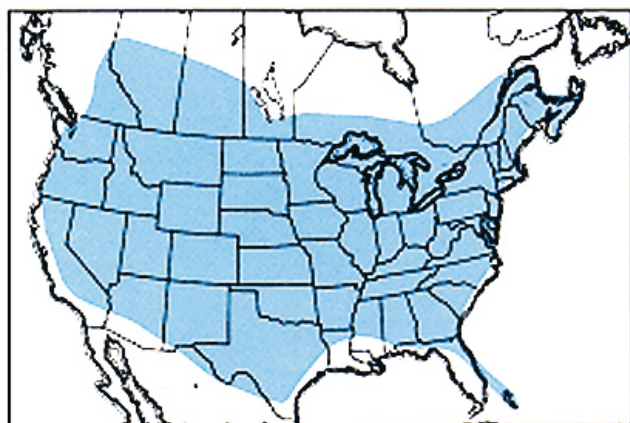


Carolina Grasshopper

Dissosteira carolina (Linnaeus)

Distribution and Habitat

The Carolina grasshopper, a large bandwinged species, ranges widely in North America inhabiting weedy grasslands. Blowouts, field margins, roadside strips, weedy fence rows, railway cuttings, and disturbed rangeland support moderate populations of this species. During the day when temperatures warm, the adults move from vegetated to bare areas such as dirt roads where they fly about and become highly conspicuous.



Geographic range of *Dissosteira carolina* (Linnaeus)

Economic Importance

The Carolina grasshopper is a minor pest of rangeland grasses. Populations occur chiefly in disturbed areas where it feeds mainly on several species of weeds. The populations that irrupt in favorable habitats, however, may disperse and damage crops. Disturbed areas reseeded with smooth brome foster large numbers of this species, which not only feed on the brome but often fly to fields of fall wheat where they cause stand damage. An outbreak of the Carolina grasshopper that irrupted in southern Saskatchewan in 1933 and 1934 caused considerable damage to the crops of this region. In some years the species has damaged tobacco in southern Ontario. It has also been recorded as causing minor damage to alfalfa. In 1935 it was especially destructive to field beans in the vicinity of Flagstaff, Arizona. In Oklahoma it has been reported to damage corn, sorghum, cotton, and potato. No detailed study of its economic importance, however, has been made.

Because of its large size the Carolina grasshopper has been regarded as a voracious feeder capable of causing much damage at moderate densities. The live weight of males averages 570 mg and of females 1,467 mg (dry weight: males 171 mg, females 387 mg).

Food Habits

The Carolina grasshopper selects food plants from both grasses and forbs. An individual's diet depends largely upon the kinds of host plants present in its habitat. An investigation of plants ingested by adults living in two different habitats reveals the wide variation that may occur naturally in their diets. In a disturbed site that had been reseeded to smooth brome and crested wheatgrass,

crop contents of adults consisted of 98 percent smooth brome, while in a disturbed site where no reseeding was done but weed invasion had taken place, crop contents consisted of 64 percent weeds and 33 percent native grasses (Table 1). Although the Carolina grasshopper may be considered a polyphagous species, it prefers some plants over others. Ingested weeds in Site 2 (Table 1) consisted principally of kochia and Russian thistle; weeds rejected included netseed lambsquarters, redroot pigweed, and curlycup gumweed.

Two-choice laboratory tests revealed that the Carolina grasshopper fed readily on downy brome, smooth brome, western wheatgrass, wheat, barley, dandelion, and kochia. Because of its wide distribution, the Carolina grasshopper undoubtedly has many more host plants than presently known.

Table 1. Mean percent dry weight of plant fragments in crops of adult *Dissosteira carolina*.

	Food	Site 1	Site 2
Grasses	Agropyron	0.6	10.9
	Andropogon		3.8
	Bromus	98.3	8.5
	Carex		7.9
	Sporobolus cryptandrus		11.0
	Sporobolus seed		0.2
Forbs	Atriplex		0.2
	Kochia scoparia	1.1	32.3
	Kochia seed		2.0
	Salsola iberica		21.4
	Seed sp.		0.6
	Sphaeralcea coccinea	0.1	
	Feather		2.0
	No. grasshopper crops	15	19

Site 1 Wyoming, Laramie Co. Pine Bluffs Rest Area, 4 September 1992, disturbed mixedgrass prairie, reseeded to smooth brome and crested wheatgrass.

Site 2 Wyoming, Laramie Co. 11 miles west Pine Bluffs (R62W T14N Sec36 NW) 16 September 1992, disturbed mixedgrass prairie, invaded by weeds.

Several observations of the Carolina grasshopper's feeding in nature have been made. On 5 August 1992 at 6:51 p.m. DST with soil temperature 81°F and air at 1-inch level 74°F, an instar III female climbed a 3-inch tall kochia plant and in a vertical head-up position fed on a kochia leaf (2 x 7 mm) beginning at the tip and devouring it to its base leaving a 2 mm stub.

On 27 July 1990 at 9:10 a.m. an adult male was discovered sitting on ground litter facing the sun in a city lot. At 9:13 a.m. the male began to stir and walked a short distance to a short grass, *Buchloe dactyloides*. At 9:14 a.m. the male reached up with its mouthparts to the tip of a leaf and consumed the whole leaf to the base. He then attacked another leaf of the same plant, cutting it near the middle. Holding onto the cut section with the front tarsi, he consumed all of it from

Instar 1



1. BL 6.5-7 mm FL 3.5-3.8 mm AS 12-14.

Instar 2



2. BL 7.8-9.1 mm FL 3.7-4.2 mm AS 15-16.

Instar 3



3. BL 8.8-13.5 mm FL 4.6-7.3 mm AS 18-20.

Instar 4



4. Males: BL 13-15 mm FL 7-7.5 mm AS 21-23.
Females: BL 16-20.5 mm FL 9.3-10.3 mm AS 20-21.

Instar 5



5. Females:
BL 20.5-22.5 mm FL 12-17.7 mm AS 21-24.

Figures 1-5. Appearance of the five nymphal instars of *Dissosteira carolina* - their sizes, structures, and color patterns. Notice progressive development of the wing pads. BL = body length, FL = hind femur length, AS = antennal segments number.

the cut end to the tip. He then cut another leaf of the same plant near the base, held onto it with the front tarsi, and ate all of it. A fourth and final leaf was eaten from the tip to the base. Feeding ended at 9:24 a.m. During all of the feeding the male sat horizontally on the ground, resting on the mid- and hindlegs and using the forelegs to handle the food. The weather was clear, warm, and calm (soil surface 94°F, air 72°F, at 1-inch level, wind 0-2 mph).

On 2 October 1992 from 4:28 to 4:37 p.m. DST (soil surface 92°F and air 1-inch level 80°F), three females wandering around on bare ground were observed to feed on ground litter (dry grass and unidentifiable vegetation). The females were horizontal on the surface. One female was observed to spread out her front legs rather than use the front tarsi to handle the food.

These few observations suggest that the Carolina grasshopper is a thrifty feeder because it appears to eat all of whatever it attacks.

Migration and Dispersal

The Carolina grasshopper is a strong, adept flier. During warm, sunny days the adults frequently fly over bare ground interacting with one another. Males are noted for their hovering flight. They rise almost vertically from the ground to heights of 3 to 6 feet, occasionally higher, and hover for 8 to 15 seconds. At the end they flutter down to the ground close to where they started. They may repeat this maneuver as many as five times. During the hovering flight they produce a soft, sibilant sound. The hovering behavior may be a part of courtship in that it attracts females. The display also attracts males so that a small aggregation of several males and a female may gather on the bare ground beneath the hovering male.

In voluntary or appetitive flights, adults fly a distance of 2 to 36 feet at heights of usually 1 to 2 feet. They undulate and may crepitate as they fly. Adults are wary and flush readily at the approach of a person. In flushed flight they may travel a distance of 4 to 70 feet or much farther in a strong wind. They fly at heights of 1 to 5 feet and often make a right angle turn at variable distances into the flight before landing on the ground.

No special study of dispersal or migratory flight has been made, but it is known that adults have moved from resident localities near Boulder, Colorado to nonresident mountain sites above 10,000 feet, approximately 14 miles west. In the vicinity of Washington, D.C., considerable numbers frequently fly around the electric lights during warm summer nights. The species has also been collected at lights in Presidio, Texas and in North Branch and Minneapolis, Minnesota.

Identification

The Carolina grasshopper, one of North America's largest grasshoppers, is a conspicuous species because of its size, colorful wings, and habit of flying over dirt roads and other bare ground (Fig. 6 and 7). The wingspread of the males

Figures 6-10. Appearance of the adult male and female, wings, inner surface of hindleg, and egg pod and exposed eggs.

measures 3 inches and that of the females 3 1/2 to 4 inches. The hind wings are black with a pale yellow margin (Fig. 8). The tegmina are colored tan, brown, or gray matching the general body color and are faintly speckled.

The nymphs are identifiable by their color patterns, shape, and external structures (Fig. 1-5).

1. Head with face nearly vertical; antennae filiform, terminal segments dark, basal segments colored like body; lateral foveolae small and triangular.
2. Pronotum with median carina strongly elevated and cut once.
3. Hind femur with medial area evenly colored like body, may be spotted in instars IV and V; inner knee tan or fuscous, basal half of inner medial and lower marginal areas fuscous, distal half with two pale yellow transverse bands (Fig. 9); hind tibia of instar I and II black with basal annulus pale yellow, hind tibia of instars III to V with variable patterns of tan, gray, and black; hind tarsus white or pale yellow except distal end fuscous.
4. General body color tan, brown, or gray. Reddish in individuals developing on red soils.

Hatching

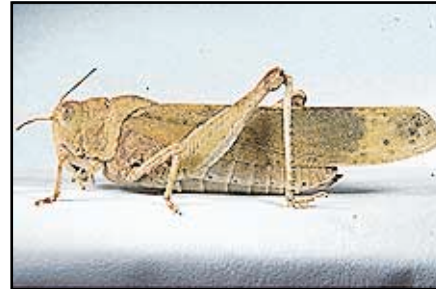
The Carolina grasshopper is an intermediate-hatching species. In eastern Wyoming hatching may start in early June or may be delayed until late June. Although egg development has not been studied in this species, the fact that oviposition takes place late in summer suggests that much development probably occurs during the following spring. This speculation appears more plausible in view of the results of subjecting overwintered field-collected eggs to five different constant temperatures. At 77°F, eggs of the Carolina grasshopper completed incubation in 22 days, whereas the two-striped grasshopper *Melanoplus bivittatus* completed incubation in 7 days and the differential grasshopper, *M. differentialis* in 21 days. Egg development of the Carolina grasshopper appears more like that of the differential grasshopper, which achieves less growth before diapausing than the two-striped.

Nymphal Development

The nymphs emerge over a period of at least two weeks and develop in a habitat of grass and weeds with much interspersed bare ground. Hatching, however, may at certain times and places be extended over several weeks so that as many as four different instars (I to IV) coexist together in a habitat. Limited data obtained in eastern Wyoming indicate a nymphal period of 40 days at an altitude of 4,700 feet and 55 days at an altitude of 6,100 feet. Reared in the laboratory, nymphs complete development in 52 days at a constant temperature of 77°F and 26 days at a constant temperature of 86°F. The Carolina grasshopper has been described as a heat-loving species that prefers the hot, bare areas of its habitat.



6. BL 29-32 mm FL 14.5-16 mm AS 25-26.



7. BL 36-39.5 mm FL 17.5-19 mm AS 25-27.



8. Left forewing (tegmen) and hindwing of female.



9. Inner surface of left hindleg of adult female.



10. Egg pod and several exposed eggs.

Male

Female

Wings

Hindleg

Eggs

Adults and Reproduction

The adults appear during May in New Mexico and eastern Nebraska, during early July in eastern Wyoming, and during late July in western Idaho. Once Carolina grasshoppers acquire functional wings, they fly and disperse extensively. Adults may move distances of several miles or more, as they have been found in the center of large cities. The full extent of individual dispersal, however, is unknown.

The habitat in which the eggs hatched and the nymphs developed remains occupied by adults, most likely by an assemblage composed of some of the original inhabitants and some immigrants. The males court females by producing a calling signal using their hindlegs and wings to stridulate. One hindleg at a time is rubbed against the tegmen in a behavior called alternate stridulation. A male sits horizontally on bare ground in sunlight and may continue to call for 5 minutes or longer until he attracts a female. She walks toward him and when she is close he approaches her and mounts. If he is successful, the pair mate. They may remain in copulo for as long as 16 hours.

Sexual maturation of females appears to be prolonged. In Minnesota, where the adult stage is reached in early June, the females do not begin to oviposit until early August, suggesting that nine weeks are required for maturation. In Manitoba, oviposition has been observed in September and in Wyoming in September and October.

The female selects compact bare ground exposed to the sun in which to oviposit. The selected site is often the edge of a gravel or dirt road. She works her ovipositor to a depth of 1 1/2 inches and deposits a large clutch of eggs that she encloses in a sharply curved pod (Fig. 10). After approximately 1 1/3 hours, she extracts her ovipositor and for one to three minutes brushes surface particles with her hind tarsi over the aperture of the hole. The pod, nearly 2 inches long, usually contains more than 40 eggs. Two egg pods obtained after observing the females oviposit at the edge of a gravel road in southeastern Wyoming contained 50 and 57 eggs, respectively. Reared in a greenhouse, caged females have laid from 30 to as many as 70 eggs in a pod. The eggs are reddish brown and 4.8 to 5.8 mm long.

Population Ecology

The population ecology of the Carolina grasshopper has received no special study. Several population characteristics, however, can be inferred from general studies of grasshopper assemblages in which the Carolina was a member. Populations appear to persist year after year as long as the habitat remains intact. Because of the Carolina grasshopper's association with human activities, habitats may be destroyed by development projects, by rerouting of ranch roads, or by changes in farming and ranching practices. Collections of nymphs and adults from a

city lot in Wheatland, Wyoming were made for a period of four years, 1989-92, during which the densities of the successive populations remained approximately the same.

Although adults are conspicuous because of their size and flashy wings, giving the impression of large numbers, the density of populations is usually low, around 0.1 to 0.2 young adults per square yard. Populations irrupt infrequently, as in southern Saskatchewan in 1933 and 1934, causing serious loss of crops. No estimates of absolute densities were determined during this outbreak.

Daily Activities

The Carolina grasshopper, a ground-dwelling species, is active chiefly during daylight hours. Emerging from overnight shelters, both nymphs and adults bask in the morning sun for two to three hours beginning approximately two hours after sunrise. They turn a side perpendicular to the rays and lower the associated hindleg to expose the abdomen, and they often appress the flexed hindleg close against the ground.

After basking, the adults begin to walk and fly about the habitat. The males are more active than the females, perhaps searching for receptive females with which to mate. Females walk and fly far less than males, but do more feeding, grooming, and resting. Seven observations of feeding by adults indicate that this activity occurs in the afternoon from approximately noon to 5 p.m. DST. An observation of courting occurred at 12:25 p.m. Mating pairs have been observed in the afternoon: two pairs at 2:15 p.m., one pair at 3:15 p.m., and one pair at 3:47 p.m. In the George Reserve, Michigan, a pair observed in copulo at 5:20 p.m. on August 4, remained together until 7:50 a.m. the next morning. Three extended observations of oviposition in eastern Wyoming indicate that females perform this function during midday with oviposition beginning as early as 10:30 a.m. and as late as 2:30 p.m.

Hot ground temperatures of 110°F. and air temperature of 90°F., 1-inch level, induce the adults to stilt. As temperatures rise, the grasshoppers climb on vegetation and place themselves 1-3 inches above ground. They face the sun directly so that only the front of the head is exposed to the rays and the rest of the body is shaded.

In the afternoon the adults bask on bare ground for a second time beginning about 3 p.m. and ending about 5 p.m. Then they walk or fly to vegetated areas where they seek shelter usually under canopies of grasses. Sampling of their density on a bare, gravel road in Laramie County, Wyoming on 4 October 1992 showed that adults (0.06 per square yard) were 20 times more prevalent at 4 p.m. DST than at 5:17 p.m., and none were found at 5:29 p.m.

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