

Anabrus simplex Haldeman

Distribution and Habitat

The Mormon cricket, a shieldbacked katydid (family Tettigoniidae, subfamily Decticinae) and not a true cricket, lives in western North America in rangeland dominated by sagebrush and forbs. Large populations develop in the open sagebrush-grass associations of the Great Basin and of mountain ranges. In the Rocky Mountains of Colorado, small resident populations occur from 6,500 feet in forest openings to above 11,000 feet in the alpine tundra.



Geographic range of *Anabrus simplex* Haldeman

Economic Importance

Mormon crickets damage forage plants on rangeland and cultivated crops in the path of their migrations. The adult Mormon cricket is a large insect; males average 3,400 mg live weight and females 4,100 mg (dry weight: males 960 mg, females 1,330 mg). Feeding tests demonstrate that during its nymphal period and 20 days of adult life, an average Mormon cricket consumes 3,518 mg of vegetation (dry weight). Calculations based on this figure indicate that at a density of one per square yard the Mormon cricket consumes an amount of rangeland forage equal to 38 pounds dry weight per acre. Because of their migratory habit, Mormon crickets may be present in a particular site for no more than three or four days. In this short time, their damage to rangeland is perceptible but not measurable by standard quantitative techniques.

The Mormon cricket breeds only infrequently in cultivated fields, but migrating bands of nymphs or adults may completely destroy fields of sugarbeets, small grains, and alfalfa. During the 1937 outbreak, crop damage in Montana amounted to \$500,000 and in Wyoming to \$383,000.

Food Habits

Although the Mormon cricket has been observed to feed on more than 400 species of plants, this insect discriminates in its choice of foods, preferring certain succulent forbs. Examinations of crop contents and direct observations of feeding show that preferred forbs include milkvetches,

penstemon, arrowleaf balsamroot, dandelion, and several mustards such as wild mustard, tumble mustard, and pepperweed. Among the abundant shrubs growing in its habitat, the Mormon cricket has often been observed feeding on saltbush and on species of sagebrush (big sagebrush, budsage, fringed sagebrush). At certain times of the season it may restrict its feeding to two to four staple foods available in its habitat. These may include various forbs, grasses, seeds, fungi, and arthropods. When grasses and forbs begin seed development, Mormon crickets (adult by this time) climb the plants and feed preferentially on the nutritious kernels.

Mormon crickets relish cultivated plants; they feed voraciously on wheat, barley, alfalfa, sweetclover, truck crops, and garden vegetables.

Migratory Habits

Despite its flightless state, the Mormon cricket is a very mobile insect. The first four instars move about extensively in search of food and shelter and in short migration. Their net travel is not far. Older instars and adults, however, migrate in cohesive bands in fixed directions and may cover from one-half to one mile in a day and travel from 25 to 50 miles in a single season. Locomotion is limited to crawling and hopping, as their wings are short and unsuited for flight. Although Mormon crickets have been observed traveling at night, they migrate chiefly during the day when skies are clear and temperatures favorable (65° to 95°F air). When two bands meet, they either coalesce into one larger band or they maintain their separate directions of migration and flow through each other as they intersect.

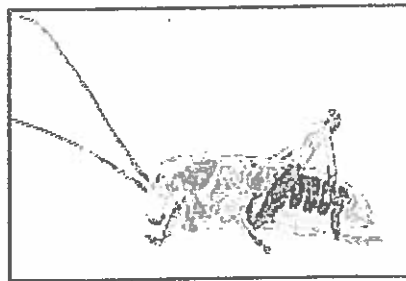
Hatching

Embryonic growth begins when the eggs are laid in summer. The eggs attain complete development by fall, at which time they diapause before entering winter dormancy. At high mountain altitudes embryonic development may be delayed, prolonging incubation of eggs an additional year. Mormon crickets emerge in spring at much lower temperatures than do grasshoppers. Hatching starts when soil temperatures reach 40°F.

Nymphal Development

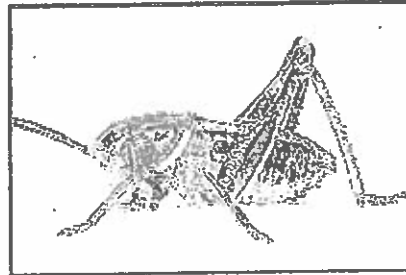
Mormon cricket nymphs develop and grow under the cool conditions of spring. They pass through seven nymphal instars and take 60 to 90 days to reach the adult stage. When ready to molt, Mormon crickets climb plants and hang head or back downwards securely fastened to a leaf or branch by the tarsal claws of all three pairs of legs. Molting is accomplished in 10 to 20 minutes, after which the insect turns upright and remains inactive on the plant

Instar 1



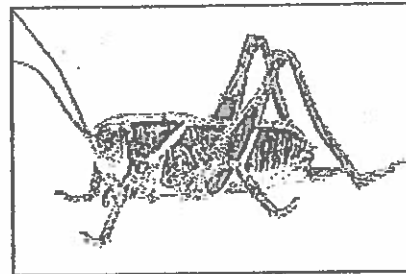
1. BL 6-8.2 mm FL 4.2-4.5 mm DV 0.2-0.3 mm.

Instar 2



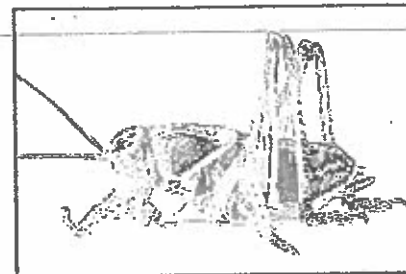
2. BL 6.8-8.9 mm FL 5.5-6.1 mm DV 0.5-0.6 mm.

Instar 3



3. BL 10.6-13.3 mm FL 7-7.7 mm DV 1-1.2 mm.

Instar 4



4. BL 12-14 mm FL 8.8-9.6 mm OVP 2.2-2.7 mm.

Instar 5



5. BL 16-19 mm FL 10.2-11.6 mm OVP 4.4-4.6 mm.

Figures 1-5. Appearance of the five nymphal instars I to V of the Mormon cricket - their sizes, structures, and color. BL=body length, FL=hind femur length, DV=dorsal valve of ovipositor length, OVP=ovipositor length.

for several minutes while its cuticle hardens and darkens. Before crawling away, it usually eats its own cast skin.

Identification

Of the more than 100 species of shieldbacked katydids in western North America, only a few are ground-dwelling, rangeland insects. The majority live in shrubs and bushes. To aid in identification of Mormon crickets, compare specimens collected on the ground from grasslands and sagebrush communities with Figures 1-9, noting the long antennae, smooth and shiny integument, color patterns, shapes, and the gentle upward curve of the ovipositor. A diagnostic character of the adult male is the bifurcation and shape of the cercus (Fig. 11). The bifurcation begins to be clearly evident in the fifth instar as a black bump on the inner surface of the cercus. The female cercus remains small and cone-shaped.

Adults and Reproduction

Courting and mating begin 10 to 14 days after Mormon crickets reach the adult stage. From a perch in vegetation a courting male attracts receptive females by rubbing his tegmina together to produce a calling song. When a female approaches, he either drops to the ground to meet her or waits for her to climb to him. The female mounts the male, who assumes a C-shaped position underneath the female, and the pair couple. The male transfers to the female's genitalia a large white spermatophore that consists of two main parts: a small sperm ampulla containing two pockets of sperm and a large proteinaceous bulb, the spermatophylax. The transfer is accomplished in a few minutes, after which the pair separates. While the sperms are draining into the spermatheca of the female, she eats the spermatophylax and then eventually consumes the empty ampulla. The extra protein and other nutrients are used by the female in producing eggs. Because the spermatophore represents up to 27 percent of the male's body weight, he makes a substantial contribution to the growth and survival of his offspring, a relatively rare occurrence among insects.

A gravid female deposits eggs singly in bare ground, often utilizing the mounds of the western harvester ant. As soon as a female lays an egg in the soil, she withdraws her ovipositor and covers the exit hole with soil by several quick, backward movements of this organ. She then moves to another location where she repeats the act of oviposition. Results of cage tests at Billings, Montana indicate that the fecundity of the Mormon cricket is approximately 86 eggs per female. Of 15 pairs caged individually, the greatest reproduction of a single female was 160 eggs and as many as 35 eggs were laid by one

Figures 6-10. Appearance of nymphal instars VI and VII, adult male and female and eggs.

female in a day. Females oviposit in bouts that occur at intervals of approximately seven days. The eggs (Fig. 10) are 7 to 8 mm long, and are dark brown when first laid but soon turn white. After several days of development the eggs become gray.

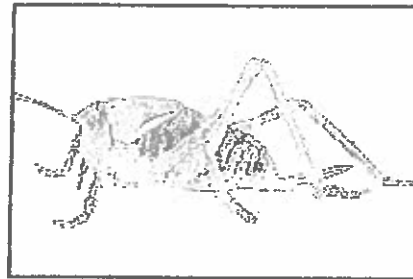
The Mormon cricket has one generation annually, but in high mountain habitats two years may be required to complete a single generation.

Population Ecology

The Mormon cricket possesses a life history well-suited to its rough habitat in the western states. Long before Europeans explored the area, outbreaks of the Mormon cricket occurred regularly enough that the indigenous peoples developed methods of harvesting these insects. Among the artifacts discovered in a cave inhabited by humans near Ten Sleep, Wyoming, the cooked remains of several hundred Mormon crickets were found in a roasting pit. Charcoal from the fire hearth gave a radiocarbon date of 222 ± 150 years BC.

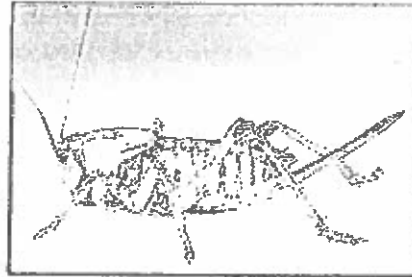
From less than one per square yard in mountain habitats, Mormon cricket densities may grow gradually over a period of several years, reaching densities of adults as great as 100 per square yard. Once populations have reached outbreak proportions, the crickets begin extensive migration to foothills, rangeland, and crops. The high densities may persist for years; numerous outbreaks have lasted from 5 to 21 years. A recent major outbreak began in 1931 and continued for 17 years. At the peak of the infestation in 1938, 19 million acres in 11 states were infested.

In some years, threatening numbers of Mormon crickets do not continue to increase and an outbreak is averted by the action of natural control factors. The exact nature of these factors has not been discovered. Variations in weather have been suspected of contributing to fluctuations of Mormon cricket populations. Yet populations have concomitantly increased and later decreased within climates ranging from 500 feet altitude in the deserts of Nevada and Washington to alpine elevations of 8,000 feet in the mountains of Montana and Wyoming, from average annual rainfall ranging from 6 to 20 inches, and from an average annual frost-free season ranging from less than 30 days to one of 180 days. During the early nymphal period (instars I to IV), substantial reductions in numbers have been observed following prolonged periods of rain, snow, or daily freezing temperatures. Another mortality factor that undoubtedly varies among populations of Mormon crickets is the number of predators, especially California gulls, hawks, crows, rodents, and the digger wasp, *Palmodex laeviventris*. The few parasites of the Mormon cricket do not appear to exert much control. Prevalence of disease varies widely. The microsporidian *Vairimorpha* produces high spore levels in many tissues of Mormon crickets, causing sluggish behavior and high mortality.



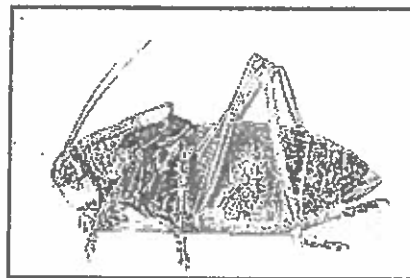
Instar 6

6. BL 17.5-22 mm FL 13.4-15 mm OVP 9.7-11.1 mm.



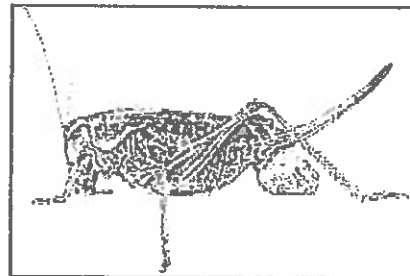
Instar 7

7. BL 27-32 mm FL 16.5-18 mm OVP 19.5-22.5 mm.



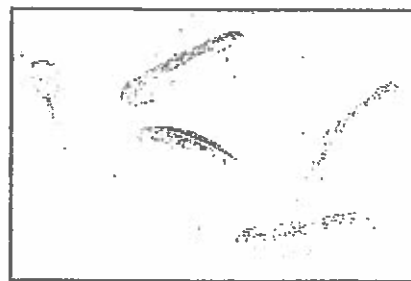
Male

8. BL 39-43 mm FL 21.5-23 mm.



Female with spermatophore

9. BL 41-49 mm FL 22-24 mm OVP 27-30 mm.



Eggs

10. Five eggs dug from soil in habitat.

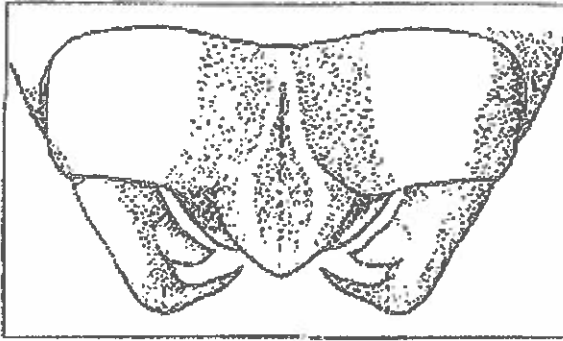


Figure 11. Paired cerci of male Mormon cricket, dorsal view. Drawing by Ashley B. Gurney.

To complicate the ecological problem even more, the Mormon cricket itself may change its morphology, physiology, and behavior as populations increase in density. Similar transformations have been found in locusts of the Old World and to a lesser extent in North American grasshoppers. An explanation of these changes was made by Sir Boris Uvarov in his promulgation of the "phase theory."

Daily Activity

The behavior patterns of Mormon crickets allow the nymphs to cope with cold nights and spells of inclement weather in early spring. They find shelter under canopies of shrubs, crawling into the litter and under large recumbent stems. Big sagebrush is an especially favored refuge, but other sagebrushes and saltbush provide good cover. Mormon crickets also crawl into soil cracks and under soil clods, and under dry sheep and cow dung. A few nymphs, however, may climb to the tops of big sagebrush in the evening and remain on these perches through the night.

On a mild spring day nymphs emerge from their shelters after sunrise and crawl to the east side of the bush to bask in the first rays of the sun. They rest on the ground, individually or in small clusters of four to 12 nymphs, and expose their sides or backs to the sun's warming rays. They may extend

both hindlegs behind themselves to expose more body surface. During the basking period Mormon crickets often stir and change positions and are easily agitated by the movement of adjacent individuals.

The nymphs bask for two to three hours, during which time ground temperatures rise from around 40° to 80°F. The warmed crickets then move away from the bush that sheltered them and begin pottering (walking about in various directions) and feeding. Eventually almost all individuals begin walking in one direction as a cohesive band. Individual crickets may stop to feed during the migration, but when satiated they again join the marching band.

Mormon crickets cease migrating two to three hours before sunset and begin basking again, this time on the west side of bushes. They bask on the ground individually or in clusters of 25 to 50 nymphs sitting close together. Near sunset, as shadows cover the ground, individuals may climb big sagebrush or saltbush to bask in the last rays of the sun. During the final three hours of daylight, Mormon crickets also do much feeding. By sunset most crickets have already retreated to their shelters.

When the day is overcast and cold, rainy or snowy, or very windy, Mormon crickets remain in their refuges. A sudden change during the day from mild to inclement weather induces them to retreat to shelters and stay hidden.

Adults behave much like the nymphs. They seek shelter in the evening and pass the night chiefly under the canopy of shrubs. An hour or two after sunrise they emerge from their shelters and bask in the warming rays of the sun. After basking for about two hours they begin to walk about and feed. Adults at low densities may stay in a favorable habitat where they survive and reproduce. At high densities, however, adults migrate extensively. A few individuals begin migrating in early morning when soil surface temperatures reach 76° to 85°F and all join in the migration when temperatures reach 96° to 105°F.

During the middle of the day, migrating adults may encounter soil temperatures too hot (above 110°F) for them to continue. They escape the extreme heat by climbing shrubs and roosting until temperatures moderate. Migration may then begin again.

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