadsides in some districts to check the drift of soil along the highways. On such strips and in

abandoned fields volunteer grain may spring from year to year and remain unharvested except by rodents and a few birds.

Perognathus appears to have no relish whatever for insect or flesh diet. When trap lines were baited with fresh or dried meat in places known to be swarming with pocket mice, only *Peromyscus* and *Onychomys* were taken; but when traps baited with rolled oats were substituted, they were quickly filled with *Perognathus*. On several occasions quantities of rolled oats or clean wheat kernels that were put out at night along pocket mouse trails were carried away to the last grain, even when several piles contained a quart of grain each.

GREEN FOOD AND WATER

Green food is available usually only for varying periods in spring, although fall-sown grain may furnish an additional supply in favorable seasons, and some of the weeds mentioned may become green in the stubble in late summer, if there is sufficient moisture. When green stuff is easy of access, pocket mice feed upon it freely; at other times their stomachs contain nothing but macerated seeds and grain. Short sections of tender grain stems and of herbaceous plants, bud clusters, and the like are carried away in the cheek pockets and stored for temporary use.

Pocket mice do not ordinarily require any water other than that obtained in their food, even when the latter is for a considerable time only dry grain. They appear to thrive when kept in captivity for months in winter and supplied with no food but wheat.

FOOD STORES

As pocket mice are storing rodents, their cheek pockets are used principally for carrying food supplies. The deft movements of the handlike front feet of the mice in filling and emptying the pockets are so quick that one can see the results only, and not the process. If cornered in a small enclosure with bulging cheek pockets, a mouse will empty the pockets in an instant, probably that it may more readily escape.

The food stores of grains and seeds are usually cached in chambers comparatively near the surface, doubtless because of the steep descent of the burrows and the great depth to which they extend. Perhaps, too, an instinctive sense of the time that would be lost in a busy harvest season if food were carried all the way down to their nests influences the mice to store as near the source of supply as practicable. Frequently, when stored too near the surface in wheat-fields, the grains sprout and form a matted ball of interlacing rootlets, which sometimes sends up shoots to form a mass of green growth above ground.

In a number of excavations the stores were found, in quantities from a tablespoonful to a cupful, at depths ranging from only a few inches to 2 feet. Occasionally a small quantity of food was located near the deeper living quarters.

ECONOMIC STATUS

Owing to the more favorable food conditions that grain farming and the introduction of certain weeds have brought about and, perhaps in a lesser degree, because of a reduction in the numbers of their natural



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A, Pocket mouse damage to spring-sown wheat plots—Lind, Wash., June 28, 1923. B, Pocket mouse damage to grain—Lind, Wash., July 11, 1923.

enemies, pocket mice have increased in some districts to the proportions of a pest, as have also the white-footed mice associated with them. Fortunately, neither group has the potential rate of reproduction that would enable it suddenly to become a plague, as in the case of the field, or orchard, mouse (*Microtus*) and allied genera.

Fortunately, too, pocket mice rear their young so late in the season that the new generation has little chance at the grain up to harvest time. The older generations, however, and the white-footed mice swarm about the edges of wheatfields in such numbers as to reduce seriously the yield of grain, and in lessened numbers they scatter everywhere through the fields after the fall and spring seedings.

Mice that remain in their old burrows in a field that is lying fallow and seek their food in the nearest grainfield sometimes cause no small annoyance to the farmer who is trying to grow pure seed. After he has seeded this fallow field in fall, he may find tufts of volunteer wheat (pl. 3, *B*) sprouting over wide strips along the borders. This "outlaw" grain, that is, grain of a variety different from the pure stand desired, has been carried by mice and cached in the shallow runways, and the tufts must be hoed out at considerable expense in time and labor.

DAMAGE TO SEED PLANTINGS

At sowing time, pocket mice follow the drill rows and dig up the sprouting seed, resulting in a reduced stand of plants. The damage is less serious, apparently, than that to ripening grain, and it is less after the fall than after the spring seedings (pl. 5, *A*), because in the autumn there is usually plenty of waste grain to be had in the stubble.

Where attempts are made to grow corn or field peas in the more favorable sections of dry-farming districts, the mice contribute their full share to the hazards of the business by following the planted rows and digging up these larger seeds, of which they seem to be especially fond.

DAMAGE TO RIPENING GRAIN

When the wheat begins to mature, the pocket mice cut the heads from the stalks and feed on the tender kernels. As the wheat ripens, they thresh out the hardening grain where the heads lie and carry it off to their stores. Inasmuch as the stalks are found cut off at heights varying from low stubble to just beneath the heads, the mice must be able to climb at least high enough to bend the stalks over (pl. 5, *B*).

In patches of considerable extent, 40 to 50 percent of the stalks, by careful estimate, were found to have been cut; and over entire fields, the damage ran from 5 to 15, or even 20, percent. In a few cases, total loss of the crop has been reported, although no such destruction has come under the writer's observation. It is the aggregate of the smaller tolls taken almost everywhere in the dry-farming wheat sections that counts as commercial loss.

Of course much of the grain eaten or stored by these small rodents is waste gleaned from harvesting operations. As nearly as could be determined by careful examination of sacks dropped from the combine and left lying for weeks in the stubble, the pocket mice were not inclined to gnaw holes in them, although it was known from the characteristic dust heaps pushed up among the bags that the mice were sheltered underneath most of the sack dumps. Damage to sacks where no pocket mouse activity was noted may be charged to species

of mice more adept at gnawing, such as the white-footed and common house mice. The latter species has established itself in the fields here and there, at long distances from any farm premises.

Control of pocket mice, when necessary, and of other mice associated with them in damaging grainfields is best accomplished through extension services of State agricultural colleges, or local farmers' organizations, in cooperation with local representatives of the Bureau of Biological Survey.

SUMMARY

Following persistent reports that pocket mice were increasing in numbers and damaging grain crops in eastern Washington, research on *Perognathus lordi* and *P. parvus* was conducted for 15 consecutive months and seasonal investigations were made in 2 other years.

Perognathus far outnumbers its mouse associates (*Peromyscus*, *Onchomys*, and *Reithrodontomys*) in the district, its lead having increased since the introduction of noxious weeds and the growing of light grain crops under dry-farming conditions.

Its natural enemies—almost any predaceous bird or mammal in its habitat—have unfortunately been greatly reduced through thoughtlessness or misguided zeal for the destruction of pests.

Pocket mice are mainly crepuscular and nocturnal in their movements abroad. During cold weather they keep within their burrows, which correlates with their food-storing habits and is not true hibernation. Signs of their presence are the burrow entrances, mounds of finely pulverized soil near some entrances in midsummer and later, and tracks in the sand and dust when associated with marks of the tail, which trails at times. The burrows run deep. Five nests were found at depths of 34 to 76 inches. There is but one main tunnel in the deeper part of the system; nearer the surface there are two to four branches with as many exits.

The period of gestation in *Perognathus lordi* is apparently 21 to 28 days, so that many females raise second litters. Duration of the breeding period can be determined from the male sex organs, which, barely distinguishable at other times, are then well developed.

Perognathus, a strict vegetarian, subsists chiefly on seeds and grains of native and introduced plants, supplemented by the green stuff available at times. It stores its food supplies, close to the surface usually but occasionally near the deep nests.

Mice that remain in their burrows in a fallow field may greatly annoy the farmer who is trying to grow pure seed, as tufts of volunteer wheat may sprout from their caches of "outlaw" grain in the shallow runways and have to be hoed out at considerable expense.

The damage to seed plantings when the mice follow drill rows and dig up sprouting seeds is less serious than that to ripening grain and is greater in spring, because in fall waste grain is to be had in the stubble. Corn and field peas seem to be especially relished.

In some districts, pocket mice have increased to the proportions of a pest, but ordinarily their rate of reproduction (about five young per litter) is not such as would permit them to become suddenly a plague. They swarm about wheatfields, where they cut the heads from stalks of maturing grain and feed on the tender kernels and as the wheat ripens thresh out and store the hardening grain. In good-sized patches, 40 to 50 percent of the stalks were found cut; and over

entire fields, damage ran from 5 to 20 percent. No total crop losses were observed. Much of the grain taken is waste gleaned from harvesting operations. Apparently these mice are not inclined to gnaw holes in sacks of grain dropped from the combine and left lying for weeks in the stubble.

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