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NATURE AND EXTENT OF MORMON CRICKET DAMAGE TO CROP AND RANGE PLANT
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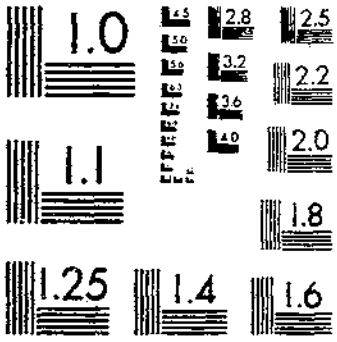

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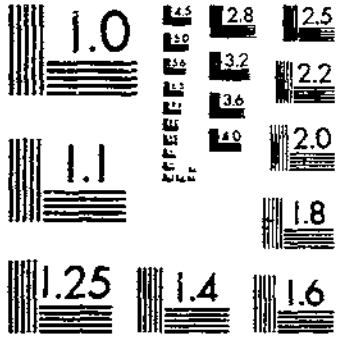

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Nature and Extent of Mormon Cricket Damage to Crop and Range Plants [1]

By RALPH B. SWAIN,[2] *Agent, Division of Domestic Plant Quarantines, Bureau of Entomology and Plant Quarantine, Agricultural Research Administration*

CONTENTS

INTRODUCTION

The Mormon cricket (*Anabrus simplex* Hald.) is economically the most important member of the subfamily Decticinae in the United States, having been a periodic menace to agriculture in the Northwest since the founding of the Mormon settlement of Salt Lake City in 1847. In 1939, 62,977 acres of crops were damaged by Mormon crickets, this total representing chiefly the crops in outbreak areas that did not receive protection because of isolation or because of noncooperation in control programs. Measurable damage to 4,821,954 acres of range land was reported by State supervisors of the Mormon cricket control project. A total of 19,074,900 acres of all kinds of land was infested by adults at the time of the 1939 fall survey.

These insects are flightless and gregarious, and from the time of hatching they move in bands, which may cover an area of from less than an acre to many square miles. A band frequently travels from 10 to 20 miles in the course of a season. There are normally 7 nymphal stages of the insect, the growth from newly hatched nymph to adult

[1] Submitted for publication June 21, 1943.

[2] General supervisor, Mormon cricket control project.

The writer is indebted to L. F. Byars, assistant supervisor, Mormon cricket control project, for aid in permanent-plot and sample-transect work in Nevada in 1939, and to all State and local supervisors who cooperated to make the damage surveys possible; also to C. Leo Hitchcock, of the University of Washington, Seattle; S. P. Doten, of the Nevada Agricultural Experiment Station, Reno; C. E. Favre, of the United States Forest Service Regional Office, Ogden, Utah; and to W. P. Cottam, of the University of Utah, and A. O. Garrett, both of Salt Lake City, for the privilege of using the herbaria at their respective institutions or for advice with regard to plant determinations.

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requiring from 60 to 90 days in the field. The adult female lays about 150 eggs, singly or in small groups, at depths of half an inch to an inch below the soil surface. Few adults live past the middle of October. The insect overwinters in the egg. A detailed account of the life history of the Mormon cricket, with descriptions and figures of all instars has been given by Cowan (*1*).[3]

Gurney has prepared descriptions and keys which will enable field workers to distinguish *Anabrus simplex* readily from the congeneric and other species with which it might possibly be confused.[4] *A. cerciata* Caudell and *A. longipes* Caudell are the only other forms of *Anabrus* considered valid by Gurney. *Peranabrus scabricollis* (Thos.), the coulee cricket, was the only member of the Decticinae other than the Mormon cricket of economic importance in 1939. In Washington and Oregon this species is locally abundant and capable of causing heavy damage to crops and range vegetation. The life history of this insect, which closely parallels that of the Mormon cricket, has been well described by Melander and Yothers (*2*). *Anabrus cerciata*, *A. longipes*, and *Peranabrus scabricollis* all occur within the range of the Mormon cricket. Their feeding habits are not known to differ from those of the Mormon cricket, and control measures applied against all of them are identical.

The range of Mormon crickets, as generally indicated in figure 1, extends from the Red River Valley in northwestern Minnesota southward into New Mexico and westward to the Sierra Nevada and Klamath Mountains of California and the Cascade Mountains of Washington and Oregon.

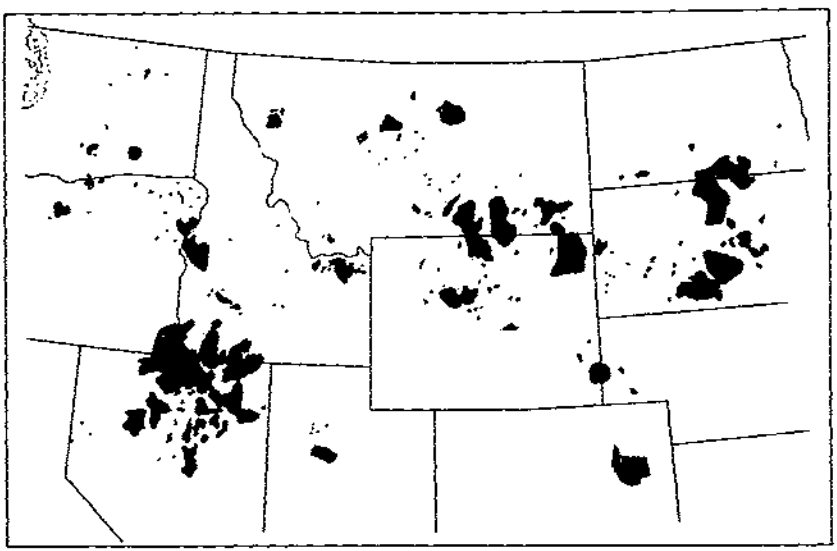

FIGURE 1.—Range of the Mormon cricket in the United States, 1939.

[3] Italic numbers in parentheses refer to Literature Cited, p. 44.

[4] GURNEY, A. B. AIDS TO THE IDENTIFICATION OF THE MORMON AND COULEE CRICKETS AND THEIR ALLIES (ORTHOPTERA: TETTIGONIIDAE, GRYLLACRIDIDAE). U. S. Dept. Agr., Bur. Ent. and Plant Quar. E-479, 11 pp., illus. 1939. [Processed.]

Mormon crickets occur as low as 300 feet above sea level along the Columbia River and as high as 13,000 feet in the Rocky Mountains. Early instars have been taken at 12,500 feet on Mount Evans in Colorado.

In 1938 and 1939 field studies of Mormon cricket damage to cultivated crops and range vegetation were carried on as a part of the control project. Their purpose was to determine, by field observations and damage surveys, the nature and economic importance of Mormon cricket injury. It was especially desirable to know more about the feeding behavior of the insect in order to gage the effect of the crickets on range vegetation, this effect having been described as both beneficial and detrimental. The intensive studies were made in Oregon, Idaho, and Nevada, where the largest and most critical outbreaks were located. The major infestations in Wyoming, Montana, South Dakota, Utah, and Nebraska were visited and briefly surveyed.

Erroneous opinions current in infested areas were that the cricket eats only every third day, that it "blights" hay or range vegetation through which it passes, that it sucks the life juices from plants, that it feeds only on harmful and nonforage species of range plants, and that it rids the range of other insects.

The status of an insect relative to the agricultural economy is never so important as in time of war, when a stricter account must be rendered of every expenditure for pest control. The results of these studies are presented with the hope that they may be helpful in arriving at a more exact evaluation of the Mormon cricket as a pest of crop and range plants.

NATURE OF INJURY TO CROP AND RANGE PLANTS

In the presence of a variety of green plants, the Mormon cricket exhibits definite food preferences, not only for certain species but also for certain plant parts. In the succeeding paragraphs the several types of injury to cultivated and range plants are discussed and illustrated.

Grasses and Grasslike Plants

The Mormon cricket, from first instar to adult, feeds on range grasses. No species is absolutely avoided, but some are seldom touched if other food is present. Two species usually left uninjured by Mormon crickets are the wheatgrasses *Agropyron smithii* and *A. dasystachyum*. Both have very coarse foliage. On the other hand, frequently 30 to 50 percent of *A. spicatum* is eaten. Perhaps the most preferred grass of all, particularly when it is very young, is downy chess (*Bromus tectorum*). When green, the foliage of this grass is frequently eaten to the ground.

In general, the inflorescence of grasses, and indeed of all plants, is most preferred as food by Mormon crickets. After grasses are in flower, the foliage is likely to escape serious injury except when there is a shortage of other suitable food.

FIGURE 2.—Mormon cricket injury to rye. Photographed in Washington County, Idaho, June 12, 1939.

FIGURE 3.—Mormon cricket feeding on the inflorescence of a tall species of bluegrass. Photographed at Elko, Nev., July 17, 1938.

Its desire to feed on the flowers and fruits of grasses and also to escape excessive ground heat leads the Mormon cricket to climb the culms of the plants. In many instances the culm is broken by the weight of the large insect. This type of injury seldom occurs to the wheatgrasses and giant wild-rye (*Elymus condensatus*)—coarse-stemmed species—but it is very noticeable in the bluegrasses, barley, timothy, and cultivated rye (fig. 2). An adult cricket feeding on the inflorescence of a bluegrass is shown in figure 3. All cultivated grasses in the Northwest are preferred food plants, a greater acreage of wheat being damaged than of any other crop.

Diffuse inflorescences, such as those of Idaho fescue and the witchgrass *Panicum capillare*, do not suffer so much flower or fruit injury as the compact ones of *Elymus condensatus* and *Agropyron spicatum*.

Very severe injury to *Agropyron spicatum* is illustrated in figure 4.

FIGURE 4.—Severe Mormon cricket injury to bluebunch wheatgrass (*Agropyron spicatum*). Photographed at Warmsprings, Oreg., May 3, 1939.

In this instance bluebunch wheatgrass was almost the only available food in a burned-over area of several acres. Owing to severe local drought, the annual bromes and fescues, which would normally have formed upwards of 90 percent of the plant cover, did not germinate. A particularly heavy infestation of crickets caused the injury shown to the scattered clumps of wheatgrass. The year's seed crop was completely lost, as was at least 75 percent of the cattle and horse forage. Such range-grass injury is unusual and not to be expected over large areas, except during severe drought in desert shrub or bunchgrass areas. In tall grass and in mixed prairie grasses cricket injury is almost confined to the inflorescences after the flowering season begins.

Since injury to the grasslike plants, such as species of *Scirpus*, *Carex*, and *Juncus*, is so like that to grasses, it will not be described separately. Some of these plants, for example *Juncus balticus*, are preferred food plants.

Weeds, Cultivated Legumes, and Garden Crops

Weeds appear to be the class of range plants most preferred by the Mormon cricket, evidently because of their usually greater succulence. They make up 65 percent of the food-plant list (p. 34). The foliage and flower stems of the common dandelion and the tender and perhaps tasty stems and leaves of many umbellifers, *Sisyrinchium* spp., and *Tragopogon* spp., may be sought out and perhaps eaten completely, whereas grasses in the same area may be almost undamaged.

As the floral parts are preferred, large-flowered species are usually more conspicuously damaged than others. A Mormon cricket band can often be trailed through desert-shrub and bunchgrass vegetation if the damaged flower heads of the lupines and balsamroot are noted. Practically all the crucifers in cricket-infested territory are among the most preferred food plants. Worthy of mention are tumblemustard (*Sisymbrium altissimum*), pennycress (*Thlaspi arvense*), shepherds-purse (*Capsella bursa-pastoris*), and the peppergrasses (*Lepidium* spp.). The destruction of the flowers and fruits

Figure 5.—Mormon crickets feeding on foliage of *Balsamorhiza sagittata*. Photographed at Mountain City, Nev., August 13, 1938.

of some species of small annuals is so thorough that they may be completely destroyed over small areas.

Mormon cricket injury to balsamroot, a valuable forage plant in bunchgrass and northern desert-shrub regions, is illustrated in figure 5. The flowers of the plant were destroyed early in the season, and the insects are removing the remaining green foliage.

Alfalfa is a choice food plant and ranks second to wheat as the crop that received the most Mormon cricket damage in 1939. At the time of flowering or fruiting the inflorescences are more severely injured than the foliage, but plants are sometimes reduced to stubble (fig. 6).

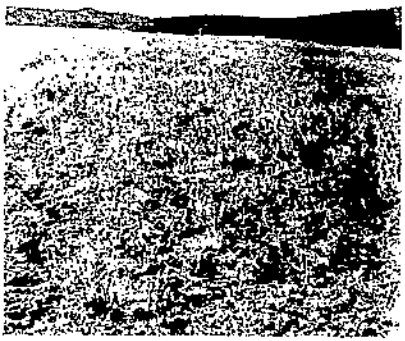

FIGURE 6.—Mormon cricket injury to alfalfa. Photograph of a 120-acre field in Washington County, Idaho, June 12, 1939.

The small garden plots on ranches in the Northwest are usually completely destroyed if bands of crickets enter them. All the garden plants commonly grown seem to be preferred over most range species. Figure 7 shows the injury done to a potato field in a few hours by an invading band of crickets before the destruction was halted by fencing

FIGURE 7.—Mormon cricket injury to a potato field. Photographed at North Fork, Nev., July 25, 1938.

and dusting operations. Figure 8 shows a cricket feeding on badly damaged sweet corn.

FIGURE 8.—Mormon cricket injury to corn. Photographed at Mountain City, Nev., August 13, 1938.

BROWSE PLANTS AND FOREST AND SHADE TREES

The Mormon cricket does not confine its feeding to grasses and weeds. Shrubs and even trees are attacked. Not only deciduous trees, but evergreens as well, are sometimes damaged.

The foliage of chokecherry (*Prunus melanocarpa*), snowberry (*Symphoricarpos* spp.), and rubber rabbitbrush (*Chrysothamnus nauseosus*) apparently are preferred food, but foliage of bitterbrush (*Purshia tridentata*) was never found to be eaten, although the flowers and fruits were. The sagebrush *Artemisia tridentata* is frequently attacked, probably because it is present almost everywhere in the Great Basin and late in the season may be the only green food available. The softer foliage of *A. frigida* and *A. gnaphalodes*, however, is more acceptable as food than that of *A. tridentata*.

Artemisia tridentata occasionally exhibits a peculiar type of injury. The soft covering of the new growth of twigs may be eaten through to the cambium. Girdling then frequently occurs and the twigs quickly

dle. *Chrysothamnus nauseosus* and *Philadelphus lewisii* are sometimes similarly damaged.

Mormon crickets are shown feeding on *Letomisia viridulata* in figure 9 and on *Prunus melanocarpa* in figure 10.

FIGURE 9.—Mormon crickets feeding on sagebrush. Photographed at Elko, Nev., July 19, 1938.

FIGURE 10.—Mormon crickets stripping foliage from chokecherry. Photographed at Halfway, Oreg., August 10, 1938.

In 1938 slight cricket injury to a seedling ponderosa pine in a permanent observational plot in the Whitman National Forest, Halfway, Oreg., was recorded. In 1939 about a dozen small and medium-sized trees in the vicinity of the plot were conspicuously damaged. The area was one of exceptionally heavy cricket damage. If more green herbage had been available, this injury to conifer foliage would probably have been negligible. Figure 11 shows a tree 12 feet high which

FIGURE 11.—Ponderosa pine 80 percent defoliated by Mormon crickets. Photographed at Halfway, Oreg., July 25, 1939.

was 80 percent defoliated by the insects. Mature needles were found to be eaten more readily than the highly resinous growing needles of the branch tips.

Poplars of several species, the largest of the deciduous trees in the regions most seen by the writer, are sometimes damaged. Usually the trees receiving the greatest injury are isolated and furnish the only shade over considerable territory. Crickets, in their desire to escape the heat of the soil surface, may linger for days on the lower branches and trunk, feeding from time to time on the leaves.

A dense stand of snowberry (*Symphoricarpos* sp.) totally defoliated by crickets is shown in figure 12.

FIGURE 12.—Mormon cricket injury to *symphoricarpos*. Photographed at Halfway, Oreg., July 25, 1939.

Mormon Cricket Injury Contrasted With a Type of Grasshopper Injury

It was not necessary to distinguish grasshopper injury from Mormon cricket injury in Nevada, Idaho, Utah, or Oregon in 1938 or 1939, since grasshoppers were present in insignificant numbers in the cricket-infested areas studied in those States. Mormon cricket areas in South Dakota, Montana, and Wyoming, however, frequently had grasshopper populations as great or greater than those of the crickets. This naturally complicated the task of determining the degree of Mormon cricket injury to either field crops or range vegetation.

Extreme damage to crops by grasshoppers can hardly be distinguished from that by Mormon crickets. Where a field of alfalfa has been reduced to stubble it is impossible to say which insect was responsible. During the period from June 25 to July 10, 1939, however, many grasshopper-damaged grain fields in northwestern Wyoming and south-central South Dakota exhibited a type of injury strikingly different from that caused by Mormon crickets. This injury, in wheat for example, consisted of the removal of the leaf blades and upper parts of the leaf sheaths, leaving the culms intact and the nodes exposed. The heads were usually uninjured. The writer has not observed that the Mormon cricket injures wheat in the manner just described. The insect in all stages shows a definite preference for the flowers and fruits of its food plants.

In figure 13 a typical example of Mormon cricket injury to wheat and an example of the type of grasshopper injury being discussed

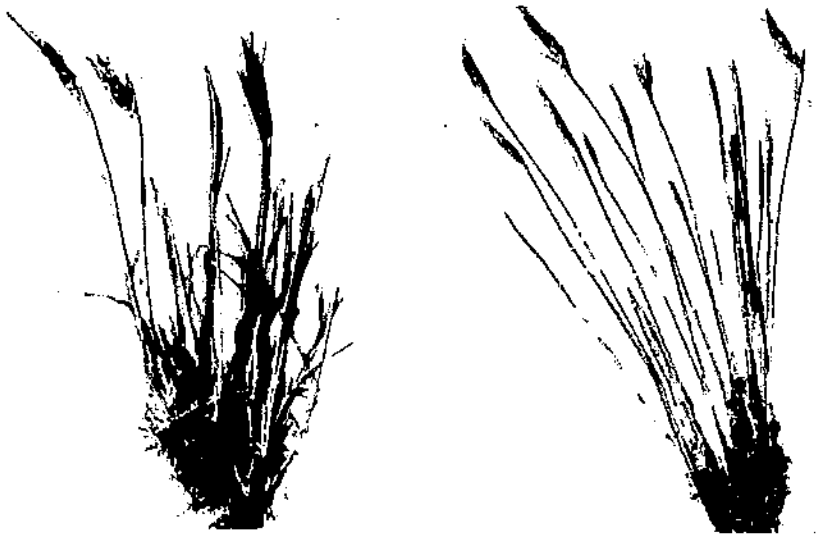

Figure 13.—Mormon cricket injury to wheat plants (left) as contrasted with grasshopper injury (right). Photographed in Wyoming, June 1939.

are shown side by side. Note the injury or entire removal of the heads of the plant on the left, the absence of injury to the heads of the plant on the right, and the great difference in the volume of foliage.

The type of grasshopper injury here described is believed to be correlated with the age and, perhaps, concentration of the insects. Very severe damage to cereal crops due to the cutting off of the entire inflorescence at a point shortly below its base is reported as frequently occurring later in the season when the grasshoppers are largely mature and when this portion of the plant possibly is the most attractive from the standpoint of water content.

No statement in this description of one type of grasshopper feeding has been intended to minimize the destructiveness of grasshoppers. In the area where the observations were made grasshopper injury far exceeded cricket injury. Grasshopper injury of the type just described was found on some of the native grasses in the area, especially the bluegrasses and bromes, whose leafless stems and whole heads marked them as having been injured by grasshoppers and not by crickets.

PREDACEOUS HABITS OF THE CRICKET

Probably Thomas (7), in 1872, first reported the Mormon cricket as a predator. He described the insects as seizing cicadas in sagebrush and devouring them. The fact that occasionally a cricket has been seen feeding on a grasshopper has evidently given rise to the rather widespread belief that Mormon crickets drive grasshoppers out of some range areas. The writer has seen the insects together in both comparable and very unequal numbers, with no sign of antagonism between them. In Humboldt County, Nev., numbers of adult Mormon crickets were observed eating small black aphids thickly clustered on the foliage of sagebrush. Possibly the crickets were merely tasting the honeydew exuded by the aphids; at least, it seemed that the crickets were not deliberately feeding on the aphids, but that in biting and tasting the leaves of the sagebrush they were consuming a few aphids.

The data collected on the food habits of the Mormon cricket demonstrate beyond question that the insect is a general plant feeder, with a strong tendency toward cannibalism, chiefly where incapacitated individuals are concerned, and a lesser tendency toward preying on other insect species.

METHODS OF GAGING CRICKET INJURY TO RANGE VEGETATION

Cricket injury to cultivated crops is relatively easy to determine and express as a weight or monetary loss, because each crop consists of plants of one species, height, and density. With range vegetation the plant cover is made up of many species and classes, from grasses, weeds, and shrubs to forest trees, some of great and some of little or no value as forage. Obviously, qualitative as well as quantitative methods of damage survey must be employed.

During the field season of 1938, 28 permanent observational plots one-tenth acre in size were staked out in Mormon cricket areas in eastern Oregon, southern Idaho, and northeastern Nevada. The plots were square, unfenced, and located either where cricket feeding was already proceeding or where a cricket band was thought likely to

pass. Another factor taken into consideration in selecting the permanent plots was the effect of grazing by livestock upon the determination of cricket injury to vegetation. Where possible, the plots were on land fenced against cattle, on rights-of-way, or on national-forest land.

In each plot 10 or more plants of about as many different species were marked with metal stakes and labels. The plots were visited at intervals of about 10 days, and records on the following were kept for each staked plant: Date of observation, height of plant, stage of development, percentage-volume injury to the entire plant and to the inflorescence, damage increase since the last observation, new growth since the last observation, and numbers of crickets and grasshoppers per square yard. Notes were made on damage to all vegetation in the plot, whether by crickets, livestock, rodents, or other insects. In some plots a complete photographic record was kept of the growth of staked plants and of cricket injury to them.

During the field season of 1939 observations were made on the plots utilized in 1938 and on one new plot, but visits to them were spaced at shorter intervals. Spot observations were largely replaced by what was felt to be a better way of determining cricket feeding. This was to run a transect of 10 point-observation plots through a cricket-damaged portion of a single vegetation type, each of these plots to be 100 square feet in area. Cricket feeding was much easier to determine for a series of small plots than for a single tenth-acre plot. The phrase "vegetation type" is here used in a range-management sense. For use in grazing surveys the United States Forest Service and other interested agencies have adopted a group of terms with corresponding numerals, 18 in all, to designate the various general kinds of vegetation.[5] For example, type 1 on a grazing-survey map indicates grassland, type 4, sagebrush land, and so forth. These types are recognized by physical aspect. It is customary to indicate the 2 or 3 most important plant species present in the type in order of their dominance.

In the running of transects sites were chosen within the boundaries of a vegetation type so that the plant cover could be characterized by the use of a regular type number and a list of the three dominant species. Transects were run in the following manner: An initial plot was laid out by driving a metal stake into the ground and marking a circle around it with a spike attached to the stake by a cord 5.65 feet long. The area enclosed in this circle was exactly 100 square feet. A distant object was then sighted in a selected direction, and the second plot located by pacing 1 chain (66 feet) toward the chosen object and again driving the metal stake and describing the circle. This procedure was repeated until 10 plots had been located.

In both the permanent plots and the transects cricket feeding could be determined in terms of loss in seasonal forage production and loss in total dry weight of herbage. The two methods of determination, together with a description of the ways in which they were adapted for use in the large plots and the point-observation plots, are described in the succeeding section.

[5] UNITED STATES FOREST SERVICE. INTER-AGENCY RANGE SURVEY COMMITTEE. INSTRUCTIONS FOR RANGE SURVEYS, AS FORMULATED BY THE INTER-AGENCY RANGE SURVEY COMMITTEE AND ADOPTED BY THE WESTERN RANGE SURVEY CONFERENCE, APRIL 21, 1937. 30 pp. 1937. [Processed.]

Determination of Mormon Cricket Feeding in Terms of Loss in Seasonal Forage Production

Field observations on the feeding habits of Mormon crickets during the spring of 1938 indicated that injury to plants was of a purely mechanical nature, resulting in the actual removal of portions of the plant tissue, and that, in general, it commenced at the peripheries, leaf tips, or inflorescences and proceeded toward the centers or lowest above-ground portions of the plants. The resemblance of at least the more severe cricket injury to the results of grazing suggested that perhaps methods already developed for estimating forage production and its consumption by livestock might be of service in the present instance. The purpose of the following discussion is to show how the range survey may be useful as a means of roughly and rapidly estimating cricket damage to forage.

"Forage" as a range-management term is considered to be that portion of the vegetation which is available to, and usable by, livestock. "Grazing capacity" (the maximum number of livestock which any range unit will support each season over a period of years without injury to the range and other related land uses and services) is obviously dependent on the available forage.

The range survey includes the determination of the grazing capacities of vegetation types. It requires the listing of all forage species present within a type and their respective percentages of the plant composition, as well as estimation of the density of the type. These are the only data collected in the field with respect to vegetation.

To compute the available forage for the type, the percentage compositions of the plant species are multiplied by their respective proper-use factors and the products added. This sum is then multiplied by the density estimate. The "proper-use factor" of a plant species is the percentage of the total current year's growth within reach of livestock that is consumed when the ranges are properly grazed. These factors are average figures, determined by tedious observation and experiment, and published in tabular form for use in range surveys by the United States Forest Service, the Division of Grazing of the Department of the Interior, and cooperating Federal and State agencies.

The procedure for computing grazing capacities is not the concern of this paper. It is described in a mimeographed pamphlet issued by the Forest Service and other agencies. In this study it is followed only so far as to determine the available forage. The necessary field data are those which would be collected in an ordinary range survey with the addition of estimates of the average percentage consumption by Mormon crickets of each major species of forage plant in the vegetation type examined. Since in the present instance cricket feeding is to be compared with livestock grazing on the same area, density need not enter into the computation.

Table 1 shows the type of data obtained in field observations and their use in computing the loss of forage due to cricket feeding.

TABLE 1.—*Mormon cricket damage to a tenth-acre range plot in terms of relative seasonal forage loss for cattle and horses and for sheep and goats, Elko County, Nev., 1938*[1, 2]

Forage species present	Percentage composition	Proper-use factor (cattle and horses)	Herbage available to cattle and horses (2)×(3)	Proper-use factor (sheep and goats)	Herbage available to sheep and goats (2)×(5)	Percentage consumption by crickets	Herbage taken by crickets (2)×(7)	Forage left for cattle and horses (4)−(8)	Forage left for sheep and goats (6)−(8)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Poa nevadensis	5	80	4.00	60	3.00	10	0.50	3.50	2.50
Poa secunda	5	45	2.25	40	2.00	50	2.50	------	------
Oryzopsis webberi	5	55	2.75	50	2.50	50	2.50	.25	------
Sitanion hystrix	10	20	2.00	20	2.00	35	3.50	------	------
Stipa thurberiana	5	60	3.00	40	2.00	35	1.75	1.25	.25
Phlox canescens	5	10	.50	10	.50	5	.25	.25	.25
Artemisia tridentata	40	10	4.00	10	4.00	0	0	4.00	4.00
Chrysothamnus viscidiflorus	25	10	2.50	10	2.50	0	0	2.50	2.50
Total	100	.....	21.00	.....	18.50	.....	11.00	11.75	9.50

[1] Cattle and horse forage taken by crickets=sum of column 4 minus sum of column 9=21.00−11.75=9.25. Forage available to cattle and horses that was taken by crickets=$\frac{\text{forage taken by crickets}}{\text{forage available to cattle and horses}}=\frac{9.25}{21.00}$=44 percent. Sheep and goat forage taken by crickets=sum of column 6 minus sum of column 10=18.50−9.50=9.00. Forage available to sheep and goats that was taken by crickets=$\frac{\text{forage taken by crickets}}{\text{forage available to sheep and goats}}=\frac{9.00}{18.50}$=48.6 percent.

[2] To George Stewart and S. S. Hutchings, Intermountain Forest and Range Experiment Station, Ogden, Utah, and to W. R. Chapline, Division of Range Research, United States Forest Service, the writer is obliged for advice with regard to the form of this table and for criticism of the description of the determination of seasonal forage-production loss.

The percentages of cricket consumption are derived from ocular estimates of the reduction in volume of individual mature plants. Estimates for a plant species are made by multiplying the estimated percentage of plants exhibiting cricket injury by the average percentage consumption of individual plants. Intensive practice in estimating the consumption of individual plants is necessary before reasonable accuracy can be achieved. Comparisons of injured and uninjured plants of the same stage of development and of about the same original size are necessary. Such plants can usually be found within a very small area at the point of observation. Estimates may also be roughly checked by weighing with a hand scale equal numbers of injured and uninjured plants, and comparing the percentage difference in weights with the percentage consumption estimate made ocularly. Consumption estimates were held to the nearest 5 percent. Removal of an estimated 1 or 2 percent of the volume of a plant was considered a trace of injury and was not considered in consumption calculations. The ocular method hardly permits estimates at smaller than 5-percent intervals. Proper-use factors vary by intervals of five. It is of course convenient to have consumption estimates and proper-use factors coincide in this respect. These methods and others, as they are applied to studies of range-grass consumption, have been described and compared by Pechanec and Pickford (*4*). As no density estimates were taken, the figures presented are relative values, and, as

such, are useful in showing percentage losses resulting from cricket injury.

Since cattle and horses differ from sheep and goats in the degree to which they consume a given plant species under proper range management, there are two sets of proper-use factors. The relative amounts of forage available to these two classes of livestock under proper grazing have been found by multiplying the percentage compositions of the various plants by their respective proper-use factors. The totals of columns 4 and 6 are these relative amounts. The comparative amount of herbage taken by Mormon crickets is the total of column 8, the figures of which were obtained by multiplying the percentages of composition of the plant species by the respective percentage of consumption.

The amounts of forage remaining for livestock after Mormon cricket feeding are the totals of columns 9 and 10, which were obtained by subtracting the weighted cricket consumption estimates of column 8 from the figures of columns 4 and 6. The difference between the amount of forage remaining for livestock and the total forage originally available is the amount of forage eaten by the crickets. The percentage of forage destroyed by crickets is computed by dividing the cricket consumption by the total forage. These are 44 percent for cattle and horses and 48.6 percent for sheep and goats. The proper-use factors of the table were taken from Proper Use Factor Table, Nevada District No. 1, approved tentatively by the United States Forest Service and other agencies at Reno, Nev., in September 1938.

The tenth-acre plot for which the figures of table 1 are given was established about 35 miles northwest of Elko on the Stewart ranch, Elko County, Nev., June 17, 1938. The vegetation type was shrub with *Artemisia tridentata* and *Chrysothamnus viscidiflorus* the dominant species. Mormon crickets are believed to have been continuously present in the plot from June 1 to 27, at average concentrations of about five per square yard.

The estimate of Mormon cricket damage to forage plants derived by the reconnaissance-survey method does not present the entire picture of the destruction to the total herbage on a range unit. It fails in two respects. First, damage to nonforage species, which occasionally make up a very large proportion of the plant density, is not shown by this method. Second, consumption by crickets exceeding the proper-use factor for livestock is not reflected in the percentage of forage destruction. However, for the purpose of evaluating cricket damage to livestock forage this may prove a fairly reliable and useful field method.

The method just described was used without modification in the case of the permanent tenth-acre plots, each plot being treated as a large unit. The estimation of consumption of seasonal forage production on a 10-plot transect required special methods of gathering data and of calculation. A sample sheet of field data from a transect is shown in table 2. The percentage composition and estimated percentage consumption are recorded for each species in each plot of the transect. In performing the calculation to determine the seasonal forage-production loss, the average percentages of composition and consumption for the 10 plots were used. It was felt that averages could be used, since each transect was confined to a single vegetation type, and, in most cases, to vegetation of rather uniform density.

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TABLE 2.—*Composition transect,*[1] *field data on consumption of seasonal forage production by Mormon crickets*

[State: Utah. County: Tooele. Locality: Little Valley, Vernon. Date: 5-15-39]

VEGETATION TYPE: SAGEBRUSH, ARTEMISIA—VICIA—ASTRAGALUS

Species	Plot number																				Average Composition	Average Consumed
	1		2		3		4		5		6		7		8		9		10			
	Composition	Consumed	Composition	Consumed	Composition	Consumed	Composition	Consumed	Composition	Consumed	Composition	Consumed	Composition	Consumed	Composition	Consumed	Composition	Consumed	Composition	Consumed		
	Pct.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
Agropyron dasystachyum	T	0																			T	0
Bromus tectorum											10	10	T	30	T	50			T	30	1.0	30
Poa sp	5	0	15	0	40	T	10	T	25	T	10	T	20	T	15	T			T	T	14.0	T
Sitanion hystrix															T	5			T	5	T	5
Agoseris sp	T	T													5	0	T	0	T	0	.5	T
Aplopappus acaulis													T	30							T	30
Astragalus beckwithii	T	10			10	T	20	5	40	5			10	5	70	5					15.0	50
Balsamorhiza sagittata			T	30	T	10															T	20
Cirsium sp																	T	20			T	20
Lomatium sp									T	20			T	50			T	10			T	26.6
Collinsia parviflora			5	50	T	50	T	50	T	50	T	50							T	50	.5	50
Erigeron sp					T	T															T	T
Lupinus caudatus	5	T			5	T	30	T			50	T			10	T	5	0	10	T	11.5	T
Microseris nutans			5	20	T	20											T	50			.5	30
Phlox longifolia	T	5					T	5	5	0	T	10									.5	6.6
Tragopogon pratensis			5	0	T	0	10	0	T	0									T	0	1.5	0
Vicia americana	65	5	70	5													80	5	20	10	23.5	6.2
Amelanchier alnifolia									5	T			20	T	T	T					2.5	T
Artemisia tridentata	25	0			45	0	30	0	25	0	30	0	50	0			10	0	50	0	26.5	0
Chrysothamnus viscidiflorus			T	0					T	0							5	0	20	0	2.5	0

[1] T=trace.

Determination of Mormon Cricket Feeding in Terms of Loss in Total Dry Weight of Herbage

Certain shortcomings of the method of measuring seasonal forage-production losses, described in the preceding section, have been enumerated. Chief among them were the facts that injury to species having proper-use factors of zero and that the volume of herbage remaining after proper use do not figure in the calculations. On the other hand, the advantages of being able to determine Mormon cricket destruction of that portion of the total forage which would be consumed under proper grazing conditions as distinct from injury to total herbage have been pointed out. The need was felt during 1938, however, for some means of determining rapidly in the field the amount of cricket damage to the total plant cover on a given area in as nearly a quantitative manner as possible. Such a determination may not be quite so valuable to the rancher as a forage loss estimate, but it provides basic data on Mormon cricket food habits, and may furnish the evidence needed to show whether Mormon cricket feeding can be a factor of importance in influencing changes in plant composition, density, or, indirectly, soil erosion.

The method which, after some consideration, seemed most suitable for the purposes of a field survey was that of "weight estimate." It has been described by Pechanec and Pickford (*5*). This paper compares the square-foot-density method with the weight estimate, and demonstrates convincingly that the latter is more accurate. Perhaps the greatest advantage of the weight-estimate method is that forage-production estimates are subject to checking by means of a hand scale.

The weight-estimate method is adaptable to the point-observation-plot (square-foot density) system of range survey. In the present work it was used in making field transects of 10 point-observation plots each and for tenth-acre plots. Since the terms "plant weight" and "plant volume" are ordinarily used interchangeably in reconnaissance-survey work, ocular estimates of percentage consumption are the same, whether weight or volume is being considered.

The method consists of listing all the plant species on a given area and recording the total weight of the plants of each species. For the purposes of this survey, weight estimates were made to the nearest 5 grams. A small hand scale calibrated at 10-gram intervals up to 250 grams was carried at all times when weight estimates were being made. During the training period, all the plants of a species on a 100-square-foot area were frequently clipped at ground level and weighed in No. 10 paper sacks. Facility in accurately estimating the weight of herbage in a small plot, even after Mormon cricket (or grazing) consumption has occurred to various degrees, is gained with surprising speed.

It was necessary, besides listing all the plant species and their total weights, to record the percentage consumption by Mormon crickets of

each species. In order to determine the actual loss in grams of herbage on a given area due to cricket feeding, the weight of herbage present before feeding commenced must be calculated. The following equation is found in the paper by Pechanec and Pickford (*3, p. 902*):

$$\frac{\text{Weight herbage remaining} \times 100}{100 - \text{percentage utilization by weight}} = \text{yield on the area if herbage was ungrazed}$$

With the data collected in the field and the calculated weight of herbage originally present on a plot, the grams of herbage, and, of course, the percentage of the total weight taken by Mormon crickets, can be calculated.

Because of the variation in the green weight of plants during the season, it was thought advisable to put the work on a dry-weight basis. For this reason, a sample of each species (exceeding 200 grams wherever possible) was clipped and placed in a sack, and the green weight, date, and locality were recorded. Such green-weight samples were taken wherever weight estimates were made in new localities, and they were taken at 2-week intervals throughout the season where weight estimates in one locality were being repeated. By the end of the season all the samples were thoroughly air-dried and were again weighed. The dry weight divided by the green weight gave a factor which was used in converting all the green weights recorded on field-data sheets to dry weights.

In estimating the green weight of herbage in the tenth-acre plots, it was found necessary to divide the large plot into smaller ones. This was done by means of a cord 1 chain long with a spike at each end. Two such devices were used in dividing the plot into five or more subdivisions of a more satisfactory size for the purpose of weight estimates. The weights of the same species in all the subdivisions were added to give a total plot weight. Consumption estimates were made for the plot as a whole.

The final estimates of percentage consumption were made toward the end of the season; that is, between July 20 and August 15. By this time many plants were showing volume losses due to agents other than crickets. For this reason a distinction was made between total consumption (i. e., that by all agents) and consumption by Mormon crickets. Notes on both had been made continuously during the season.

Table 3 shows how plot data were arranged in order to calculate the percentage dry-weight loss due to Mormon cricket feeding. The values in column 6 were calculated from the estimated percentages of consumption of all agents. The percentages of consumption by Mormon crickets were then used in calculating the grams of dry herbage removed.

TABLE 3.—*Mormon cricket damage to a tenth-acre range plot in terms of loss in dry weight of herbage*[1]

[Plot No. M-2. Location: Mountain City, Nev. Date: 7-28-39 Vegetation Type: Perennial weeds]

Forage species occurring in the plot	Green weight[2]	Dry weight[2]	Consumption damage by all agents[2]	Consumption by Mormon crickets[2]	Dry weight of all herbage if no consumption had occurred[2]	Dry weight taken by crickets[2]	Conversion factor—green weight to dry weight
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Grams	*Grams*	*Percent*	*Percent*	*Grams*	*Grams*	
Agropyron spicatum	1,230	984	7.51	0	1,064	0	0.800
Bromus carinatus		10	T	0	10	0	
Bromus tectorum		205	T	T	205	T	
Elymus condensatus	240	120	60.00	0	300	0	.400
Festuca idahoensis	140	97	17.09	0	117	0	.878
Melica bulbosa	T	T	0	0	T	0	
Poa spp		380	26.92	T	520	T	
Sitanion hystrix		140	16.16	T	167	T	
Stipa lettermani	70	53	56.55	T	122	T	.750
Achillea lanulosa		50	T	0	50	0	
Agoseris tarazacifolia	T	T	0	0	T	0	
Arabis sp.	T	T	10.00	10.00	T	T	
Aster leucanthemifolius	30	15	0	0	15	0	.500
Balsamorhiza sagittata	4,800	3,441	47.96	30.00	6,612	1,843	.643
Crepis acuminata		10	15.00	15.00	12	2	
Eriogonum heracleoides	640	338	T	T	338	T	.528
Eriogonum proliferum	70	53	T	0	53	0	.750
Gayophytum diffusum	T	T	0	0	T	0	
Geranium viscosissimum	155	109	T	0	109	0	.372
Helianthella uniflora	975	551	7.01	T	586	T	.568
Lappula floribunda	85	58	6.45	5.00	62	3	.682
Lupinus caudatus	2,560	1,461	42.45	5.00	2,511	127	.572
Mertensia foliosa	0	T	0	0	T	0	
Navarretia breweri		5	0	0	5	0	
Phlox stansburyi		T	T	T	T	T	
Polygonum douglasii	405	270	0	0	270	0	.667
Senecio integerrimus		T	T	T	T	T	
Unknown umbellifer	T	T	T	T	T	T	
Viola nuttallii		T	0	0	T	0	
Wyethia amplexicaulis	1,555	588	19.23	T	728	T	.378
Artemisia gnaphalodes	100	33	0	0	33	0	.326
Chrysothamnus viscidiflorus	3,510	1,873	0	0	1,873	0	.529
Symphoricarpos rotundifolius	315	232	5.00	5.00	244	12	.673
Total		10,845			15,539	1,957	

[1] Dry weight of plot herbage taken by crickets / Calculated dry weight of herbage originally on plot = 12.59 percent of dry weight of plot herbage taken by crickets.

[2] T=trace.

The transect type of range survey was particularly well adapted to the weight-estimate method. Data collected in the field were placed on a form (table 4). It was necessary to average percentage consumption estimates, but this was done after converting them into grams of loss in dry weight; hence, they were true averages. Table 5 shows how data from the field sheets were arranged in order to determine the percentage loss of plot herbage. Transects were almost exclusively used in areas where the only plant consumption was by Mormon crickets. When no distinction needs to be made between the injury of Mormon crickets and other destructive agents, several steps in the calculation of herbage loss are saved.

TABLE 4.—*Weight-estimate transect—field data* [1]

[State: Idaho. County: Clark. Locality: Spencer. Date: 7-14-39]

VEGETATION TYPE: MEADOW, MELILOTUS—PHLEUM—LITHOSPERMUM

Species	Plot number																			
	1		2		3		4		5		6		7		8		9		10	
	Weight	Consumption	Weight	Consumption	Weight	Consumption	Weight	Consumption	Weight	Consumption	Weight	Consumption	Weight	Consumption	Weight	Consumption	Weight	Consumption	Weight	Consumption
	Gm.	*Pct.*	*Gm.*	*Pct.*	*Gm.*	*Pct.*	*Gm.*	*Pct.*	*Gm.*	*Pct.*	*Gm.*	*Pct.*	*Gm.*	*Pct.*	*Gm.*	*Pct.*	*Gm.*	*Pct.*	*Gm.*	*Pct.*
Agropyron smithii			40	0							180	0								
Agrostis alba											25	0	450	0	15	0				
Bromus sp																			10	0
Hordeum jubatum			T	0	20	0					25	0								
Hordeum nodosum			70	0							300	0								
Phleum pratense	180	T	35	0	180	0	25	0	90	0	1,020	0	450	0	500	T			230	T
Achillea lanulosa	390	T																		
Capsella bursa-pastoris			5	10	100	90														
Chenopodium album			30	T	120	0			T	0			5	T	35	10	40	50		
Epilobium sp					65	0							T	0						
Equisetum sp					T	T														
Helianthus annuus			275	0	170	0			10	0					20	0			25	0
Iva axillaris							110	0					T	0	T	0				
Lithospermum sp													20	0	20	0	30	0	3,500	0
Medicago sativa	40	60					130	5	60	30										
Melilotus alba	1,120	5	600	T	250	T	1,500	0	1,000	0			160	0	230	0	350	0	60	0
Orthocarpus luteus			190	T																
Polygonum aviculare	T	45	330	5	300	T							140	T	45	0	600	T		
Potentilla sp											30	0								
Taraxacum officinale	400	80			200	80	700	25	1,000	20	5	0								
Thlaspi arvense	T	30			150	20									5	20	120	30		
Rosa sp											90	0								

[1] T=trace.

TABLE 5.—*Average Mormon cricket damage to 10 plots of 100 square feet each in terms of loss in dry weight of the total current year's herbage production*[1, 2]

[Spencer, Clark County, Idaho—7-11-39]

Plant species present	Average dry weight	Average consumption by Mormon crickets	Calculated dry weight of herbage originally present	Average dry weight taken by crickets
	Grams	*Percent*	*Grams*	*Grams*
Agropyron smithii	8.6	0	8.6	0
Agrostis alba	16.9	0	16.9	0
Bromus sp	.4	0	.4	0
Hordeum jubatum	1.7	0	1.7	0
Hordeum nodosum	11.8	0	11.8	0
Phleum pratense	90.2	T	90.2	T
Achillea lanatosa	16.3	T	16.3	T
Capsella bursa-pastoris	3.8	89.36	36.6	32.8
Chenopodium album	4.8	16.05	5.7	.9
Epilobium sp	1.5	0	1.5	0
Equisetum sp	T	T	T	T
Helianthus annuus	8.6	0	8.6	0
Iva axillaris	3.3	0	3.3	0
Lithospermum sp	71.6	0	71.6	0
Medicago sativa	6.3	28.79	8.8	2.5
Melilotus alba	186.9	.66	182.2	1.2
Orthocarpus luteus	3.9	T	3.9	T
Polygonum aviculare	39.9	.83	40.2	3.3
Potentilla sp	1.0	0	1.0	0
Taraxacum officinale	38.6	55.17	86.6	48.1
Thlaspi arvense	8.1	24.65	10.8	2.7
Rosa sp	3.9	0	3.9	0
Total	527.2		615.7	91.5

[1] Dry weight of herbage taken by crickets / Calculated dry weight of herbage originally present = 14.9 percent of dry weight of herbage taken by crickets.

[2] T=trace.

MORMON CRICKET DISTRIBUTION WITH RELATION TO THE MAJOR VEGETATION REGIONS

The map (fig. 1) showing the distribution of the Mormon cricket indicates that the crickets are found in a variety of vegetation types. Since it shows only areas where Mormon crickets were present in appreciable numbers, it demonstrates clearly enough that they are not confined to one or a few types of plant cover. This map must be compared with one of the natural vegetation of the United States, such as that of Shantz and Zon (*6*), before the actual variety of types in which crickets occur can be appreciated.

The map of Shantz and Zon shows that the northeastern limit of Mormon cricket distribution lies in oak-hickory forest and tall grass prairie. Tall grass prairie occupies a narrow strip of eastern North Dakota and eastern South Dakota. Short grass, or plains grassland, is a wide belt through eastern Nebraska, Colorado, Wyoming, and Montana, east of the Rocky Mountains. Except for high mountain areas of yellow pine, Douglas fir, and lodgepole pine forest, the Mormon cricket range in Colorado, Nevada, Utah, western Montana, and southern Idaho is mostly in northern desert shrub. This area also contains islands of greasewood (salt desert shrub) and Pacific grassland (bunchgrass). In Washington and Oregon the insects are distributed

mostly through Pacific grassland, yellow pine-douglas fir forest, and northern desert shrub.

By referring again to figure 1 it can be seen that most of the 1939–40 infestations lie in northern desert shrub and short grass areas. It is in these areas, especially the former, that the greatest economic losses due to Mormon crickets occur. The northern desert shrub of Shantz and Zon characterizes an area having, on the whole, a cool climate with low rainfall (mostly well under 20 inches) and a permanently dry subsoil.

The plant which marks the climax vegetation over much of this really vast region is the big sagebrush, *Artemisia tridentata*. According to Weaver and Clements (*9*), the sagebrush cover as a true climax occurs from central Utah and southern Idaho to eastern Oregon, northeastern California, and Nevada. It has displaced Pacific grassland and short grass vegetation over large areas outside the central Great Basin.

Shrubs frequently associated with the big sagebrush are several species of rabbitbrush (*Chrysothamnus*), saltbush (*Atriplex*), horsebrush (*Tetradymia*), and bitterbrush (*Purshia tridentata*). The grasses tend to be of the bunch type; several species of *Poa* and *Festuca* are the dominant ones. Small early blooming annuals are abundant during normal springs.

The short grass plains of Shantz and Zon occupies an area most of which Weaver and Clements designate as a "mixed prairie" climax—the largest of the grassland associations in this country. The latter authors consider the short-grass vegetation a subclimax brought about by overgrazing. Certainly the region in question is not always short grass plain by aspect. Extensive associations of western wheatgrass (*Agropyron smithii*) and several species of *Stipa* are found, the latter often attaining a rather uniform height of at least 3 feet. The true short grasses are grama grass (*Bouteloua gracilis*) and buffalo grass (*Buchloë dactyloides*). They are both widespread throughout the area and often are the dominant species. They characterize the mixed prairie or short grass (Shantz and Zon) vegetation better than any other species.

That part of the Pacific grassland occurring within the range of the Mormon cricket—that is, in central and eastern Washington and Oregon and western Idaho—is of two types, according to H. L. Shantz (*5*), "wheatgrass bunch" and "wheatgrass sod." The former is more widespread, occurring at higher elevations in northern Nevada as well as in the large region just mentioned. Bluebunch wheatgrass (*Agropyron spicatum*) is usually the dominant plant, with a good representation of Idaho fescue (*Festuca idahoensis*) and bluegrasses (*Poa* spp.). Owing to overgrazing, large parts of this association have been invaded by sagebrush or displaced by downy chess (*Bromus tectorum*). Characteristic weeds are balsamroot (*Balsamorhiza sagittata*) and lupine (*Lupinus* spp.). The "wheatgrass sod" is confined principally to the Palouse section of Washington, Idaho, and Oregon, in better and more moist soil; the dominant plants are the same.

No description of the oak hickory forest and tall grass prairie seems necessary, since sizable Mormon cricket bands have never been reported from those vegetation areas. They were not visited by the writer. Greasewood vegetation is common in Utah and Nevada, and many small expanses of it were traversed by Mormon crickets during the season of 1939. The dominant plant is, of course, *Sarcobatus vermiculatus*. Associated with it are, frequently, saltgrass (*Distichlis stricta*) and various species of pickleweed (*Iondia*).

The pinon-juniper association is a woodland. In Nevada and Utah it lies at the higher altitudes, on ridge tops and mountains above the desert shrub of the valleys and lower slopes. Where visited in the course of observations on Mormon cricket damage to the range, it was found to be open, with a sparse stand of bluegrasses, wheatgrasses, and needlegrasses, and with varying amounts of sagebrush.

Yellow pine, douglas fir, and lodgepole pine forests need no further description at this point. The occurrence of Mormon cricket bands in the former was observed in central and eastern Oregon and in Idaho. Mormon crickets were present in large bands in the pure ponderosa pine (*Pinus ponderosa*) forests covering the Black Hills near Sundance, Wyo.

The major plant areas in which the Mormon cricket occurs have now been briefly described or named; it is obvious that the insect, in its distribution, is not limited by them. In the succeeding sections the actual food-plant preferences exhibited by the Mormon cricket, and the degrees of injury occurring in various smaller units of vegetation, will be considered in detail.

CONSUMPTION OF SMALL VEGETATION TYPES BY THE MORMON CRICKET

When the temperature permits, the Mormon cricket is almost constantly wandering. When weather conditions are favorable for migration, they are likewise favorable for feeding. Therefore the bands of crickets moving over the range leave a trail, often clearly defined, of injured plants. The degree of injury to a unit of area traversed by Mormon crickets is, of course, dependent upon the concentration of crickets per square yard, the number of days crickets are present, the temperature, and the physiological state of the insects. That it depends upon at least as many variables as this is evidenced by the fact that no correlation could be found between the numbers of crickets in the permanent observational plots per square yard per day and the amount of damage suffered by the vegetation.

No cricket bands less than 2 chains in width were encountered by the writer. It was not unusual for bands to be one-half mile or a mile across, and 1 to 10 miles long. In a few instances single areas of as much as 200,000 acres were very solidly infested at one time or another during a season by different bands. As has been stated, from egg bed to oviposition grounds a band of crickets may traverse 10 to 20 miles or more.

Mormon crickets, like most other animals that move in droves, appear at any given point to be moving in a straight line and in a

common direction. Uvarov (*8*) states that it is the tendency of grasshopper nymphs to move parallel to one another that gives a band a common direction. The writer believes that this is true of Mormon crickets. That is, the course taken by a band when morning temperatures are high enough to stimulate movement depends upon the direction taken by the first cricket or small group of crickets, the others falling in line with these leaders.

This explanation seems the more plausible when it is remembered that one of the first means of protecting crops against cricket invasion was the beating of pans, ringing bells, and beating the ground with switches in an effort to change the direction of march. If enough crickets could be frightened into taking a different direction, the whole band would fall in line and go around or away from a garden or field.

Again, it can be noted that when one is walking through a band of crickets, the disturbance causes a circular and ever widening wave of madly hopping insects to radiate away from the observer. In this case hundreds of different directions have been taken by as many insects. In a very short time, however, a common direction has been assumed.

This explanation of Mormon cricket movements does not find wide acceptance among farmers and ranchers. Most often it is believed that crickets orient themselves with the cardinal points of the compass, or that the presence of water, slope of land, or distant attractive fields of alfalfa or wheat influence the direction of march.

It is, of course, an advantage, probably a necessity, that large gregarious insects be migratory. It would be possible for a stationary population of 100 adult crickets per square yard to destroy the plant cover completely. That this seldom, if ever, occurs on the range is due to the food-plant preferences and the migratory nature of the Mormon cricket. While total destruction of that part of the herbage which would properly be consumed by livestock was found to occur in a few areas, consumption of as much as 60 percent of the total dry weight of range herbage was never found. (Mormon cricket destruction of fields of alfalfa and grain—concentrations of choice food plants—often approached 90 percent by weight.)

Table 6 presents estimated losses of seasonal forage production during 1938 and 1939 and of dry weight of herbage in 1939 for the permanent observational plots. The cricket-concentration estimates made during the periodic visits to the plots have been converted into "estimated minimum number of cricket days per square yard," the product of the estimated average number of crickets per square yard and the number of days this concentration existed. The figures are rough estimates and, as has been pointed out, show no direct relation to the amount of injury done to the plot vegetation.

Sixteen of the 26 plots set up in 1938 were revisited by Mormon crickets in 1939. It was not unusual for a tenth-acre plot to be crossed by several distinct bands or to be revisited by the same band during the course of one season. In most plots staked-plant records showed progressive injury, but this was because the plots were situated in the worst outbreak areas. Most of the range covered by Mormon crickets is injured during the course of only 3 or 4 successive days during any 1 year.

TABLE 6.—*Summary of Mormon cricket damage to seasonal forage production and to total weight of herbage on the tenth-acre observational plots*

Plot number and vegetation type	Minimum cricket days per square yard [1]		Loss of seasonal forage production for—				Loss in total dry weight of herbage	Loss per acre in dry weight of herbage
			Cattle and horses		Sheep and goats			
	1938	1939	1938	1939	1938	1939	1939	1939
	Number	*Number*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Pounds*
BR-1, desert shrub	224	21	39.58	8.33	57.37	17.91	4.15	25
BR-2, desert shrub	336	21	39.85	13.75	59.13	15.08	4.69	36
BR-3, sagebrush	6	130	9.26	6.64	12.94	8.96	5.16	15
BR-4, sagebrush	2	3	.....	3.45	.....	4.54	.99	2
E-1, sagebrush	100	.....	12.90	.....	13.75	.....	.....	.....
E-2, sagebrush	56	.....	44.05	.....	48.64	.....	.....	.....
E-3, sagebrush	110	.....	87.93	.....	86.79	.....	.....	.....
E-4, sagebrush	56	.....	37.97	.....	54.58	.....	.....	.....
E-5, sagebrush	140	1	52.06	.....	52.08	.....	.....	.....
E-6, sagebrush	70	53	57.83	12.52	55.65	16.80	6.06	21
EP-1, sagebrush	1	300	3.50	9.65	4.80	13.32	.....	.....
EP-2, grassland	300	100	66.40	16.88	85.06	17.37	4.65	29
EP-3, sagebrush	90	52	45.51	11.02	52.79	12.78	.56	3
H-1, conifer	(2)	(2)	100.00	81.52	99.27	91.00	50.15	29
IS-1, sagebrush	680	366	85.00	70.00	88.89	77.78	27.01	311
M-1, desert shrub	110	259	11.41	13.33	41.65	12.28	6.09	34
M-2, perennial weed	80	152	19.45	15.68	21.18	20.19	12.59	43
M-3, sagebrush	12	15	1.57	4.33	2.00	7.13	10.56	110
NF-1, grassland	21	.....	31.20	.....	41.11	.....	.....	.....
R-1, sagebrush	40	2	7.48	.....	8.43	.....	.....	.....
R-2, sagebrush	6	3	21.24	29.21	23.45	35.13	3.28	5
S-1, sagebrush	420	(2)	45.88	33.00	36.84	33.58	.....	.....
S-2, sagebrush	105	(2)	98.13	98.12	97.80	58.76	.....	.....
S-3, sagebrush	70	17	61.11	14.99	78.79	15.26	2.77	8
S-4, desert shrub	.....	75	.....	100.00	.....	84.00	27.37	55
T-1, grassland	30	225	53.66	73.98	54.32	98.00	45.01	282
T-2, broadleaf tree	30	(2)	78.21	41.05	87.55	56.21	56.52	483

[1] The product of the estimated average number of crickets per square yard and the number of days this concentration existed.

[2] Constant cricket populations of from 5 to 20 per square yard were present all season.

Transects to determine losses in dry weight of herbage and in percentage of seasonal forage production were run, and general observations and plant collections were made in a variety of vegetation types in and outside the northern Great Basin area. Table 7 presents the location of these transects, the type of vegetation examined, and the results of office calculations from the field data.

TABLE 7.—*Summary of the results from transect samples of Mormon cricket injury to range vegetation, 1939*

Locality	Date	Vegetation type and dominant plants	Loss in seasonal forage production		Loss in dry weight of total herbage
			Cattle and horses	Sheep and goats	
Idaho			*Percent*	*Percent*	*Percent*
Washington County	June 13	Grassland. *Agropyron pauciflorum.* *Bromus tectorum.* *Poa secunda.*	10.54	13.90	.....
Clark County	July 14	Meadow *Melilotus alba.* *Phleum pratense.* *Lithospermum* sp.	.....	.....	14.9
Do	do	Abandoned field *Chenopodium album.* *Salsola pestifer.* *Polygonum douglasii.*	21.81	21.19	.....

TABLE 7.—*Summary of the results from transect samples of Mormon cricket injury to range vegetation, 1939*—Continued

Locality	Date	Vegetation type and dominant plants	Loss in seasonal forage production		Loss in dry weight of total herbage
			Cattle and horses	Sheep and goats	
Idaho—Continued.			*Percent*	*Percent*	*Percent*
Clark County	July 14	Meadow *Juncus balticus.* *Stipa columbiana.* *Bromus carinatus.*	4.40	5.03	
Do	July 15	Sagebrush *Artemisia tridentata.* *Carex* sp. *Festuca ovina.*	.81	.97	
Do	do	Conifer *Picea engelmanni.* *Populus tremuloides.* *Agropyron subsecundum.*	2.03	3.01	
Fremont County	July 16	Sagebrush *Artemisia tripartita.* *Stipa williamsii.* *Stipa lettermani.*	2.10	2.09	
Montana					
Hardin County	July 8	Grassland *Agropyron smithii.* *Salsola pestifer.* *Sisymbrium altissimum.*	.02	2.26	
Nevada					
Elko County	June 15	Sagebrush *Artemisia tridentata.* *Sitanion hystrix.* *Iva axillaris.*			6.9
Do	June 16	Sagebrush *Artemisia tridentata.* *Sitanion hystrix.* *Elymus condensatus.*			34.5
Do	Apr. 17	Sagebrush *Artemisia tridentata* *Bromus tectorum.* *Poa secunda.*	45.37	46.92	
Do	do	Sagebrush *Artemisia tridentata.* *Bromus tectorum.* *Poa secunda.*	41.44	39.12	
Do	Apr. 12	Sagebrush *Artemisia tridentata.* *Chrysothamnus viscidiflorus.* *Oryzopsis hymenoides.*			.7
Do	Apr. 8	Sagebrush *Artemisia tridentata.* *Agropyron dasystachyum.* *Carex douglasii.*			5.2
Do	July 3	Sagebrush *Artemisia tridentata.* *Chrysothamnus viscidiflorus.* *Poa secunda.*			4.5
Humboldt County	May 14	Sagebrush *Artemisia tridentata.* *Bromus tectorum.* *Poa* spp.	28.09	30.27	
Do	Aug. 13	Sagebrush *Artemisia tridentata.* *Bromus tectorum.* *Poa* spp.	67.63	71.25	
Elko County	July 11	Sagebrush *Artemisia tridentata.* *Festuca idahoensis.* *Elymus condensatus.*			14.0
Do	do	Sagebrush *Artemisia tridentata.* *Chrysothamnus nauseosus.* *Sitanion hystrix.*			3.0
Do	Apr. 26	Sagebrush *Artemisia tridentata.* *Stipa thurberiana.* *Chrysothamnus viscidiflorus.*	10.63	21.82	

TABLE 7.—*Summary of the results from transect samples of Mormon cricket injury to range vegetation, 1939*—Continued

Locality	Date	Vegetation type and dominant plants	Loss in seasonal forage production		Loss in dry weight of total herbage
			Cattle and horses	Sheep and goats	
Nevada—Continued.			*Percent*	*Percent*	*Percent*
Elko County	Apr. 28	Sagebrush *Artemisia tridentata.* *Chrysothamnus nauseosus.* *Poa* sp.	24.45	28.59	
Do	May 25	Sagebrush *Artemisia tridentata.* *Poa secunda.* *Wyethia amplexicaulis.*	9.00	10.15	
Do	Aug. 18	Sagebrush *Artemisia tridentata.* *Festuca idahoensis.* *Agropyron spicatum.*	6.57	8.53	
Do	June 7	Meadow *Poa* spp. *Juncus balticus.* *Carex* sp.	2.44	3.35	
Do	June 16	Meadow *Poa* spp. *Juncus balticus.* *Muhlenbergia squarrosa.*			2.6
Humboldt County	June 21	Meadow *Agrostis alba.* *Elymus condensatus.* *Carex* sp.			1.2
Elko County	May 11	Grassland *Bromus tectorum.* *Agropyron* sp. *Elymus condensatus.*	15.02	18.04	
Do	do	Grassland *Bromus tectorum.* *Festuca idahoensis.* *Poa* sp.	1.02	.87	
Do	July 8	Greasewood *Sarcobatus vermiculatus.* *Elymus condensatus.* *Distichlis stricta.*			2.0
Do	July 14	Greasewood *Sarcobatus vermiculatus.* *Stipa comata.* *Elymus condensatus.*			20.3
Humboldt County	July 16	Broadleaf tree *Populus tremuloides.* *Bromus tectorum.* *Symphoricarpos* sp.	97.69	96.75	
Do	Aug. 14	Broadleaf tree *Artemisia tridentata.* *Bromus tectorum.* *Symphoricarpos* sp.	80.73	82.03	
Eureka County	July 7	Broadleaf tree *Prunus demissa.* *Artemisia tridentata.* *Chrysothamnus nauseosus.*			20.1
Elko County	June 26	Pinon-Juniper *Pinus monophylla.* *Agropyron spicatum.* *Festuca idahoensis.*	7.03	10.01	
Do	do	Pinon-Juniper *Juniperus scopulorum.* *Artemisia tridentata.* *Agropyron spicatum.*	7.39	9.39	
Oregon					
Wasco County	May 2	Sagebrush *Artemisia tridentata.* *Purshia tridentata.* *Bromus tectorum.*	97.09	95.90	
Do	do	Broadleaf tree *Prunus demissa.* *Bromus tectorum.* *Scirpus* sp.	95.58	92.21	

TABLE 7.—*Summary of the results from transect samples of Mormon cricket injury to range vegetation, 1939*—Continued

Locality	Date	Vegetation type and dominant plants	Loss in seasonal forage production		Loss in dry weight of total herbage
			Cattle and horses	Sheep and goats	
Oregon—Continued.			*Percent*	*Percent*	*Percent*
Wasco County	May 2	Grassland *Bromus tectorum.* *Agropyron spicatum.* *Festuca pacifica.*	77.52	87.67	
Do	do	Grassland *Bromus tectorum.* *Festuca pacifica.* *Gayophytum diffusum.*	100.00	98.98	
Do	do	Grassland *Poa* sp. *Gayophytum diffusum.* *Bromus tectorum.*	55.86	59.12	
Do	do	Grassland *Poa* sp. *Festuca pacifica.* *Bromus tectorum.*	100.00	99.10	
Baker County	June 10	Perennial weeds *Balsamorhiza sagittata.* *Eriogonum* spp. *Gayophytum ramosissimum.*			35.1
Do	June 11	Perennial weeds *Balsamorhiza sagittata.* *Lomatium* sp. *Purshia tridentata.*			30.1
Do	June 10	Sagebrush *Artemisia rigida.* *Poa secunda.* *Agropyron spicatum.*	18.82	27.06	
Do	July 24	Conifer *Vaccinium membranaceum.* *Ribes* spp. *Rosa* sp.	56.57	58.37	
Do	July 25	Grassland *Bromus tectorum.* *Agropyron spicatum.* *Balsamorhiza sagittata.*			55.5
Do	July 26	Grassland *Agropyron spicatum.* *Bromus tectorum.* *Balsamorhiza sagittata.*	89.16	56.47	
Utah					
Tooele County	May 15	Sagebrush *Artemisia tridentata.* *Agropyron* sp. *Vicia americana.*	.80	.90	
Do	do	Sagebrush *Artemisia tridentata.* *Vicia americana.* *Astragalus beckwithii.*	15.70	17.02	
Do	May 28	Sagebrush *Artemisia tridentata.* *Agropyron dasystachyum.* *Vicia americana.*	24.12	37.81	
Do	do	Sagebrush *Artemisia tridentata.* *Vicia americana.* *Poa* sp.	18.71	21.31	
Wyoming					
Crook County	June 23	Grassland *Poa secunda.* *Festuca* sp. *Danthonia californica.*	.50	1.10	

It was found that in many areas outside the northern desert shrub and Pacific bunchgrass regions the transect method was not applicable. That is, cricket populations were so low in comparison with the volume of herbage per unit of area in mixed prairie, for example, that reliable damage estimates could not be made on a volume bass.

The clipped green weight of herbage on 100 square feet (a transect plot) of typical grassland in the mixed prairie (*Poa, Festuca, Danthonia*) of Crook County, Wyo., was found to weigh 3,680 grams. This is just 7 times the average weight found on 10 plots of the same area in typical sagebrush vegetation in Nevada. Even greater differences are found between the weights of good western wheatgrass and northern desert shrub vegetation.

In mature stands of mixed prairie—grasses with a thin scattering of plants such as *Taraxacum, Tragopogon, Penstemon*, etc.—Mormon cricket injury was almost confined to the grass inflorescences and the inflorescences and leaves of the more succulent weeds. Damage to grass fruits frequently could only be called a "trace," and volume-loss estimates of less than 5 percent were not used in calculations of either weight loss or seasonal-forage-production loss. Although weeds may have received much injury, still they often made up a negligible portion of the plant composition or were of no value as forage. A few transects were run in Montana, in mixed prairie, merely to determine food-plant selection, the injury to forage being insignificant.

In tall grass vegetation the Mormon cricket is probably still less a menace. Not only would a smaller percentage of range vegetation per unit area be destroyed, but rapid migration and close banding might be hindered by the denser and higher growth. It can hardly be expected that the insect's preference for cultivated plants would be affected, but scattered crickets are less to be feared. Mormon cricket infestations in tall grass prairie, although they were reported in 1939 in South Dakota, were so few and unimportant from the damage standpoint that they were not visited by the writer.

The Mormon cricket is able to consume all the vegetation types in which it occurs. There are, however, differences in the degree and nature of consumption. The variation in weight of herbage per unit area has been given as one reason why mixed prairie and tall grass prairie will suffer less injury from cricket feeding than will northern desert shrub, on a strictly weight basis. It is true, also, that "forage" losses, as distinct from weight losses, were found to be much higher in the northern desert shrub than in the mixed prairie. This is a matter of plant composition and food-plant preference.

In the types dominated by *Artemisia* and *Chrysothamnus viscidiflorus* the grasses tend to the bunch habit and are rather sparsely distributed. With perhaps 50 percent or more of the plant cover occupied by relatively unacceptable shrubs, the Mormon cricket will be found heavily utilizing grasses, foliage as well as reproductive parts, at least before they have cured.

Broadleaf tree types, which, with the exception of some aspen forest at high altitudes, are narrow stream-side types, are attractive to the insects for their shade, moisture, and the type of succulent vegetation they support long after the best food plants of the grassland and sagebrush have cured. The bands concentrated in the shade of these types may remain for many weeks, causing extremely heavy forage losses.

The high percentage forage losses found in conifer types in the Whitman National Forest, Baker County, Oreg., are due not only to unusually large concentrations of Mormon crickets but to the relative scarcity of forage in the forest.

The greasewood types in which Mormon crickets were found were all small. Although the insects may be able to live upon the shrub itself and upon *Distichlis* (saltgrass) and other salt-desert plants, it is doubtful if eggs laid in the strongly alkaline soils of the larger types could survive the desiccation. The extreme heat and the dearth of vegetation of any sort would make it impossible for Mormon crickets to live on the Great Salt Desert itself.

INFLUENCE OF SEASON ON THE AVAILABILITY OF FOOD PLANTS AND THEIR RECOVERY FROM INJURY

As the season progresses from the time of Mormon cricket hatching until after oviposition in August and September, there are noticeable changes in the natural diet. Small, early, succulent annuals, choice food in April and May, will be withered and dead by June. Some grasses and coarse weeds whose tender first leaves may have been acceptable in the spring will be avoided a few weeks later. Late-blooming plants whose foliage was spurned during June may have flowers and fruits in July very attractive to Mormon crickets.

The records kept through two seasons on marked plants have given information on the seasonal history of those plants and on the degree of recovery to be expected after Mormon cricket injury of various types.

In the northern Great Basin area most of the precipitation available for plant growth comes during the winter. Growth during April and May is rapid, and most grasses and many weeds are mature and perhaps dry by the middle or end of June. Appreciable recovery from Mormon cricket feeding was seldom noted among the early small annuals. In grasses it was marked only when injury had occurred well before the leaves had reached their full lengths. When inflorescences of grasses or weeds were injured they apparently were not replaced during the current season.

In the spring, when wheat, barley, and rye plants are only a few inches tall, first- to third-instar Mormon crickets may eat them to the ground. Except during drought years, recovery from this injury may be complete. Later, during the dry summers which are frequently almost rainless, injury to the developing inflorescences and the foliage is permanent. As a rule, seedling alfalfa plants and garden stuffs cannot withstand severe injury. Mature alfalfa, which sometimes appears to have been mowed by machine after a band of crickets has been present, can recover rapidly if irrigated. Injury to seed alfalfa is, of course, permanent so far as the current crop is concerned.

EFFECTS OF CLIMATIC FACTORS UPON FEEDING BEHAVIOR OF THE MORMON CRICKET

Temperature, light, and, to a lesser degree, wind movement have a direct bearing upon the feeding behavior of the Mormon crickets. The most important of these is probably temperature. Active feeding has been observed most frequently at air temperatures of from 70° to 95° F., but crickets in the first to third stadia have been found feeding at an air temperature of 44°, and adults at 101°.

At air temperatures above 95° F., and at soil temperatures above 100°, feeding is inhibited, and the insects cluster on sagebrush, fence posts, or any objects that will take them from the heat of the soil surface. Crickets have been observed to go without feeding during the hours of sunlight for a week at a time during periods of excessive heat, feeding being confined to the cool parts of the early morning and the evening.

Those temperatures favorable for feeding are likewise favorable for migration. The two activities do not necessarily conflict. Individuals in a migrating band are continually stopping to feed, and, on the other hand, a field of young wheat may be abandoned if the desire for food is exceeded by the desire to migrate. The writer's conclusions concerning the relation of temperature to Mormon cricket feeding in the field are in agreement with those of all who have studied this problem.

Both migrating and feeding are most active in bright sunlight. Cloudy skies at midday often cause clustering and, in adults, may stimulate oviposition.

Moderate and light breezes of a velocity of less than 20 miles an hour do not hinder feeding. During strong winds and rainstorms crickets cluster beneath shrubs or hide at the bases of grass clumps, among rocks, or in cracks in the soil.

EFFECTS UPON FEEDING BEHAVIOR OF BIOLOGICAL EVENTS IN THE LIFE CYCLE OF THE MORMON CRICKET

No very remarkable differences have been observed between the youngest nymphs and the adults in feeding behavior or food-plant selection. First instars readily climb the tallest weeds available, showing the usual preference for the flowers. Injury to shrubs and trees is caused almost exclusively by the older nymphs and adults, but this is not really due to different food preferences. All the plants fed upon by the early instars are acceptable food for adults if they are available later in the season.

A band of Mormon crickets still in the first and second stadia may have moved several hundred yards from the egg bed. Its size may be due to the coalescence of a number of small separate groups of crickets from the same egg bed or different egg beds. During its movement the only thing that entirely stopped the feeding activities of its members, excluding adverse weather conditions and periods of rapid migration, was the molting process, which may have inhibited feeding over most if not all of a day.

The molting of all individuals in a band of Mormon crickets on the same day or even during 2 successive days would be a very good reason for the apparently erratic feeding behavior of the nymphs. It is the writer's opinion, however, that the molting process, while it most certainly affects the feeding of the individual cricket, is probably never the reason why, on a particular day with all other conditions seemingly favorable, a band of crickets sometimes does almost no feeding. The basis for this opinion is the number of different stadia represented at any one time in a large Mormon cricket band. As many as six different instars were seen in one band at one time. Frequently three different ones were present in roughly equivalent

numbers. Variations in temperature and moisture alone can account for rather extreme differences in hatching dates for the crickets from a single egg bed. These age differences persist and others arise, as when insects from different egg beds gather in one band, so that during the entire nymphal period, climatic conditions being favorable, there are probably few days when some individuals are not molting. Thus the effect of molting upon the feeding of a band is probably a more or less constant factor rather than a periodic one.

After the insects have reached sexual maturity, mating and oviposition—the first a morning and the second an afternoon function—occupy a considerable amount of the time previously spent in migrating or feeding. Food, of course, no longer is necessary for body enlargement. The tendency to migrate seems to be much weakened after oviposition begins. However, migration does not entirely cease. After the first of September the insects may move some miles from an area where they have been actively ovipositing for weeks. The more stationary populations of mature adults are seldom responsible for so much crop and range damage as the actively migrating nymphs and new adults.

The dearth of green food late in the summer may be conducive to cannibalism. At any rate, cannibalism is exceedingly rife late in July and in August, when very often the insects are found eating the aging and weakened members of their own band.

Table 8 summarizes a part of the information in local supervisors' monthly crop-damage reports. The number of acres covered in these reports is about 6,000 less than the total number given in the annual State reports. The table indicates that more than half the total acreage was infested by the end of May, and that the months of greatest cricket migration into new crop areas were May and June. Many fields invaded during May were reinvaded during June and July or were continuously infested by more or less permanent adult populations. Comparatively little new crop land was invaded in July and almost none in August.

The decrease in the number of damaged crop acres after May and June is due partly to the fact that mature adults are less migratory than the nymphs, but also to the harvesting of grain and hay crops and to the extermination of the insects in and adjacent to important farming sections. In 1939, however, at least half the reported crop damage was done by nymphal Mormon crickets.

TABLE 8.—*Acreages of crops newly damaged each month by Mormon crickets in 1939, listed by States*

State	April	May	June	July	August	Seasonal total
Idaho	775	2,929	840	233		4,777
Montana	7,050	625	1,873.25	105		9,653.25
Nebraska		2,800	4,600	600		8,000
Nevada	607	7,079	1,242	467		9,395
Oregon	50	2,878.75	371	170.50		3,470.25
South Dakota		2,162	3,637	248		6,047
Utah	295	547	85	78		1,005
Washington		1,024.50	1,971			2,995.50
Wyoming	90	4,719.75	5,230	613.13	80	10,732.88
Total	8,867	24,765.00	19,849.25	2,514.63	80	56,075.88

FOOD PLANTS OF THE MORMON CRICKET

Crop Plants Attacked

Since most of the cultivated plants in the Northwest are preferred food for the Mormon cricket, no attempt will be made to classify them. It should be stated, however, that injury to fruit trees is unusual and is chiefly confined to the fruits themselves. The crops for which there are injury records are listed alphabetically.

Alfalfa
Barley
Beans (garden)
Bulbous bluegrass
Canteloupe
Clover (red, white, alsike)
Corn
Crested wheatgrass
Flax
Garden stuffs
Millet
Native hay
Oats
Pasture (cultivated)
Peaches
Potatoes
Rye
Sorghum
Spelt
Strawberries
Sudan grass
Sugar beets
Sweetclover
Timothy
Tomatoes
Truck crops (miscellaneous)
Watermelons
Wheat

Range Plants Classified in Accordance With the Food Preferences of the Mormon Cricket

It was assumed that, under natural feeding conditions, estimates of percentage volume of destruction indicated the relative attractiveness of plants as cricket food. Therefore all plants for which there were records of Mormon cricket damage were arranged in four classes according to the relative volumes usually destroyed by crickets. Wherever possible, estimates of average percentage injury were utilized in classifying the plants. These figures were taken from records of permanent plots and from data from transects giving estimates of plant composition and weight, or from incidental field observations. Occasionally a species appears on the list whose consumption estimate was made on the basis of observations on one or a few scattered plants. In these cases the maximum consumption estimates were used in classification.

Class A contains the names of plants frequently observed to incur losses of 20 percent or greater; Class B, losses ranging from 10 to 19 percent; Class C, 1 to 9 percent. Class D includes plants whose injury estimates ran lower than 1 percent and were recorded as traces; also, those plants for which no percentage estimates of injury were made. The plants in each class are subdivided as follows: Grasses, grasslike plants, weeds, and browse and trees. The common name and the years of record are given with each botanical name.

CLASSIFIED LIST OF MORMON CRICKET FOOD PLANTS

CLASS A

Grasses

Agropyron pauciflorum (Schwein.) Hitchc. Slender wheatgrass '38, '39.
Agropyron spicatum (Pursh) Scribn. and Smith. Bluebunch wheatgrass '38, '39.
Bromus commutatus Schrad. Hairy chess '38, '39.
Bromus secalinus L. Chess '38, '39.
Bromus tectorum L. Downy chess '38, '39.
Elymus condensatus Presl. Giant wild-rye '38, '39.
Elymus glaucus Buckl. Blue wild-rye '38, '39.
Festuca pacifica Piper. Fescue '38, '39.
Festuca spp. Fescue '38, '39.
Muhlenbergia squarrosa (Trin.) Rydb. Mat muhly '38, '39.
Poa scabrella (Thurb.) Benth. Pine bluegrass '38, '39.
Poa secunda Presl. Sandberg bluegrass '38, '39.
Polypogon monspeliensis (L.) Desf. Rabbitfoot grass '38, '39.
Sitanion hystrix (Nutt.) J. G. Smith. Squirreltail '38, '39.

Grasslike plants

Carex douglasii Boott. Douglas sedge '38, '39.
Carex nebraskensis Dewey. Nebraska sedge '38, '39.
Carex spp. Sedge '38, '39.
Scirpus microcarpus Presl. Rush '38, '39.

Weeds

Agastache urticifolia (Benth.) Kuntze. Nettleleaf horsemint '38, '39.
Agoseris taraxacifolia (Nutt.) D. Dietr. False mountain-dandelion '38, 39.
Agoseris spp. False mountain-dandelion '38, '39.
Allium acuminatum Hook. Wild onion '38, '39.
Allium textile Nels. and Macbr. Wild onion '39.
Allium spp. Wild onion '38, '39.
Anaphalis margaritacea (L.) A. Gray. Pearly everlasting '38, '39.
Aplopappus lanceolatus (Hook.) Torr. and Gray. Goldenbane '39.
Arenaria congesta Nutt. Sandwort '39.
Argemone hispida A. Gray. Prickly poppy '38, '39.
Aster scopulorum A. Gray. Aster '38, '39.
Astragalus beckwithii Torr. and Gray. Vetch '38, '39.
Astragalus spp. Vetch '38, '39.
Balsamorhiza hookeri Nutt. Balsamroot '38, '39.
Balsamorhiza sagittata (Pursh) Nutt. Arrowleaf balsamroot '38, '39.
Brassica kaber (DC.) Wheeler. Mustard '38, '39.
Brassica sp. Mustard '38, '39.
Brickellia sp. '38, '39.
Calochortus gunnisonii Wats. Mariposa lily '39.
Calochortus nuttallii Torr. and Gray. Mariposa lily '38, '39.
Camelina microcarpa Andrzej. Falseflax '39.
Capsella bursa-pastoris (L.) Medic. Shepherds-purse '39.
Chamaenerion angustifolium (L.) Scop. Fireweed '38, '39.
Chenopodium leptophyllum Nutt. '38, '39.
Cirsium spp. Thistle '38, '39.
Collinsia parviflora Dougl. Blue-eyed-mary '38, '39.
Crepis acuminata Nutt. Tapertip hawksbeard '38, '39.
Delphinium menziesii DC. Spring larkspur '38, '39.
Delphinium spp. Larkspur '38, '39.
Draymocallis fissa (Nutt.) Rydb. '38, '39.
Erigeron spp. Fleabane '38, '39.
Eriogonum nudum Dougl. Barestem eriogonum '38, '39.
Eriophyllum watsoni A. Gray. '38, '39.
Erodium cicutarium (L.) L'Her. Alfilleria '38, '39.
Fritillaria pudica (Pursh) Spreng. Yellowbell '39.

Gilia filifolia (Nutt.) Rydb. '38.
Glycyrrhiza lepidota Pursh. Licorice '38, '39.
Heracleum lanatum Michx. Cow-parsnip '39.
Hieracium sp. Hawkweed '39.
Hydrophyllum alpestre Nels. and Kennedy. Waterleaf '38, '39.
Hydrophyllum capitatum Dougl. Ball-head waterleaf '38, '39.
Iris missouriensis Nutt. Rocky Mountain iris '38, '39.
Lactuca pulchella (Pursh) DC. Wild lettuce '38, '39.
Lactuca scariola L. Wild lettuce '38, '39.
Lepidium densiflorum Schrad. Peppergrass '39.
Lepidium perfoliatum L. Peppergrass '38, '39.
Lepidium virginicum L. Peppergrass '39.
Leptotaenia multifida Nutt. Carrotleaf '38, '39.
Lewisia rediviva Pursh. Bitterroot '38, '39.
Lomatium nudicaule (Pursh) C. and R. '38, '39.
Lomatium spp. Whiskbroom parsley '38, '39.
Lupinus caudatus Kellogg. Tailcup lupine '38, '39.
Lupinus spp. Lupine '38, '39.
Lygodesmia juncea (Pursh) D. Don. '39.
Marrubium vulgare L. Hoarhound '38, '39.
Melilotus alba Desr. Sweetclover '38, '39.
Melilotus officinalis (L.) Lam. Yellow sweetclover '38, '39.
Mertensia foliosa A. Nels. Bluebells '38, '39.
Microseris nutans (Geyer) Schultz Bip. '39.
Microsteris micrantha (Kellogg) Greene. '38.
Monolepis nuttalliana (Roem. and Schult.) Engelm. '39.
Odostemon repens (Lindl.) Cockerell. Creeping hollygrape '38, '39.
Paeonia brownii Dougl. Brown's peony '38, '39.
Phlox spp. Phlox '38, '39.
Polygonum sp. Knotweed '38, '39.
Camassia quamash (Pursh) Greene. Common deathcamas '38, '39.
Ranunculus cymbalaria Pursh. Trailing buttercup '38, '39.
Rumex venosus Pursh. Dock 38, '39.
Senecio hydrophilus Nutt. Groundsel '38, '39.
Senecio integerrimus Nutt. Lambstongue groundsel '38, '39.
Senecio serra Hook. Groundsel '38, '39.
Senecio spp. Groundsel 38, '39.
Sidalcea spp. Prairie mallow '38, '39.
Sisymbrium altissimum L. Tumblemustard '38, '39.
Solidago elongata Nutt. Creek goldenrod '38, '39.
Sphaeralcea munroana (Dougl.) Spach. Globemallow '38, '39.
Stanleya elata Jones. Squaw cabbage '38, '39
Taraxacum officinale Weber. Dandelion '38, '39.
Thelypodium sp. '39.
Thlaspi arvense L. Field pennycress '38, '39.
Tragopogon pratensis L. Salsify '38, '39.
Trifolium spp. Clover '38, '39.
Trillium petiolatum Pursh. Wake-robin '38, '39.
Veratrum californicum Durand. False-hellebore '38, '39.
Verbascum thapsus L. Mullein '39.
Wyethia amplexicaulis Nutt. Mules-ears '38, '39.

Browse and trees

Artemisia gnaphalodes Nutt. Sagebrush '38, '39.
Artemisia tridentata Nutt. Black sagebrush '38, '39.
Ceanothus velutinus Dougl. Snowbrush '39.
Chrysothamnus nauseosus (Pall.) Britton. Rubber rabbitbrush '38, '39.
Lepargyrea argentea (Pursh) Greene. Buffaloberry '39.
Philadelphus lewisii Pursh. Mockorange '38, '39.
Prunus demissa (Nutt.) D. Dietr. Chokecherry '38, '39.
Ribes aureum Pursh. Golden currant '38, '39.
Ribes spp. Currants '38, '39.
Salix spp. Willow '38, '39.
Symphoricarpos oreophilus A. Gray. Snowberry '38, '39.
Symphoricarpos sp. Snowberry '38, '39.
Vaccinium membranaceum Dougl. Blueberries '39.

CLASS B

Grasses

Bromus sp. Bromegrass '38, '39.
Melica sp. Melicgrass '38.
Oryzopsis hymenoides (Roem. and Schult.) Ricker. Indian ricegrass '38, '39.
Oryzopsis webberi (Thurb.) Benth. Ricegrass '38, '39.
Poa nevadensis Vasey. Nevada bluegrass '38, '39.
Poa pratensis L. Kentucky bluegrass '38, '39.
Poa spp. Bluegrass '38, '39.

Weeds

Arabis sp. '38, '39.
Arenaria sp. Sandwort '38, '39.
Aster spp. Aster '38, '39.
Chenopodium album L. Lambsquarters '38, '39.
Erysimum sp. Western wallflower '39.
Fritillaria atropurpurea Nutt. Yellowbell '39.
Hedysarum cinerascens Rydb. '38.
Hydrophyllum sp. '38, '39.
Lappula spp. Stickweed '38, '39.
Lithospermum ruderale Dougl. Stoneseed '38, '39.
Oxalis stricta L. Woodsorrel '39.
Oxytropis lambertii Pursh. Loecweed '39.
Penstemon spp. Beardtongue '38, '39.
Phacelia linearis (Pursh) Holz. '38, '39.
Rumex sp. Dock '38, '39.
Sisyrinchium douglasii A. Dietr. Blue-eyed-grass '38, '39.
Solidago sp. Goldenrod '38, '39.
Sputhyris plantaginea Benth. '39.
Thermopsis montana Nutt. Golden pea '39.
Trifolium hybridum L. Alsike clover '38, '39.
Trifolium repens L. White clover '38, '39.
Valeriana sp. Valerian '38.
Zigadenus paniculatus S. Wats. Foothill deathcamas '38, '39.
Zigadenus sp. Deathcamas '38, '39.

Browse and trees

Sambucus melanocarpa A. Gray. Blackhead elder '38, '39.
Sorbus scopulina Greene. Mountain-ash '39.

CLASS C

Grasses

Agropyron smithii Rydb. Bluestem '38, '39.
Agrostis alba L. Redtop '39.
Bouteloua gracilis (H. B. K.) Lag. Blue grama '39.
Bromus inermis Leyss. Smooth brome '38, '39.
Deschampsia caespitosa (L.) Beauv. Tufted hairgrass '38, '39.
Elymus arenicola Scribn. and Smith. Wild-rye '38, '39.
Festuca idahoensis Elmer. Bluebunch fescue '38, '39.
Hordeum nodosum L. Meadow barley '38, '39.
Hordeum sp. Barley '38.
Koeleria cristata (L.) Pers. Junegrass '38, '39.
Melica bulbosa Geyer. Oniongrass '38, '39.
Phleum pratense L. Timothy '38, '39.
Poa epilis Scribn. Skyline bluegrass '39.
Stipa comata Trin. and Rupr. Needle-and-thread '38, '39.
Stipa thurberiana Piper. Thurber needlegrass '38, '39.

Grasslike plants

Carex sp. Sedge '38, '39.
Eleocharis palustris (L.) Roem. and Schult. Spike rush '39.
Eleocharis sp. Spike rush '38, '39.

Weeds

Achillea lanulosa Nutt. Western yarrow '38, '39.
Allium lemmoni Wats. Wild onion '38.
Antennaria dimorpha (Nutt.) Torr. and Gray. Cat's-foot '39.
Aplopappus acaulis (Nutt.) A. Gray '38.
Aplopappus falcatus (Rydb.) Blake '39.
Apocynum ambigens Greene. Dogbane '38, '39.
Arenaria macradenia S. Wats. Sandwort '39.
Aster leucanthemifolius Greene '38 ,'39.
Castilleja angustifolia (Nutt.) Don. Indian paintbrush '38, '39.
Castilleja sp. Indian paintbrush '38, '39.
Chaenactis douglasii (Hook.) Hook. and Arn. False-yarrow '38, '39.
Chenopodium sp. Goosefoot '38, '39.
Chimaphila umbellata occidentalis (Rydb.) Blake. Pipsissewa '39.
Chylisma sp. Chylisma '38.
Cirsium arvense (L.) Scop. '39.
Cordylanthus ramosus Nutt. Thumeweed '38, '39.
Descurainia incisa (Engelm.) Britton. Tansymustard '38, '39.
Descurainia pinnata (Walt.) Britton. Tansymustard '39.
Dondia sp. Seepweed '39.
Erigeron pumilus Nutt. Fleabane '38, '39.
Erigeron concinnus (Hook. and Arn.) Torr. and Gray. Fleabane '38, '39.
Eurotia lanata (Pursh) Moq. Winterfat '38.
Fragaria sp. Wild strawberry '38, '39.
Galium boreale L. Cleavers '38, '39.
Gayophytum diffusum Torr. and Gray. Kitchenweed '38, '39.
Geranium viscosissimum Fisch. and Mey. Sticky geranium '38, '39.
Gilia congesta Hook. '38.
Gilia sp. '39.
Helianthus annuus L. Sunflower '38, '39.
Leucelene hirtella (A. Gray) Rydb. '38, '39.
Lithophragma parviflora (Hook.) Nutt. Woodland star '38, '39.
Lithophragma sp. Woodland star '38, '39.
Mentzelia albicaulis (Hook.) Torr. and Gray. Blazing-star '38.
Mentzelia dispersa S. Wats. Blazing star '38.
Navarretia breweri (A. Gray) Greene '38.
Oenothera marginata Nutt. Evening-primrose '39.
Oenothera trichocalyx Nutt. and Gray. Evening-primrose '39.
Opuntia humifusa Raf. Prickly pear '39.
Opuntia sp. Prickly pear '38, '39.
Orcocarya confertiflora Greene. Hairyleaf '38.
Penstemon rydbergii A. Nels. Penstemon '38, '39.
Phlox canescens Torr. and Gray. Phlox '38, '39.
Phlox longifolia Nutt. Phlox '38, '39.
Phlox stansburyi (Torr.) Heller. Phlox '38, '39.
Plantago purshii Roem. and Schult. Wooly Indianwheat '38, '39.
Polygonum aviculare L. Knotweed '38, '39.
Potentilla gracilis Dougl. Cinquefoil '38, '39.
Rorippa nasturtium-aquaticum (L.) Schinz and Thell. Watercress '38, '39.
Rumex mexicanus Meisn. Dock '38.
Salsola pestifer A. Nels. Russian-thistle '38, '39.
Sieversia ciliata (Pursh) G. Don. Old-man's-whiskers '39.
Sisyrinchium sp. Blue-eyed grass '38, '39.
Sphaerostigma sp. '39.
Streptanthus sp. '39.
Tradescantia occidentalis Britton. Spiderwort '39.
Trifolium pratense L. Red clover '38, '39.
Yucca glauca Nutt. Spanish-bayonet '39.

Browse and trees

Acer douglasii Hook. Maple '39.
Amelanchier cusickii Fernald. Serviceberry '39.
Artemisia frigida Willd. Sagebrush '38, '39.
Betula sp. Birch '38.
Chrysothamnus spp. Rabbitbrush '38, '39.
Crataegus douglasii Lindl. Hawthorn '38, '39.
Physocarpus malvaceus (Greene) Kuntze. Ninebark '38, '39.
Peraphyllum ramosissimum Nutt. '38, '39.
Prunus emarginata (Dougl.) D. Dietr. '38, '39.
Rosa spp. Wild rose '38, '39.
Sambucus sp. Elder '38, '39.
Symphoricarpos albus (L.) Blake. Snowberry '39.
Symphoricarpos rotundifolius A. Gray. Snowberry '38, '39.
Vaccinium sp. '39.

CLASS D

Grasses

Agropyron dasystachyum (Hook.) Scribn. Thickspike wheatgrass '38, '39.
Agropyron repens (L.) Beauv. Quackgrass '39.
Agropyron riparium Scribn. and Smith. Streambank wheatgrass '39.
Agrostis hiemalis (Walt.) B. S. P. Ticklegrass '39.
Agrostis sp. Bentgrass '38, '39.
Andropogon furcatus Muhl. Big bluestem '39.
Andropogon scoparius Michx. Little bluestem '38.
Beckmannia syzigachne (Steud.) Fernald. American sloughgrass '38.
Bouteloua curtipendula (Michx.) Torr. Side-oats grama '39.
Bromus carinatus Hook. and Arn. California brome '38, '39.
Bromus rigidus Roth. Ripgut grass '39.
Bromus rubens L. Foxtail chess '38.
Buchloë dactyloides (Nutt.) Engelm. Buffalograss '39.
Calamagrostis inexpansa A. Gray. Northern reedgrass '38.
Dactylis glomerata L. Orchard grass '38, '39.
Danthonia californica Boland. California oatgrass '39.
Danthonia unispicata (Thurb.) Munro. One-spike oatgrass '39.
Deschampsia sp. Hairgrass '38.
Distichlis stricta (Torr.) Rydb. Desert saltgrass '39.
Elymus canadensis L. Canada wild-rye '39.
Festuca rubra L. Red fescue '39.
Hordeum jubatum L. Foxtail barley '39.
Hordeum murinum L. Mouse barley '38.
Hordeum pusillum Nutt. Little barley '39.
Panicum capillare L. Witchgrass '39.
Poa ampla Merr. Big bluegrass '39.
Poa canbyi (Scribn.) Piper. Canby bluegrass '39.
Poa interior Rydb. Inland bluegrass '39.
Poa juncifolia Scribn. Alkali bluegrass '39.
Puccinellia nuttalliana (Schult.) Hitchc. Nuttall alkali-grass '38.
Puccinellia sp. Alkali-grass '39.
Schedonnardus paniculatus (Nutt.) Trel. Tumblegrass '39.
Setaria viridis (L.) Beauv. Green bristlegrass '39.
Sitanion jubatum J. G. Smith. Big squirreltail '38, '39.
Stipa columbiana Macoun. Columbia needlegrass '38, '39.
Stipa lettermani Vasey. Letterman needlegrass '38, '39.
Stipa occidentalis Thurb. Western needlegrass '39.
Stipa viridula Trin. Green needlegrass '39.

Grasslike plants

Eleocharis pauciflora (Lightf.) Link. Bulrush '39.
Equisetum sp. Horsetail '38.
Juncus longistylis Torr. Wire rush '38.

Weeds

Aconitum columbianum Nutt. Columbia monkshood '38.
Amaranthus graecizans L. Tumbleweed '38, '39.
Amaranthus retroflexus L. Pigweed '39.
Amsinckia rugosa Rydb. '38.
Amsinckia sp. Fiddleneck '38.
Antennaria rosea Greene. Cat's-foot '39.
Anogra pallida (Lindl.) Britton. Evening primrose '38.
Aplopappus carthamoides eusickii A. Gray. Goldenbane '38, '39.
Apocynum sp. Indian hemp '38, '39.
Aquilegia formosa Fisch. Sitka columbine '38.
Argentina anserina (L.) Rydb. Silverweed '38.
Asclepias mexicana Cav. Milkweed '38.
Asclepias sp. Milkweed '38.
Aster eatoni (A. Gray) Howell '38.
Astragalus parshii Dougl. Vetch '38, '39.
Boisduvalia densiflora (Lindl.) S. Wats. '38.
Brodiaea douglasii S. Wats. '38.
Carum gairdneri (Hook. and Arn.) A. Gray '38.
Caulanthus crassicaulis (Torr.) S. Wats. Stenflower '38, '39.
Cirsium drummondii Torr. and Gray. Thistle '38, '39.
Clarkia pulchella Pursh '38.
Claytonia perfoliata Donn. Squaw lettuce '38.
Claytonia sp. Spring beauty '38.
Clematis ligusticifolia Nutt. Clematis '38.
Collomia linearis Nutt. Slender-leaved collomia '38, '39.
Collomia sp. Collomia '38.
Convolvulus arvensis L. Bindweed '39.
Crepis occidentalis Nutt. Hawks beard '38.
Dillisia nyctelea L. '38.
Epilobium adenocaulon Hausskn. Willow herb '38, '39.
Erigeron bloomeri A. Gray. Fleabane '38.
Eriogonum andinum Nutt. '39.
Eriogonum aridum Greene. '38.
Eriogonum heracleoides Nutt. '38.
Eriogonum microthecum Nutt. '38, '39.
Eriogonum neglectum Greene. '39.
Eriogonum spp. '39.
Gaillardia aristata Pursh. Gaillardia '39.
Galium sp. Bedstraw '38, '39.
Gaura coccinea Nutt. '39.
Gaura sp. '38.
Gayophytum ramosissimum Torr. and Gray. Kitchenweed '38, '39.
Gilia aggregata (Pursh) Spreng. Timpinte '38.
Gilia pungens (Torr.) Benth. Prickly gilia '38.
Grindelia squarrosa (Pursh) Dunal. Gumweed '38, '39.
Hedeoma sp. '38.
Helianthella uniflora (Nutt.) Torr. and Gray. Little sunflower '38, '39.
Humulus lupulus L. Hopvine '38.
Idahoa scapigera (Hook.) Nels. and Macbr. '38.
Iva axillaris Pursh. Silver povertyweed '38, '39.
Iva xanthifolia Nutt. Marsh elder '39.
Linum lewisii Pursh. Prairie flax '38, '39.
Lithospermum spp. Stoneseed '38, '39.
Malvastrum coccineum (Pursh) Gray. Scarlet mallow '38, '39.
Mentzelia pumila (Nutt.) Torr. and Gray. Blazing-star '38.
Mimulus guttatus DC. Common monkeyflower '38, '39.
Mimulus nanus Hook. & Arn. Monkeyflower '38.
Monarda menthaefolia Graham. '39.
Nepeta cataria L. Catmint '39.
Nicotiana attenuata Torr. Tobacco '39.
Nymphaea polysepala (Engelm.) Greene. Yellow waterlily '39.
Onagra hookeri (Torr. and Gray.) Small. Evening-primrose '38.
Oreocarya multicaulis (Torr.) Greene. Hairyleaf '39.
Oreocarya sp. Hairyleaf '38.

Orthocarpus luteus Nutt. Yellow owlclover '38, '39.
Penstemon deustus Dougl. Beardtongue '38, '39.
Penstemon gairdneri var. *oreganus* A. Gray. '38.
Penstemon speciosus Dougl. '38.
Phlox douglasii Hook. Phlox '39.
Phlox spp. Phlox '38.
Physaria didymocarpa (Hook.) A. Gray. Double bladderpod '38.
Plantago major L. Plantain. '39.
Polygonum douglasii Greene. Knotweed '38.
Polygonum persicaria L. Smartweed '39.
Psoralea purshii Vail. '38.
Pteridium aquilinum (L.) Kuhn. Bracken fern '38.
Rudbeckia occidentalis Nutt. Cone-flower '39.
Ratibida columnaris (Sims) D. Don. Cone-flower '39.
Sanguisorba annua Nutt. '38.
Sidalcea glaucescens Greene. Prairie mallow '38.
Sisyrinchium halophyllum Greene. '38.
Smilacina amplexicaulis Nutt. False solomonseal '38, '39.
Solanum rostratum Dunal. Buffalo-bur '39.
Solidago rigida L. Goldenrod '39.
Sonchus arvensis L. Sow thistle '39.
Sphaeralcea rivularis (Hook.) Torr. Glove mallow '39.
Streptanthus cordatus Nutt. '38.
Thysanocarpus curvipes Hook. '38.
Trifolium macrocephalum (Pursh) Poir. '38, '39.
Urtica holosericea Nutt. Nettle '38.
Valeriana edulis Nutt. Edible valerian '38.
Vicia americana Muhl. American vetch '38.
Vicia sp. '39.
Viola nuttallii Pursh. Violet '39.
Zigadenus elegans Pursh. Mountain deathcamas '38, '39.

Browse and Trees

Abies concolor (Gord.) Engelm. White fir '39.
Amelanchier alnifolia Nutt. Common serviceberry '38, '39.
Artemisia cana Pursh. Silver sagebrush '38, '39.
Alnus tenuifolia Nutt. Alder '38, '39.
Artemisia rigida (Nutt.) A. Gray. Stiff sagebrush '38, '39.
Artemisia spinescens D. C. Eat. Budsage '38, '39.
Artemisia spp. Sagebrush '38, '39.
Atriplex confertifolia (Torr. and Frem.) S. Wats. Shadscale '38, '39.
Cercocarpus ledifolius Nutt. Mountain-mahogany '38, '39.
Chrysothamnus viscidiflorus (Hook.) Nutt. Little rabbitbrush '38, '39.
Gutierrezia sarothrae (Pursh) Britt. and Rusby. Snakeweed '38, '39.
Gutierrezia sp. Snakeweed '38.
Larix occidentalis Nutt. Western larch '39.
Lygodesmia spinosa Nutt. '38, '39.
Pinus monophylla Torr. and Frem. Singleleaf pifion '39.
Populus angustifolia James. Narrowleaf poplar '38, '39.
Populus italica DuRoi. Lombardy poplar '38.
Pseudotsuga taxifolia (Poir.) Britton. Oregon Douglas-fir '39.
Populus trichocarpa Torr. and Gray. Black balsam poplar '38, '39.
Purshia tridentata (Pursh) DC. Bitterbrush '38, '39.
Rhus trilobata Nutt. Skunk bush '39.
Rubus parviflorus Nutt. Blackberry '39.
Sarcobatus vermiculatus Torr. Greasewood '38, '39.
Spiraea corymbosa Raf. Dwarf spiraea '39.
Symphoricarpos albus (L.) Blake. Snowberry '38, '39.
Tetradymia comosa A. Gray. Horsebrush '38, '39.

Table 9 summarizes the food-plant list. It shows that 21 percent of the entire list is composed of grasses and grasslike plants, most of them important forage species. Fourteen percent of the total is composed of shrubs and trees.

TABLE 9.—*Number of species of grasses, grasslike plants, weeds, and browse and trees in each class of the Mormon cricket food-plant list*

Class	Species of grasses		Species of grasslike plants		Species of weeds		Species of browse and trees		Total number of species in each class
	Number	Percentage of class total	Number	Percentage of class total	Number	Percentage of class total	Number	Percentage of class total	
A	14	12	4	3	86	74	13	11	117
B	7	21	0	0	24	73	2	6	33
C	15	17	3	3	57	64	14	16	89
D	38	23	3	2	96	59	27	16	164
Total	74	18	10	3	263	65	56	14	403

SUMMARY

During the field seasons of 1938 and 1939, field studies and surveys were conducted by the Mormon cricket control project of the Bureau of Entomology and Plant Quarantine with the view of determining the nature and economic importance of Mormon cricket damage to cultivated and range plants. Intensive studies were largely confined to Nevada, Idaho, and Oregon, where the heaviest and most critical outbreaks were to be found. The major infestations in adjacent States were visited and briefly surveyed. Damage surveys covered all States in which control programs were in operation, injury records being supplied through the cooperation of local and State supervisors of the Mormon cricket control project.

Detailed field studies consisted of a series of permanent tenth-acre observational plots located in areas where Mormon cricket utilization of the range was heaviest. The plots, which were visited periodically, contained marked plants for which growth and injury records were kept. "Spot" observations and transects of point-observation plots were used to sample range feeding of the Mormon cricket elsewhere. Injury was measured in the permanent plots in terms of both percentage loss in seasonal forage production and percentage loss in dry weight of all herbage. The transects measured injury in terms of one or the other, depending upon the method of collecting field data. A food-plant list was compiled and arranged so as to indicate broadly the preference of the Mormon cricket for the various species.

The Mormon cricket (*Anabrus simplex* (Hald.)) and the coulee cricket (*Peranabrus scabricollis* (Thos.)) are at present the only members of the subfamily Decticinae of economic importance in the northwestern part of the United States. The former occurs from the Red River Valley in northwestern Minnesota southward through western Kansas and Colorado into the mountains of northern New Mexico. From these points it ranges westward to the Sierra Nevada and Klamath Mountains of California and the Cascades of Washington and Oregon. In Canada the species occurs in the southern portions of the Provinces adjacent to its range in the United States. The coulee cricket is present in Washington, Oregon, Idaho, Montana, and probably other Western States, but was of economic importance in 1939 in a single area in Jefferson and Wasco Counties, Oreg. The feeding habits of the two insects are identical, as are the control measures employed against them. *Anabrus cerciata* Caudell and *A.*

longipes Caudell are potentially important pests but in 1939 they did not constitute a problem. Collection records for the last two species are confined to the northwestern quarter of the range of the Mormon cricket.

Mormon crickets are general feeders upon vegetation and on occasion are both cannibalistic and predatory upon other insect species. They prefer cultivated plants to most range species as food. For this reason the almost total destruction of a wheat or alfalfa field may occur while the range in the vicinity shows much less injury per unit of area. The injury to plants is due to the removal of vegetative and reproductive parts, breaking of the flower stalks by the weight of the feeding insects, or, rarely, by the girdling of the twigs of shrubs, such as the big sage *Artemisia tridentata*.

The first three instars of the Mormon cricket injure plants in the same way as do older nymphs and adults. Because of the range of instars present at any one time in an average band of nymphal crickets, the molting period does not appear to cause periodic cessations of feeding by the band as a whole. The insects were most frequently observed feeding at temperatures between 70° and 95° F. Feeding was heavier on sunny days than on cloudy ones; it usually ceased at dusk but sometimes continued well into the night if high daytime temperatures prevailed.

Mormon crickets show a definite preference for the inflorescences of plants. This means that moderate damage to a cereal crop on a percentage volume basis may result in the almost complete destruction of all grain, and that small, scattered, annual range plants may be exterminated locally. The kind of grasshopper damage most frequently observed in northeastern Wyoming and parts of South Dakota during 1939 differed strikingly from Mormon cricket damage in that leaves and leaf sheaths were stripped from the culms of cereals and range grasses whereas the inflorescences were left unharmed.

Of the 62,977 acres of crops damaged in 1939, at least two-thirds were infested with nymphal crickets by the end of May. After June 30, 1939, a constantly diminishing number of acres of crops were newly infested. In August, with most of the cereal crops harvested, only 80 acres of cultivated crops were reported newly invaded. The greater proportion of crop damage was done by nymphs and adults previous to the time of oviposition.

Mormon crickets occur in all the major vegetation types found within the limits of their geographical distribution. Plant composition and altitude do not noticeably affect distribution. Plant composition, however, does determine the relative importance of Mormon cricket damage to range land in different States. Damage to the range is of great importance in the sparse herbage of the northern desert shrub areas in Oregon, Nevada, Idaho, and Utah. Here, because the dominant plants are shrubs relatively unattractive as food, heavy injury may be inflicted upon the principal forage grasses and weeds. Range damage is of less importance than elsewhere in the short grass (mixed prairie) vegetation of Montana, South Dakota, Wyoming, and Nebraska. The weight of herbage per unit of area in these States is so great, as compared with that in northern desert shrub areas, that similar amounts of cricket feeding cause much less percentage injury. In these same States the destruction of seeds of perennial grasses could not be measured in terms of forage production or weight

loss; in 1939 it is believed to have had an imperceptible effect, if indeed it had any, upon the density and composition of the range.

Range damage by Mormon crickets can be measured by reconnaissance-survey methods in terms of percentage loss in seasonal forage production and in dry weight of total herbage. In 1939, range damage was so slight in the States of Wyoming, Montana, South Dakota, and Nebraska that it was not subject to measurement by these methods. In Oregon, Idaho, and Nevada recurrent Mormon cricket injury to browse plants, particularly snowberry (*Symphoricarpos* spp.), may be great enough to cause the death of the plants. This was demonstrated by records of marked plants in permanent plots in Oregon and Nevada. Perceptible changes in plant density and composition occurred in some of the permanent observational plots which are believed to have been due both to Mormon cricket feeding and drought. The exact weight of each of these factors could not be determined.

Maximum seasonal forage loss due to Mormon cricket feeding reached 100 percent in several localities in Nevada and Oregon. Where this occurred, crickets were present throughout the season. A heavily damaged area in Humboldt County, Nev., lost 45 percent of its total weight of herbage during 1939. This amounted to 280 pounds (dry weight) per acre of forage and nonforage plants. The seasonal forage losses for the same area were 74 percent for cattle and 98 percent for sheep. This example illustrates how percentage loss in total herbage was very regularly exceeded by percentage losses in seasonal forage production. Two years' observations at the same sites have shown that almost total destruction of seasonal forage may occur in successive years. The areas where this did occur and is likely to occur are, as a rule, small and limited in number.

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