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*Museum of Zoology, University of Michigan, Ann Arbor. Received December 3, 1952. (Current address: Arctic Aeromedical Laboratory, Ladd AFB, Fairbanks, Alaska)*

## SEASONAL ACCEPTANCE OF BAIT BY SMALL MAMMALS

BY HENRY S. FITCH

Intensive and long continued live-trapping of small mammals in localities of diverse habitats in the western, central, and southern states has impressed me with the importance of seasonal changes in bait acceptance. Certain kinds of small mammals such as shrews are notoriously difficult to trap, being indifferent to many of the baits that are commonly used. Others, which take bait well at times, may become indifferent to the same bait at certain seasons and in certain places, with the result that they are rarely caught, even though they are abundant. Under such conditions the trapper often may receive a false impression of a low population. I suspect that these seasonal changes are of general occurrence. Marked changes in trapping success probably are more often caused by change in bait acceptance than by change in actual population density of the animals. My experience with 14 kinds of small mammals, at three localities, in northeastern Kansas, central Louisiana and central California, is summarized in the following accounts.

### OBSERVATIONS

**Opossum (*Didelphis marsupialis*).**—At the University of Kansas Natural History Reservation in northeastern Kansas a study of the opossum was initiated in October 1949, and since then 111 individuals have been trapped, marked and released. Study of the feeding habits at this locality (Sandidge, MS) has shown that the opossum is somewhat omnivorous, but that insects are by far the most important food source. In autumn, fruits make up an important part of the diet. In winter, the season of food scarcity, the opossum lives chiefly as a scavenger, utilizing such miscellaneous food sources as garbage and storm-killed, small vertebrates.

In late autumn, winter, and early spring, opossums can be trapped readily, and during this whole period—the colder half of the year—the weight declines and the physical condition of the average animal steadily deteriorates as stored fat is lost. The largest catches were recorded after unusually warm nights in the winter. Occasionally, individual opossums were found foraging in the daytime when there had been a sudden warming after days of subfreezing weather. During winter storms, opossums seem to remain inactive, and they fast for days at a time. By late April and early May they may have declined to half their autumn weights, and are then in critical condition and easily killed by exposure in traps on cool nights. In autumn, while still fat, they can tolerate lower temperatures and much longer exposure without apparent ill effects. As insects become abundant, with the advent of warm weather in May, opossums become progressively more difficult to trap. Trapping in summer, despite the fact that the population was then at its annual high, was so unproductive of opossums that it was discontinued. In this season of plenty, tracks and other sign frequently indicated that an opossum had passed near a trap without heed for the bait. Rapid deterioration of the baits (horse meat, either canned or fresh, meat scraps, lard, bacon grease, sardine oil, raisins, carcasses of small vertebrates) at high temperatures with frequent heavy rains and an abundance of carrion-feeding insects also handicapped trapping operations in the warmer part of the year. The total of 273 recorded captures were distributed by months as follows: July, 13; August, none; September, 4; October, 16; November, 25; December, 34; January, 35; February, 30; March, 43; April, 38; May, 30; June, 5 (Figure 2).

**Short-tailed shrew (*Blarina brevicauda*).**—On the Kisatchie National Forest in central Louisiana, in the fall, winter, and spring of 1947–48, collaborating with the U. S. Forest Service's reforestation experiments through direct seeding, I maintained lines of snap traps and live-traps baited exclusively with seeds of longleaf pine. Numerous small birds and mammals of kinds that are mainly insectivorous were trapped. Prominent among these species was the short-tailed shrew. In some situations it was caught in larger numbers than was any small rodent. The shrew caught in live-traps had gnawed the seeds in a characteristic manner making them easily distinguishable from those gnawed by rodents. Shrew damage was identified both in pine seeds artificially sown and in some which had fallen from the trees. The largest catches of shrews were made on nights with subfreezing temperatures. Even in mid-winter, periods of relatively mild weather brought a marked reduction in the catch of shrews. In spring, as insect life came into greater prominence, shrews no longer were caught except as rare accidents. It was evident that for these shrews as well as for other insectivorous mammals and birds, the pine seeds constituted an acceptable substitute food rich in fat and protein content and available at a time when invertebrates were relatively scarce and inaccessible.

At the University of Kansas Natural History Reservation, short-tailed shrews are abundant, but are rarely caught in mouse live-traps—only about one per thousand trap-days. In most instances, these captures are made when there are heavy rains. It is not clear whether the shrews enter the traps to feed on the grain bait or for some other reason.

**Little short-tailed shrew (*Cryptotis parva*).**—This shrew was also abundant on the Kisatchie National Forest in Louisiana where pine reseeding studies were made. *Cryptotis*, like *Blarina*, was trapped in large numbers with the pine seed bait in the coldest part of the winter, but this shrew rarely entered the traps at other times.

At the University of Kansas Natural History Reservation, *Cryptotis* is known to be common because many have been caught in pitfalls and funnel traps, but only one capture in a mammal live-trap has been recorded in many thousands of trap days. Since, on this occasion, the shrew ate a harvest mouse that was already in the trap, it probably was not attracted by the original bait.

**California ground squirrel (*Citellus beecheyi*).**—The seasonal trends in bait acceptance of this injurious rodent are of much economic importance. Effective control depends on a knowledge of its seasonal schedule of activity and feeding habits. A study at the San Joaquin Experimental Range, on the west flank of the Sierra Nevada foothills, resulted in

findings that probably would apply, in a general way, throughout the extensive range of the species (Horn and Fitch, *Jour. Mamm.*, 27: 220-224, 1946; Fitch, *Amer. Midland Nat.*, 39: 513-596, 1948). However, in other localities some allowance would need to be made for the effects of climatic and vegetational changes that occur farther north or south or that result from proximity to the ocean, or high altitude in mountain ranges.

In brief, experience in the year-round live-trapping of these squirrels on an 80-acre study area showed that the largest daily catches could be expected in late winter when the population was at its lowest ebb in the annual cycle. Successful trapping at this time of year is based on a combination of factors. The new green crop of annual vegetation on which the squirrels subsist is still short, and the squirrels, ravenously hungry after periods of

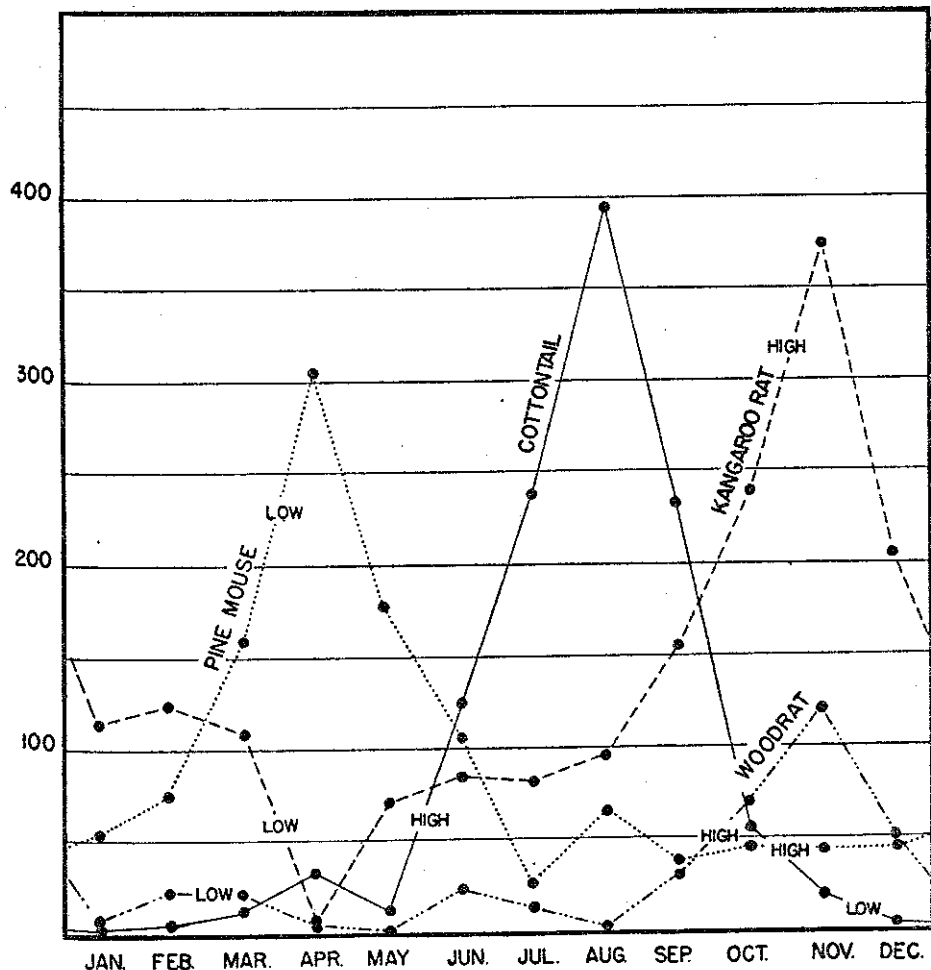


FIG. 1.—Variations from month to month in numbers of live-trap captures for four kinds of mammals, with fairly constant year around trapping. Data for three years are combined for each species; cottontail, and kangaroo rat (females only) at San Joaquin Experimental Range, Madera County, California, 1939, 1940, 1941; woodrat at University of Kansas Natural History Reservation, late 1948, 1949, 1950, early 1951; pine mouse, at same locality 1950, 1951, 1952. Approximate times of maximum and minimum population densities in the normal annual cycle are shown for each species.

dormancy, must concentrate their foraging in the mid-day hours of greatest warmth in the short winter days. With the onset of warm spring weather, in March, as vegetation makes rapid growth and food becomes more plentiful, squirrels become more difficult to trap. By late April the annual forage crop has matured and the squirrels have grown fat on it, doubling their winter weights in extreme cases. Acceptance of grain bait is then at its lowest level. Within a few weeks the daily catch will have tapered off to perhaps ten per cent of its late winter peak—this despite the fact that the active population has been increased several fold by the appearance above ground of the annual crop of young squirrels. The young feed upon the same natural foods used by the adults. On the trapping area, however, they were individually much harder to catch than the adults, and were never represented in the trapped sample in their true ratio. They may have been less inclined to feed upon hard foods such as the grain bait. Perhaps the chief factor was the previous conditioning of the adults to the grain bait at other seasons; consequently they were apt to take it occasionally even when preferred natural foods were available. After the vegetation dries out in May, dry seeds make up a large part of the natural food and the squirrels take grain more readily.

**Kangaroo rat (*Dipodomys heermanni*).**—On an 80-acre area of the San Joaquin Experimental Range, kangaroo rats were trapped alive every month in the year. Trapping success varied a great deal from one time of year to another (Fig. 1). The trends in each of three years were similar, although the population level fluctuated markedly from year to year. As was the case with the ground squirrel, bait acceptance by these rats was poorest in April, and for the same reason. Abundance of plants with maturing fruits and seeds, notably filaree (*Erodium botrys*) provided the rodents with a food source much preferred to any artificial bait. At this season each year the daily catch declined steadily to a small fraction of its early spring level. After the drying out of the chief forage crop in May, kangaroo rats were caught in increasing numbers as bait acceptance rapidly improved and the population was augmented by continued breeding through the summer and early fall. Bait acceptance was excellent during winter and early spring.

**Jumping mouse (*Zapus hudsonius*).**—At the University of Kansas Natural History Reservation jumping mice have been caught from time to time but they are not common, and their usual indifference to grain bait causes them to seem scarcer than they actually are. In the University of Kansas Natural History Museum there is a small series taken in snap traps at various times and places near Lawrence, Kansas. Collection dates of these are as follows: May 1, 1948—2 animals; May 4, 1948—6; May 7, 1949—1; May 7, 1950—1; May 16, 1921—1; May 16, 1950—1; July 15, 1922—1.

It is noteworthy that 12 of these 13 were collected in early May when they must have only recently emerged from hibernation. Natural, preferred foods such as seeds and herbaceous vegetation in general seem to be relatively scarce at that time of year. In more than 30,000 live-trap days on the Natural History Reservation, only nine captures of jumping mice have been recorded—on April 24, 29, and 30, 1952; June 7, 1951; June 8, 1950; June 24, 1952; July 4, 1950; and September 13 and 28, 1951.

For 24 more *Zapus* taken on the Reservation by methods other than with baited mouse live-traps, the seasonal distribution was as follows: early June, 2; late June, 2; early July, 1; late September (14–30), 6; early October, 8; late October, 5. Several of these were drowned in pitfall traps that filled with water during heavy rains, but most of them were caught in wire funnel-traps set for reptiles, along hilltop rock-ledges at the edge of woodland. These records suggest that the jumping mice move from nearby grasslands at the onset of cool autumn weather to rock ledges where it is presumed they are in search of suitable places in which to hibernate.

**Deer mouse (*Peromyscus maniculatus*).**—At the San Joaquin Experimental Range on the 80-acre area which was intensively trapped for kangaroo rats, many *Peromyscus* were caught, recorded, marked and released in 1938, 1940, and 1941. From October until mid-May, when there was green vegetation, the mice were caught most frequently, even though trapping at that season was less intensive and was often suspended in the coldest weather,

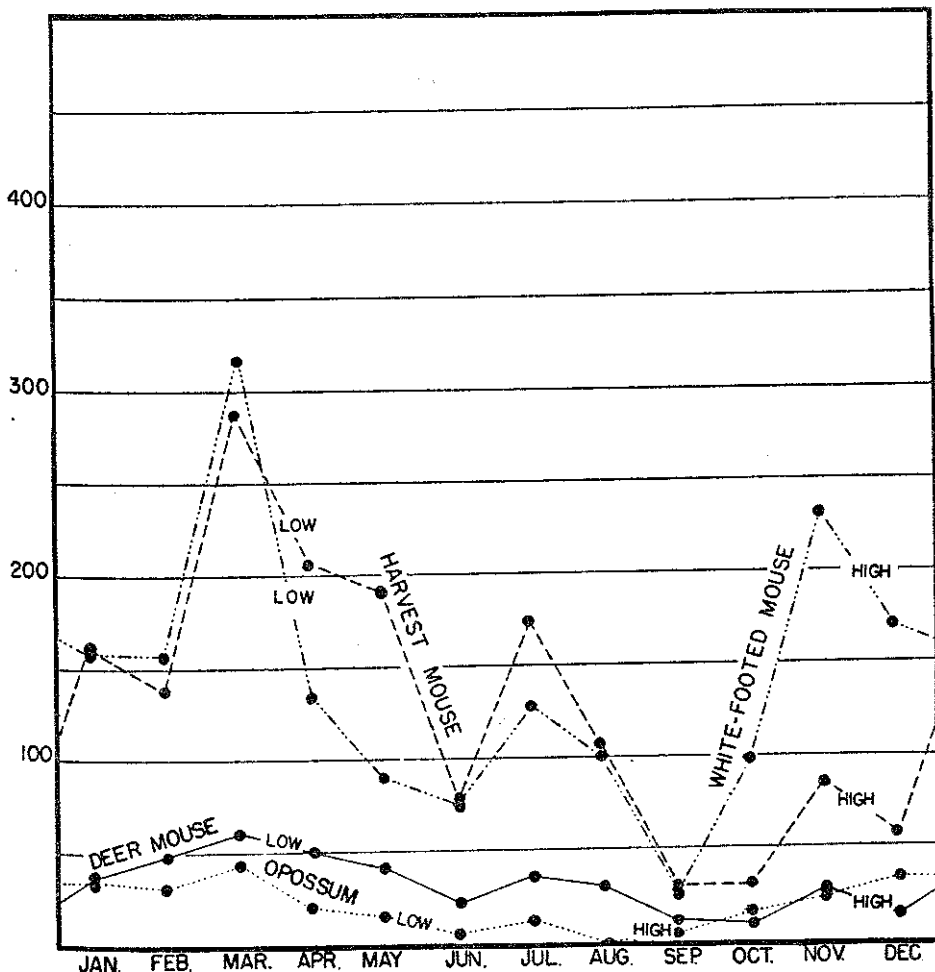


FIG. 2.—Variations from month to month in numbers of live-trap captures for four kinds of mammals at the University of Kansas Natural History Reservation; for each species, data are combined for three years (1948-1952).

in January and parts of December and February, to avoid mortality. During the dry season, May through September, deer mice were almost absent from the catch. Numbers of individuals caught in the different months were as follows: October, 9; November, 10; December, 24; January, 21; February, 27; March, 40; April, 2; May, 3; June, 0; July, 0; August, 1; September, 0.

At the University of Kansas Natural History Reservation, under different habitat conditions and climate, the seasonal trends were somewhat similar, but less pronounced (Fig. 2). From mid-November through May the daily catch, with a grid of one hundred live-traps in a three-acre grassland study plot, usually included several deer mice, but in the remainder of the year, summer and early autumn, fewer were caught (Table 1). In each of these instances it seems that the downward trend in numbers of deer mice caught in the warmer part of the year, did not correspond with an actual decrease in population. Rather, the population may have reached its annual high point within this period of minimum

TABLE 1.—Fluctuations in average catch per day with a grid of 100 live-traps on a three-acre area, of four kinds of rodents

TRAPPING PERIODS	AVERAGE CATCH PER DAY			
	<i>Microtus ochrogaster</i>	<i>Reithrodontomys megalotis</i>	<i>Peromyscus maniculatus</i>	<i>Sigmodon hispidus</i>
March 23-30, 1950	19.7	10.8	3.6	—
April 7-13, 1950	21.0	9.3	3.0	—
May 1-4, 1950	28.8	11.8	4.0	—
May 29-June 9, 1950	45.8	3.1	1.0	—
July 2-6, 1950	18.0	4.0	1.2	—
July 19-29, 1950	25.5	6.5	1.3	—
August 4-12, 1950	42.0	3.7	2.3	—
August 29-September 7, 1950	41.7	3.4	.4	—
September 21-27, 1950	33.0	—	.9	—
October 14-23, 1950	29.1	1.4	.3	.3
October 27-November 2, 1950	58.4	1.0	1.0	—
November 16-19, 1950	35.0	5.8	3.0	1.0
December 13-14, 1950	43.5	7.5	5.0	.5
January 9-13, 1951	23.8	5.5	4.6	—
February 5-12, 1951	21.3	7.3	4.3	—
February 25-March 2, 1951	32.7	10.2	4.5	—
April 4-8, 1951	35.6	15.4	3.0	—
May 6-11, 1951	59.7	15.0	3.0	.7
June 2-8, 1951	102.0	2.8	.6	2.0
July 20-27, 1951	69.9	4.6	.8	4.6
August 10-16, 1951	79.3	4.1	1.4	5.1
September 1-5, 1951	61.2	.8	.6	5.4
October 1-6, 1951	60.2	.3	—	2.3
November 8-13, 1951	39.5	3.0	.8	10.8
November 29-December 3, 1951	57.4	4.4	.8	11.6
January 9-12, 1952	33.5	12.8	1.8	6.8
January 17-20, 1952	49.8	10.3	.8	8.3
February 1-4, 1952	33.8	5.8	1.0	5.3
February 27-March 1, 1952	31.0	11.5	—	.3
March 20-29, 1952	25.8	3.8	—	1.9
April 24-27, 1952	53.8	6.5	—	—
May 14-22, 1952	49.1	2.8	—	1.0
June 13-22, 1952	29.6	1.8	1.0	.9
July 4-8, 1952	32.8	5.6	2.0	—
August 14-19, 1952	16.2	1.3	.5	—
September 4-9, 1952	23.2	1.8	.3	—

trapping success. In many instances, individuals caught frequently in early spring, but absent from the records for long periods during hot weather, reappeared in the traps at approximately their original locations with the return of cool weather in the autumn. A possible explanation is that these mice, being partly insectivorous in their feeding, are little attracted by grain bait at the season when insects are abundantly available.

**White-footed mouse (*Peromyscus leucopus*).**—At the University of Kansas Natural History Reservation this mouse has been caught in large numbers at all times of year and in a variety of habitats. Its presence often has interfered with trapping operations for other mammals or birds. Although it takes bait at all times of year it seems to enter traps with

grain bait most readily in winter, and especially in early spring (Fig. 2). A line of 102 live-traps operated at monthly or more frequent intervals for a year, made the largest catches in March, when two samples averaged more than twice the average for the 15 samples of the remainder of the year. All mice of this species caught in March were adults, and most of them were breeding—the population was then at its annual low point. Lowest catches were made in June, July, August, and September, and the five samples from within this period, corresponding with the annual high in the white-footed mouse population, averaged only 5.2—less than 27 per cent of the March average. The general abundance of invertebrates and plant food in summer may divert both this species and the deer mouse from grain bait.

**Western harvest mouse (*Reithrodontomys megalotis*).**—This mouse is moderately abundant on the 3-acre grassland area at the University of Kansas Natural History Reservation where a grid of 100 live-traps is set frequently throughout the year, and a well-defined seasonal trend is apparent. (Table 1 and Fig. 2.) The largest catches in both 1950 and 1951 were made in late February, March, April, and early May, but by early June the catch abruptly declined to a fraction of its former level. It was consistently low through the summer and even poorer in early fall. In the spring when best catches were made, the mice caught were almost all old adults, and this time was the peak of their breeding activity. Many females caught in April gave birth to litters of young in the traps overnight. The few harvest mice caught in summer included a high proportion of young, and it seemed that the spring population had been much augmented by this new generation. Thus, changes in the numbers caught were not at all indicative of trends in the population, but rather the season of minimum numbers corresponded with maximum trapping success and *vice versa*. In summer, preferred plant foods, probably certain seeds, divert harvest mice from the grain bait.

**Pine mouse (*Microtus pinetorum*).**—On the University of Kansas Natural History Reservation the pine mouse occurs in small numbers in scattered colonies. It was not discovered on the area until March, 1950, after nearly two years of trapping. Subsequently, special effort was made to catch and mark those of one colony confined to a narrow 150-yard grassland strip at the edge of woods near the Reservation headquarters. In two years 1155 captures were made of 106 individuals. The number of traps employed and the amount of trapping effort varied somewhat. Trapping was generally intensified at the times when results were most rewarding and was curtailed during the coldest weather. In each year, best catches were made in spring and the catch dwindled to a small fraction in the hotter part of the summer, even though the pine mouse population was then at an annual high. For the two years combined, total number of captures for each month were as follows: January, 53; February, 76; March, 183; April, 305; May, 176; June, 106; July, 26; August, 65; September, 37; October, 45; November, 44; December, 39.

**Prairie vole (*Microtus ochrogaster*).**—In the past two years at the University of Kansas Natural History Reservation, this vole has been caught in greater numbers than all other mammals combined. Most captures have been made on a three-acre grassland area with a grid of one hundred live-traps. At all seasons of the year voles were caught in substantial numbers each time the traps were set (see Table 1). Seasonal changes in bait acceptance were not as clear cut as they were in most of the other species studied. The thousands of records accumulated have not yet been fully analyzed. However, it is obvious that the population is at low ebb annually in December, January, February and early March. In winter almost all voles caught were adults or subadults. In this season the trap line was usually tended only once daily. In summer it was usually checked each morning and again in the late afternoon, so that the figures for daily catches in Table 1 are not entirely comparable between the two seasons. In view of the wide differential between winter and summer population levels, it appears that trapping success was much higher in the winter in proportion to the number of individuals present. From time to time traps were set outside the study plot and, in summer, catches on such new areas were generally meager despite abundance of vole sign. Successful summer trapping on the study area may have involved

long conditioning of the vole population there to the grain bait. This species fitted the pattern found in most other small mammals, in that individuals tend to take grain bait best in the season of food scarcity, corresponding with the annual low in population density.

A noteworthy trend in the vole catch was the progressive increase in numbers on successive days at the start of a trapping period. The catch was likely to be light on the first day after the trap line was set. As the voles discovered the bait at the set trap they tended to concentrate their activities there. For 29 trapping periods of 4 to 12 days each, including each month of the year, first, second, third and fourth days' catches average respectively, 68.6, 83.1, 94.3 and 114.6 per cent of the mean daily catch for each separate period. After the fourth day of a trapping period the numbers caught tended to level off.

**Florida woodrat** (*Neotoma floridana*).—This woodrat is moderately common on the University of Kansas Natural History Reservation. For the past three years traps have been set frequently wherever sign occurred on a 300-acre area, to catch and mark all the woodrats there. For the three years the total number of captures, by months, were as follows: January, 8; February, 22; March, 22; April, 5; May, 1; June, 23; July, 13; August, 2; September, 30; October, 68; November, 120; December, 50 (Fig. 1). These changing numbers reflect seasonal bait acceptance to some extent, although other factors are involved. Woodrats are most easily caught in autumn when they are at their annual high point of population density. Bait acceptance was excellent in winter, but relatively little trapping was done in December, January and February because of the danger of mortality in traps. In March, trapping effort was far less rewarding and the catch continued to decline to the annual low point in April and May. Catches in June and July were unduly costly in time and effort and consisted principally of immature woodrats. Presumably the abundance and variety of foliage and other plant foods tend to make the woodrats indifferent to grain bait during late spring, summer, and early fall.

**Audubon cottontail** (*Sylvilagus audubonii*).—This rabbit was live-trapped in large numbers at the San Joaquin Experimental Range, and of all the species of mammals studied, it provided the most clear-cut and striking example of seasonal fluctuations in catch. Trapping of rabbits on this area was incidental since the trap line was maintained for study of ground squirrels. Comparable data for each month of the year were obtained, although in winter and spring months rabbits were caught in such small numbers that it was impractical to maintain the trap line for them alone. On the 80-acre area, approximately 200 traps were kept set for several days each week throughout the year, and 228 rabbits were trapped a total of 1159 times (Fig. 1). "Throughout the growing season, October through May, while green food was abundantly available, rabbits only rarely entered the traps. It is assumed that natural foods were much preferred to the grain mixture of wheat and milo maize with which the traps were baited. In summer after the main forage crop had dried out, grain was taken freely, and nearly all recorded captures of rabbits were in the dry season—summer and early fall. Each year the catch was highest in August at the peak of the dry season. Trends were similar for all three years. . . ." (Fitch, California Fish and Game, 33: 160, 1947.)

In summer, when grain bait is readily taken, the natural foods available are of types high in fiber content and low in crude protein (Gordon and Sampson, California Agr. Exp. Sta. Bul., 627: 1-96, 1939). Vegetation consists chiefly of annuals that are dead and dry during the hot, virtually rainless summer, and the "growing season" begins with the advent of October rains. During the growing season, late autumn, winter and spring, the green plants have a high crude protein content. Like the ground squirrels living on the same area, cottontails attained their maximum annual weights in April or May when nutritious natural foods were most abundant. It is noteworthy that the seasonal trend of bait acceptance for this cottontail is exactly opposite from that of the deer mouse, with reference to the same bait on the same area.

**Florida cottontail** (*Sylvilagus floridanus*).—This rabbit is abundant at the University of Kansas Natural History Reservation but no comparable year-round trapping data are available as yet. In winter and early spring, the rabbits have often hindered the trapping

of mice by overturning many of the wire traps to obtain the grain bait. After killing-frosts in the fall, the rabbits feed partly upon dry foliage and partly upon the inner bark of shrubs and saplings. In the season of food scarcity, when the ground is covered with snow, bark is the principal food source.

In summer, grain is unattractive. For several weeks in June and July, 1951, two dozen traps were kept set along a woodland edge where cottontails were numerous, and various baits were tried. The few captures made were in traps that had been baited with green vegetables.

#### CONCLUSIONS

For 14 species of small mammals including a marsupial, two insectivores, nine rodents, and two lagomorphs, live-trapping data have been accumulated throughout the entire year or over periods of months. With every one of these species, success in trapping varied according to season. In some the seasonal difference in the catch was small. In others, seasonal change from a high incidence of success to complete failure was recorded. Even in the same locality species differed in the time and duration of maximum and minimum bait-acceptance. Varying success in trapping each kind of mammal at different times of year was found to have little correlation with the actual population level but was determined by the extent to which the animals were attracted to bait at any particular time. Baits are least attractive at times when natural foods are abundantly available, and are most attractive when natural foods are scarce. Best catches are most likely to be made at the season when preferred food sources are in short supply even though the population then may be at its annual low point. The annual maximum population ordinarily corresponds with a time of food surplus when animals tend to be indifferent to baits, and when adults attain their maximum weights.

In each species, bait acceptance tends to conform to the same seasonal pattern from year to year, altered somewhat by the population density and the food supply. For example, at the San Joaquin Experimental Range in the summer of 1939, drought conditions were unusually severe. The crop of annual vegetation was sparse and dried in early May. The few summer growing weeds, such as tarweed (*Hemizonia virgata*) which ordinarily provide some succulence in the dry season, were sparse and stunted. Under these conditions, ground squirrels, kangaroo rats, and cottontails were trapped much more easily than they were in other years.

At the University of Kansas Natural History Reservation in July, 1952, after weeks of nearly rainless weather, white-footed mice and harvest mice were caught much more readily than they were at that season in other years, but pine mice could not be caught at all.

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