# Competition Between Ground Squirrels and Cattle for Range Forage

**W. E. HOWARD, K. A. WAGNON, AND J. R. BENTLEY**

*Specialist, Field Station Administration, University of California, Davis; Specialist in Animal Husbandry, Department of Animal Husbandry, University of California, Davis; and Range Conservationist, California Forest and Range Experiment Station[1], Forest Service, U. S. Department of Agriculture, Berkeley, California*

"On open range and in pasture lands ground squirrels *(Citellus)* feed largely on filaree and bur clover, two of the most valuable forage plants in California, and become serious competition for subsistence against the flocks and herds upon which man depends for his own support" (Grinnell and Dixon, 1918). Even though ground-squirrel populations are no longer as dense as in former years, they are still sufficiently numerous to be of major concern locally. The degree to which these squirrels compete with cattle for range forage is still a question among livestock operators and range technicians.

The purpose of this study was to determine the role of ground squirrels *(Citellus beecheyi)* on range land by expanding the experimental approach from cages and field enclosures to a pasture scale. The experiment was designed to see if rodent utilization of green forage in the winter was great enough to measure in changes in cattle weights.

Grinnell and Dixon (1918) calculated that 200 ground squirrels "consume" the same amount of range forage as a 1,000-pound steer. Fitch and Bentley (1949), studying the effects of range rodents on forage cover at the San Joaquin Experimental Range, found that 6 male ground squirrels confined to a half-acre enclosure decreased potential forage yield by 529 pounds — more than 10 times the amount the squirrels may have eaten. The results also suggested that natural field populations of ground squirrels, pocket gophers *(Thomomys)*, and kangaroo rats *(Dipodomys)* in some pastures of the station might be reducing the annual herbaceous forage crop by more than one-third.

Fitch (1947 and 1948), studying the seasonal feeding habits of ground squirrels, found this rodent to be highly selective in its diet, feeding for part of the year exclusively on forage plants that Wagnon *et al.* (1942) had shown were also being grazed at that season by cattle. These studies showed that both the ground squirrels and the cattle began feeding on the new annual plants soon after seed germination and continued through the winter months, while the plants were growing slowly. It is during this period of inadequate forage growth (Bentley and Talbot, 1951) that ground-squirrel competition with livestock for range forage is most critical. A surplus of forage for both rodents and livestock is usually available after vegetation starts its rapid spring growth.

## Experimental Area

The study was conducted at the San Joaquin Experimental Range, in the Sierra Nevada foothills in Madera County, California, at an elevation of about 1,150 feet. Topography is rolling, with generally southwesterly exposures. Soils are of granitic origin, and rock outcrops are numerous. The area is in the woodland-grass type, with an open stand of trees and shrubs and a herbaceous cover of annual grasses and forbs. Interior live-oak *(Quercus wislizenii)*, blue oak *(Q. douglasii)*, Digger pine *(Pinus sabiniana)*, and wedge-leaf ceanothus *(Ceanothus cuneatus)* are the dominant trees and shrubs. More detailed descriptions of the Experimental Range are presented by Talbot, Nelson, and Storie (1942), and Bentley and Talbot (1951).

## Procedures

One pair of pastures was used, with a reversal of treatment to help rule out site differences between pastures. The plan was to use 2 years for pasture calibration, then eliminate the squirrels from one pasture for at least 2 years, and then let the squirrels come back on the poisoned pasture and remove them from the other pasture for several more years.

### Pasture

Pasture 1 (formerly part of pasture 8S) and Pasture 2 (formerly part of pasture 3, Bentley and Talbot, 1951) were established for this study in 1948. The two pastures were selected as areas with satisfactory populations of ground squirrels and similar plant covers containing considerable broad-leaved filarees *(Erodium* spp.) (Wagnon and Biswell, 1947). The pastures were separated by about 1 mile, but equally accessible to stock-weighing facilities.

The two pastures varied in site qualities, but an attempt was made to make them equal in grazing capacity. Because Pasture 1 showed greater capacity during the first year of calibration, its acreage was reduced in 1949, from 40.40 to 31.53 acres.

[1] *The California Forest and Range Experiment Station is maintained at Berkeley in cooperation with the University of California.*

The size of Pasture 2 was held at 48.40 acres throughout the experiment. Acreages of the various site classes, total areas, and grazable area for each pasture (after size of Pasture 1 was reduced) were:

| | Pasture 1 Acres | Pasture 2 Acres |
|---|---|---|
| Swale | 1.07 | 2.76 |
| Open, rolling slope | 9.79 | 1.11 |
| Rocky, brushy slope | 20.67 | 44.53 |
| Total area | 31.53 | 48.40 |
| Grazable area | 28.15 | 41.30 |

The two pastures differed in past grazing treatment. Pasture 1 had formerly been grazed primarily during the dry-forage and winter-forage periods, at a moderate stocking rate. For 12 years Pasture 2 had been grazed during the green forage period, at a heavy stocking rate.

#### Rodent Census and Poisoning

A census of ground squirrels and certain small rodents was maintained in both pastures each year of the study. The adult breeding population of ground squirrels was censused each year from January to March, before appearance of the young. Some censusing was also done in the summer and fall. During the 2 years of pasture calibration, when squirrels were in both pastures, an attempt was made to count the squirrels by stationing oneself in the pasture and observing with field glasses. To facilitate counts, numbers about 12 inches high were painted on rocks adjacent to each colony. Later a plan of live trapping, which was more efficient and gave precise counts was adopted. Each trapped squirrel was marked by cutting off the tip of the tail and clipping most of the hair from the rest of the tail. The few that were not caught and marked were easily seen and counted while walking through the pasture. The Lincoln Index was also used with trapped animals. It did not give reliable population density figures, because of the large number of dispersals of squirrels.

In the fall of 1950 the ground squirrels were poisoned in Pasture 2 and in a 1,000-foot-wide buffer strip. The Madera County Agricultural Commissioner did the control work, using oat groats and Compound 1080 (sodium fluoroacetate). The pasture was kept free of squirrels in the 1950-51 and 1951-52 seasons by frequent checking, and additional local poisoning where needed. After the ground squirrels were kept out of Pasture 2 for two seasons, the pasture poisoning treatment was reversed. Pasture 1 was poisoned in the fall of 1952 and kept free of ground squirrels for the next 4 years, in the manner previously followed in Pasture 2. In an attempt to expedite reestablishment of ground squirrels in Pasture 2, 80 individuals were live trapped in Pasture 1 and released in Pasture 2.

To measure the effect of squirrel poisoning on the populations of other small rodents, N.A.C.S.M. (North American Census of Small Mammals) trap lines (Calhoun, 1956) were maintained in the spring and fall of each year.

#### Pasture Stocking

Each pasture was stocked with 10 head of yearling heifers each year (except in 1951, when 12 head were used) after the new forage was well started but still inadequate to promote weight gains in cattle. The forage season was divided into two periods: *the winter forage period,* when forage grew slowly and the competition of cattle and squirrels for forage was to be studied, and the *green forage period,* which included the rapid growth and drying of the forage. The cattle were not in the pastures in summer. Both pastures were deliberately stocked so that the cattle would lose weight during the winter forage period—to determine if the influence of squirrels on the pasture could be measured by a change in cattle liveweight when the squirrels were removed from one pasture. The heifers were maintained in both pastures until the close of the following green forage period. If, at this time, one pasture was judged to contain more ungrazed vegetation than the other, all the heifers were placed in it until the vegetation was grazed to a comparable degree. The heifers received no supplemental feeds other than plain block salt. They were weighed individually at about monthly intervals, after being confined overnight in a dry corral lot.

#### Herbage Measurements

Herbage yield in each pasture was measured annually near plant maturity, in May, to determine the relative productivity of the pastures. The vegetation was clipped on fifty 60-square-foot quadrats in each pasture. These quadrats were relocated each year and protected from livestock grazing by cages made of 2-inch-mesh poultry netting. Smaller rodents may have eaten some of the vegetation on the quadrats, but ground squirrels apparently did not enter the cages.

Herbage residue remaining after the heifers were removed was sampled in each pasture, except in one year, by picking up the ungrazed vegetation on square-foot quadrats. These measurements were taken after both pastures appeared to have been grazed to a comparable degree.

## Results

#### Rodent Numbers

Pasture 2 contained a substantially greater population of breeding ground squirrels than did Pasture 1 during the 2-year calibration period. The estimated numbers of adult squirrels present during the winter months (Table 1) shows that, for the first year, Pasture 1, with 2.79 ground squirrels per grazable acre, had only about half the density of squirrel population of Pasture 2, with 5.32. During the

**Table 1. Estimated number of ground squirrels per pasture and per grazable acre for each winter forage period (January to March).**

| Year | Pasture 1 | | Pasture 2 | |
|---|---|---|---|---|
| | Number of squirrels | Squirrels per grazable acre | Number of squirrels | Squirrels per grazable acre |
| 1949* | 100 | 2.79 | 220 | 5.33 |
| 1950 | 90 | 3.20 | 200 | 4.84 |
| 1951 | 120 | 4.26 | 0 | 0 |
| 1952 | 100 | 3.55 | 0 | 0 |
| 1953 | 0 | 0 | 20 | 0.48 |
| 1954 | 0 | 0 | 40 | 0.97 |
| 1955 | 0 | 0 | 85 | 2.06 |
| 1956 | 0 | 0 | 60 | 1.45 |

* In 1949 Pasture 1 had 35.83 grazable acres, then it was reduced to 28.15.

second year of calibration the population of Pasture 1 increased to 3.19 squirrels per grazable acre, and the density in Pasture 2 dropped to 4.84.

At the end of the calibration period the ground squirrels were removed from Pasture 2 by poisoning in the fall of 1950. During the next 2 years, 1951 and 1952, the squirrel population remained about the same in Pasture 1: 4.26 squirrels per grazable acre in 1951, and 3.55 in 1952.

After the completion of data collection in 1952 the squirrels in Pasture 1 were poisoned. But an attempt to expedite the rebuilding of a squirrel population in Pasture 2 by introducing 80 squirrels from Pasture 1 was not very successful. Only about 10 of these squirrels were still present in Pasture 2 a year later, when the total population was only 20. In the next 3 years, the squirrel population of Pasture 2 came nowhere near its original density. In 1955, at its highest population, it was still only 40 percent of the average density for the calibration years. In 1956 the squirrel density decreased to 29 percent of the calibration period.

For some unexplained reason the number of smaller rodents caught in Calhoun-line trapping *(Peromyscus boylei, P. maniculatus, P. truei, Perognathus inornatus,* and *Dipodomys heermanni)* was usually lower in the pasture that was free of ground squirrels. In 1951 and 1952, after squirrels in Pasture 2 were poisoned, Pasture 1 had 50 to 76 percent (68 percent average) more small rodents than did Pasture 2. For the next four years after Pasture 1 was poisoned, Pasture 2 had 6 to 80 percent (34 percent average) more rodents than did Pasture 1. The reasons for these changes are not known.

Other herbivores present that did not show up in the trapping included a few gray squirrels *(Sciurus),* fewer than three pocket gophers *(Thomomys)* per acre, a small number of harvest mice *(Reithrodontomys),* an occasional jack rabbit *(Lepus),* a cottontail *(Sylvilagus)* about every 4 or 5 acres, and an occasional mule deer *(Odocoileus).* No meadow mice *(Microtus)* were found in the grazed pastures.

### Herbage Yield and Utilization

Yearly herbage yields of one pasture in relation to the other varied considerably during the 8 years of the study (Table 2). The yield per grazable acre in Pas-

**Table 2. Dry weight herbage yields per grazable acre from control and experimental pastures, with yield differences and weight of residue on the experimental pastures.**

| Year | Base yield control pastures | Pasture | Herbage at plant maturity | Residue after heifers removed |
|---|---|---|---|---|
| | *lbs.* | | *lbs.* | *lbs.* |
| 1949 | 1,300 | 1 | 1,053 | 197 |
| | | 2 | 790 | 174 |
| | | | 263 | |
| 1950 | 2,300 | 1 | 1,912 | 833 |
| | | 2 | 1,845 | 637 |
| | | | 67 | |
| 1951 | 3,100 | 1 | 2,718 | 605 |
| | | 2 | 2,322 | 797 |
| | | | 396 | |
| 1952 | 2,200 | 1 | 1,687 | 732 |
| | | 2 | 2,041 | 1,266 |
| | | | —354 | |
| 1953 | 1,700 | 1 | 1,714 | 651 |
| | | 2 | 1,264 | 684 |
| | | | 450* | |
| 1954 | 2,400 | 1 | 2,265 | 998 |
| | | 2 | 1,420 | 892 |
| | | | 845** | |
| 1955 | 2,000 | 1 | 1,805 | ..... |
| | | 2 | 1,134 | ..... |
| | | | 671** | |
| 1956 | 1,600 | 1 | 1,549 | 567 |
| | | 2 | 1,502 | 410 |
| | | | 47 | |

* Difference significant at .05 level.
** Difference significant at .01 level.

ture 1 averaged 299 pounds more than the yield of Pasture 2, varying from 845 pounds greater to 354 pounds less. Neither pasture showed a consistent upward or downward trend in productivity when compared with the other.

By comparing the annual production on Pastures 1 and 2 with two control pastures used in another experiment, it is apparent that the yield of Pasture 2 deviated from the annual base yield of the two control pastures more than did the yield of Pasture 1 (Table 2). Yields of Pasture 1 averaged 89 percent of the base yields of the control pastures during the 8 years, and did not vary significantly from the base yield in any year. Yields of Pasture 2 were more variable, 61 to 94 percent, averaging 74 percent of the base yields.

During the first two winters, the pasture calibration period, plant growth was noticeably greater in Pasture 1 than in Pasture 2. In 1951 (the 1950-51 season) and for the remainder of the study, winter forage growth was typically slow in both pastures. The reduction in winter plant growth in Pasture 1 in 1951 apparently was the result of close grazing this pasture for 2 years. This pasture had previously been moderately grazed (Bentley and Talbot, 1951).

Each year—except during the calibration period and in 1955 at the conclusion of the study—heifers were moved from Pasture 1 and added to those in Pasture 2, a much larger pasture, until the utilization on the two pastures appeared equal. Utilization of the two pastures was fairly comparable during all 8 years except 1952 (Table 2).

Because the two pastures were less alike in herbage production than desired, a longer calibration period would have helped rule out certain inconsistencies. Even so, the pastures served adequately to show that changes in rodent populations affected gains of the heifers.

**Livestock Gains and Losses**

Data on stocking of the pastures and average livestock weight changes are given in Table 3. The initial pasture-stocking date varied from December 5 to February 25, and the terminating date of the ensuing winter-forage periods varied from February 19 to April 7. The terminating date of the green-forage periods varied from May 2 to June 20. Thus, the winter-forage period varied from 32 to 97 days, with an average of 62 days, and the green-forage period varied from 55 to 105 days, with an average of 74 days. During the first 2 years the heifers were kept in both pastures after the forage had dried. For the remaining 6 years, except 1955, only Pasture 2 received additional grazing (varying from 180 to 680 heifer-days) after the green-forage period each year, to adjust its grazing use to that of Pasture 1.

During the calibration period (1949 and 1950) the heifers in Pastures 1 and 2 showed average individual weight losses for the winter-forage period of 30 and 29.5 pounds, respectively, and average weight gains for the green-forage period of 156.5 and 155.5 pounds, respectively. Average weight variations for the various weigh periods are quite comparable, and the small differences are not significant. During this period the average number of ground squirrels in Pasture 1 was 95 compared to 210 in Pasture 2 (Table 1).

In 1951 and 1952 ground squirrels were present in Pasture 1 (average of 110) but removed from Pasture 2. During the winter-forage period for these two years the heifers in Pasture 1 (with squirrels) showed average weight losses of 24 and 9 pounds (average 16.5), respectively, while the heifers in Pasture 2 (no squirrels) made an average weight gain of 72 and 37 pounds (average 54.5), respectively. Thus, during this 2-year period, 1951-1952, the heifers in the squirrel-free pasture averaged 71 pounds greater gain (average greater daily gain of 1.03 pounds) than the heifers in the pasture that contained squirrels. The differences in heifer weights between pastures are significant at the 1 percent level. In the green-forage period the heifers in Pasture 1 made average gains of 116 and 138 pounds (average 127), respectively, as compared to 120 and 139 pounds (average 129.5), respectively, for the Pasture-2 heifers. These results are quite comparable.

From 1953 through 1956, ground squirrels were removed from Pasture 1 and allowed to return to Pasture 2. Unfortunately, the squirrel population did not build up again in Pasture 2, and the average population for the 4 years was only 51 squirrels, instead of the 210 present during the first 2 years of calibration. During the winter-forage period the Pasture-1 heifers showed average weight changes of +11, —18, —30, and —45 pounds (average —20.5), respectively, as compared to +22, —30, —41, and —38 pounds (average —21.7), respectively, for the Pasture-2 heifers. There was little difference between the 4-year average weight losses of the heifers in the two pastures.

In the green-forage period the heifers in Pasture 1 made average gains of 130, 135, 176, and 173 pounds (average 153.5), respectively, as compared to 130, 159, 189, and 223 pounds ( average 175.2), respectively, for the Pasture-2 heifers. Thus, in the first year of reversal of poisoning treatment of the pastures, the average weight gains in Pastures 1 and 2 were identical, whereas, in the 3 following years, the heifers in Pasture 2 (some squirrels) made greater average gains—24, 13, and 50 pounds (average 21.7), respectively. Reasons for these differences are not apparent.

**Table 3. Summation of pasture stocking, average heifer weights, and average weight gains and losses on the experimental pastures.**

| Pasture | Number of heifers | Winter Forage Period | | | Green Forage Period | | | Additional heifer-days of grazing to equalize grazing conditions | Number of squirrels |
|---|---|---|---|---|---|---|---|---|---|
| | | Weigh period | Average initial heifer weight lbs. | Average weight gain or loss lbs. | Weigh period | Average initial heifer weight lbs. | Average weight gain or loss lbs. | | |
| 1 | 10 | 2-25-49 to 3-29-49 | 573 | — 8 | 3-29-49 to 5-26-49 | 565 | +109 | 400 | 100 |
| 2 | 10 | 32 days | 566 | — 4 | 58 days | 562 | +113 | 400 | 220 |
| 1 | 10 | 1-6-50 to 3-2-50 | 541 | —52 | 3-2-50 to 6-4-50 | 489 | +204 | 310 | 90 |
| 2 | 10 | 55 days | 543 | —55 | 94 days | 488 | +198 | 310 | 200 |
| 1 | 12 | 12-5-50 to 3-8-51 | 520 | —24 | 3-8-51 to 5-2-51 | 496 | +116 | 0 | 120 |
| 2 | 12 | 93 days | 517 | +72* | 55 days | 589 | +120 | 480 | 0 |
| 1 | 10 | 2-5-52 to 4-7-52 | 557 | — 9 | 4-7-52 to 6-5-52 | 548 | +138 | 0 | 100 |
| 2 | 10 | 62 days | 554 | +37* | 59 days | 591 | +139 | 680 | 0 |
| 1 | 10 | 1-16-53 to 2-19-53** | 484 | +11 | 2-19-53 to 5-5-53 | 495 | +130 | 0 | 0 |
| 2 | 10 | 34 days | 488 | +22 | 75 days | 510 | +130 | 180 | 20 |
| 1 | 10 | 1-6-54 to 3-3-54 | 560 | —18 | 3-3-54 to 5-5-54 | 542 | +135 | 0 | 0 |
| 2 | 10 | 56 days | 561 | —30 | 63 days | 531 | +159 | 180 | 40 |
| 1 | 10 | 12-14-54 to 3-21-55 | 530 | —30 | 3-21-55 to 6-14-55 | 500 | +176 | 0 | 0 |
| 2 | 10 | 97 days | 530 | —41 | 85 days | 489 | +189 | 0 | 85 |
| 1 | 10 | 12-30-55 to 3-7-56 | 550 | —45 | 3-7-56 to 6-20-56 | 505 | +173 | 0 | 0 |
| 2 | 10 | 68 days | 550 | —38 | 105 days | 512 | +223 | 180 | 60 |

* Differences significant at the 1 percent level.

** Forage conditions were not as adverse in this period as in the other periods.

## Discussion

A number of complications developed with this experiment. The most serious one was that the original squirrel populations did not return when the pasture poison treatment was reversed in an attempt to rule out some of the inevitable differences in site conditions. It later developed that the size of Pasture 1 should not have been so drastically reduced after the first year.

In spite of the above shortcomings, the presence of squirrels on Pasture 1 in 1951 and 1952 did appreciably affect heifer weights during the winter forage period of inadequate green feed. The heifers on the squirrel-free pasture averaged a daily gain of 1.03 (1951) and 0.75 (1952) pounds more than did the heifers on the pasture containing squirrels. Expressing these data differently, for each squirrel that was destroyed in Pasture 2 in 1951, there was an increase of about 4.5 pounds of heifer weight during the winter forage period; in 1952 the increase per squirrel destroyed was about 2.2 pounds.

Comparing average squirrel populations and heifer gains during the 2-year calibration period, 1949-50, with those during the first poisoning period of 2 years, 1951-52, also shows the extent to which squirrel-poisoning increased heifer gains. The relative squirrel populations were changed by 225 squirrels; 210 were removed from Pasture 2, and the population increased 15 squirrels in Pasture 1 (Table 1). For the total grazing season the heifers gained an average of 74 pounds more in the poisoned pasture than in the pasture with squirrels, compared to equal gains during the calibration period when squirrels were in both pastures (Table 3). The in-

creased production in poisoned pasture equaled 33 pounds per heifer for every 100 squirrels that had been removed. This totals 330 pounds for the 10 heifers in the pasture.

The heifers in the poisoned pasture put on most of their greater weight during the winter season, when competition for the short vegetation was greatest between squirrels and heifers in the unpoisoned pasture. Gains during the green-forage season were not significantly affected by reduction of squirrel numbers, because ample forage was available in both pastures.

The increased cattle gain obtained by removing squirrels probably represents the major effect of squirrels during the entire year. During the summer and fall the squirrels mainly eat non-forage plants. However, they destroy some dry forage and take acorns that, under some conditions, would be valuable mast for cattle.

**Summary**

Two pastures, one of 32 and the other of 48 acres, were established at the San Joaquin Experimental Range in an attempt to measure the degree that ground squirrels *(Citellus beecheyi)* compete with livestock for green forage during the winter forage period, when feed is short and squirrels show greatest competition with livestock for the forage. Each year for 8 years, rodents were censused on the pastures, 10 heifers in each pasture were weighed at about monthly intervals, and the yield of mature herbaceous forage was determined. After 2 years of calibration, the squirrels were kept out of one pasture for 2 years. The pasture poisoning treatment was then reversed, and the squirrels were allowed to come back on the previously poisoned pasture. Unfortunately, the squirrels in the previously poisoned pasture never recovered to more than 40 percent of their former density.

The greatest effect occurred during the winter forage period of 1951 and 1952, when each heifer on the pasture without ground squirrels averaged 96 and 46 pounds, respectively, greater gain than the heifers on the pasture containing squirrels. This represents a greater daily gain of 1.03 and 0.75 pounds. Technique difficulties that were encountered are discussed. Results illustrate that the degree to which ground squirrels compete with cattle for forage on rangelands is highly variable from year to year.

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