Dispersal of Marked Adult Coccinellids from Crops in South Dakota[1,2]

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ABSTRACT

In 1969, ca. 7175 adults of *Hippodamia convergens* Guérin-Méneville, *H. tredecimpunctata tibialis* (Say), and *H. parenthesis* (Say) were obtained locally, marked with enamels, and released in spring wheat, corn, and alfalfa in South Dakota. Only 9 of those freed were recaptured 24 or more h postrelease; 4 of the 9 were recaptured in fields other than the release field, one 2 miles away the day postrelease. A total of 1,125,000 *H. convergens* in 1970, and 2,250,000 in 1971, were imported from California and marked and released. One shipment (450,000 beetles) freed in October remained in aggregation but failed to survive the winter. Other beetles dispersed rapidly and were not detected at sites of release after 4 days.

Lady beetles have been widely recognized as important predators of aphids and have been credited with regulating field populations of some species of aphids (Hagen and van den Bosch 1968). Some of the principles underlying their successful management as biological control agents are well understood, but their effective application to specific crops and to different climatic areas require additional research and integration with other methods of aphid control (Hodek 1970). To avoid the complexities of ecological management of populations of aphid predators, some growers of grain and forage in the Midwest have resorted to ordering adult lady beetles from California for mass-release in their fields. Releases may be made to control aphids already colonizing crops or as insurance vs. future infestations. The tacit understanding seems to be that such introduced beetles will remain near the site of release. This procedure was not successful in reducing aphid populations in California, primarily because of rapid dispersal (Davidson 1924; Hagen and van den Bosch 1968). Nevertheless, some midwestern growers have claimed benefits from the releases.

Our principal objective was to determine how long adult coccinellids obtained locally or from California would remain near the site of release when they were freed in E South Dakota. Other observations of behavior and biology were made in the course of the tests. The species of coccinellids studied commonly occur in crops in South Dakota and are known to be aphidophagous.

METHODS AND MATERIALS.—In 1969, ca. 7175 adult coccinellids were obtained in South Dakota. Most were the convergent lady beetle, *Hippodamia convergens* Guérin-Méneville, and the thirteenspotted lady beetle, *H. tredecimpunctata tibialis* (Say), but a smaller group of *H. parenthesis* (Say) also was collected. About 2300 adult *H. t. tibialis* were acquired by collecting pupae attached to willow leaves infested with aphids, and confining the adult beetles as they emerged from pupation. The other beetles were obtained by aspirating adults from crop plants or from vegetation lining the shores of small lakes. All beetles were marked by spotting a small amount of various colors of quick-drying enamel on elytra with a fine camel's hair brush. Marked beetles were confined on moist filter paper until released in the field, but none were held for more than 3 days between the time of capture and release. (They were not fed in the interval.)

In 1970 and 1971, larger numbers of adult *H. convergens* (1,125,000 and 2,250,000, respectively) were obtained in a total of 9 shipments from Bio-Control Co., Auburn, CA. Ca. 150,000 of those received in 1970, and 450,000 of those received in 1971, had wintered in the Sierra Nevada mountains, but most were of the current season and had migrated to the mountains early in the summer. Beetles were shipped by air and were moistened and stored at 4°C postarrival. Most were marked and released within 10 days, and practically no mortality occurred during shipment or storage. Marking was done at the site of release by spraying ca. 10,000 at a time, with an acrosol mist of selected colors of Pactra® fast-drying enamel, from a pressurized dispenser (some brands of enamel were toxic to beetles). Care was taken to avoid fouling beetles with discreet droplets of enamel. Metallic colors gave best results. Marked beetles usually were easily identifiable, even at a distance of 6 ft or more. Samples of marked beetles were kept in the laboratory for a month to observe the influence of the enamel on behavior and longevity, and check on the durability of the enamel on elytra. Estimates of sex ratios also were made from these samples.

In all 3 years, marked beetles were released in a 36-acre field 7 miles S of Castlewood in Hamlin County, SD. The field was divided into three 12-acre strips planted to spring wheat, alfalfa or corn; it was bordered N by several hundred acres of marsh and W by a lake with an area of ca. 1300 acres. Cropland planted to small grains, alfalfa, corn, and flax extended S and E. Releases were deliberately made over a range of environmental conditions, including different seasons of the year and times of day, with attendant differences in temperature, humidity, and light intensity. Availability of aphid prey and density of indigenous predators also varied.

Dispersal of marked beetles was assessed by sampling fields of release at 24-h intervals for 10 days postrelease, and once a week thereafter for 6 weeks. Wheat and alfalfa were sampled by making 200 sweeps (at random, across rows) with a standard insect net, and corn was sampled by examining 500 hills of corn at random for presence of marked beetles. Supplemental information was obtained by beetle-catch on Stikem®-coated traps spaced around fields, and by reports from farmers in the area.

RESULTS AND DISCUSSION.—Adult coccinellids obtained locally, marked, and released during 1969, ap-

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Table 1.—Dispersal of coccinellids collected in South Dakota, 1969.

Species	Release			Recapture[d]	Environment at release				
	Date	No.	Crop		Time (H)	Temp (F°)	Weather[a]	Aphid prey[b]	Predators[c]
H. t. tibialis	7/3	400	alfalfa	0/24 h	1500	75	F-SE15	20 aphids[e]/sw	1 LB/200 sw
	7/5	600	alfalfa	3 in wheat, 7/9	2100	65	C-SE5	20 aphids[e]/sw	1/200 sw
	7/6	1,000	alfalfa	1, 7/9	1700	75	C-SE20	20 aphids[e]/sw	1/200 sw
	7/8	350	wheat	0/24 h	1400	85	F-SW10	1 aphid[f]/sw	7/200 sw
H. convergens	7/15	1,680	wheat	1, 7/16, 2 miles away	2100	80	F-W3	1 aphid[f]/sw	3/200 sw
H. parenthesis	7/15	560	wheat	0/24 h	2100	80	F-W3	1 aphid[f]/sw	3/200 sw
H. t. tibalis	7/16	440	wheat	0/24 h	1400	83	F-NE5	1 aphid[f]/sw	3/200 sw
H. convergens	8/6	435	corn	2, 8/11	1300	80	F-NW8	aphids[g] 65% plants	5/250 hills
	8/9	1,300	corn	2, 8/11	1300	84	F-W5	aphids[g] 65% plants	5/250 hills
H. t. tibialis	8/9	410	corn	0/24 h	1300	84	F-W5	aphids[g] 65% plants	5/250 hills

[a] Sky condition (fair, cloudy)—wind direction and velocity in mph.
[b] No. aphids/sweep or % of plants colonized by aphids at time of release.
[c] No. predators/200 sweeps of net or predators/250 hills of corn at time of release; LB = lady beetles.
[d] Recapture information about marked beetles released; 0/24 h = 0 recaptured after 24 h.
[e] *Acyrthosiphon pisum* (Harris).
[f] *Macrosiphum avenae* (F.).
[g] *Rhopalosiphum maidis* (Fitch).

Table 2.—Dispersal in South Dakota of H. convergens imported from California, 1970–71.

Species	Release			Recapture[d]	Environment at release				
	Date	No.	Crop		Time (H)	Temp (F°)	Weather[a]	Aphid prey[b]	Predators[c]
H. convergens (California)	6/17/70	75,000	wheat	3, 6/23	1500	78	C-W30	2 aphids[f]/sw	44 LB; 11N/200 sw
	8/18	75,000	alfalfa	3, 6/23	1500	65	C-NW12	0.5 aphids[e]/sw	2 LB; 1N/200 sw
	8/7	75,000	corn	2, 8/8; 1 8/12 Stikem® traps	1700	75	C-W2	aphids[g] 90% plants	43 LB/250 hills
	9/8	150,000	corn	0/4 days	1700	90	F-SW15	aphids[g] 20% plants	52 LB/250 hills
	9/10	300,000	corn	5, 9/11 Stikem® traps	1700	67	F-W8	aphids[g] 20% plants	52 LB/250 hills
	10/6	450,000	alfalfa	Aggregated	1700	72	F-SW12	0 aphids	3 LB/200 sw
	5/7/71	225,000	alfalfa	Aggregated until 5/10	1300	72	F-N3	0 aphids	1 LB; 1N/200 sw
	5/7	225,000	wheat	Aggregated until 5/10	1300	72	F-N3	0 aphids	0
	8/2	600,000	corn	0/4 days	1700	74	F-NW5	aphids[g] 70% plants	3 LB/250 hills
	8/3	600,000	corn	0/4 days	1500	82	F-NW3	aphids[g] 70% plants	3 LB/250 hills
	8/10	600,000	corn	1, 10/16 12 miles away	1500	84	F-NW10	aphids[g] 70% plants	15 LB/250 hills

[a] Sky condition (fair, cloudy)—wind direction and velocity in mph.
[b] No. aphids/sweep or % of plants colonized by aphids at time of release.
[c] No. predators/200 sweeps of net or predators/250 hills of corn at time of release; LB = lady beetles.
[d] Recapture information about marked beetles released; 0/24 h = 0 recaptured after 24 h.
[e] *Acyrthosiphon pisum* (Harris).
[f] *Macrosiphum avenae* (F.).
[g] *Rhopalosiphum maidis* (Fitch).

peared to disperse from the study area within 4 days postrelease. Only 9 of 7150 beetles were recaptured later than 24 h postrelease, and 4 of the 9 were taken in fields other than the release fields (Table 1). One specimen was recaptured 2 miles away on the day postrelease.

Adult *H. convergens* contained in 7 of the 9 shipments from California in 1970–71 dispersed rapidly when liberated, but 2 shipments were exceptional in that released beetles formed aggregations rather than dispersing.

One of the 2 (a shipment of 450,000 beetles released Oct. 6, 1970, in alfalfa (Table 2)) formed numerous aggregations of several hundred insects at the bases of alfalfa plants, all within 200 ft of the 40 release sites. A 500-beetle sample taken from the snow-covered field on Dec. 2, yielded 452 live beetles, but none survived the winter, based on a sample of 500 beetles taken in early March 1971 from the same field. Consumption of beetles by mice during the winter was inferred from mouse droppings and tiny heaps of beetle elytra, but it probably occurred after beetles died (Kieckhefer 1972). Temperatures were mild when the beetles were freed in October, but conditioning in the Sierras preshipment may have inhibited dispersal when they were released in South Dakota.

The other shipment of beetles that failed to disperse rapidly in South Dakota involved 500,000 beetles that had wintered in the Sierras. When these beetles were freed in fields of alfalfa and spring wheat (250,000/crop May 7, 1971), they formed groups of several hundred, which were maintained 3 days before rapid dispersal. A residue of dead beetles remained postdispersal. We estimated this mortality to be ca. 10% of the total released. This instance was the only one in which significant mortality was noted in the course of dispersal.

The beetles in the 7 other shipments (those that dispersed immediately) from California were identified by the supplier as having recently migrated into the Sierras. Their behavior invariably followed the same pattern, regardless of differences in the environment at the time of release. Within 24 h, marked beetles had distributed themselves throughout the release field, and thousands were recaptured in samples (immediately freed again). In 48 h, the numbers present declined noticeably, but hundreds were still recaptured. After 3 days, any recapture was uncommon. In 1970, only 6 of the 675,000 freed were recaptured in the field of release more than 4 days later. In 1971, 1 of the 2,250,000 was recaptured later than 4 days post release (6 days later, 12 miles away).

Surprisingly few marked beetles were caught on Stikem®-coated traps bordering the release sites. However, we noticed that marked beetles frequently flew off at steep angles (60° or more), which may account for the low catches on traps at the edges of the field. We never observed beetles from California feeding on pollen or aphids, even when they travelled directly through large colonies of aphids. Native *H. convergens* often were observed feeding on aphids at the time when the marked beetles were dispersing. In 1969, marked *H. convergens* fed on aphids postrelease. However, male and female *H. convergens* from California frequently were seen in copula with California and native *H. convergens*. A sample of 600 beetles taken from shipments from California was 79% ♀ vs. 55% ♀, in collections of several thousand *H. convergens* taken locally.

The rate of dispersal of the marked beetles seemed to be independent of weather, availability of food, or relative number of predators in the field at the time of release. For example, releases on Aug. 7, 1970, and Aug. 2, 3, and 10, 1971, appeared to place the beetles in ideal circumstances, with an abundance of food and few competitors. Nevertheless, dispersal was immediate and rapid (Tables 1 and 2).

Marking of the beetles had no apparent effect on behavior and did not inhibit flight. In the laboratory, marked forms were similar to unmarked controls in food consumed, fecundity, and longevity. Although enamel faded slowly from elytra, marked insects were readily identifiable after 5 weeks.

Adult *H. convergens* and *H. t. tibialis* are known to be mobile and nomadic and to move freely within and between fields (Ewert and Chiang 1966). Our studies tend to confirm this roving flight activity by coccinellids. Unless the behavior of adult lady beetles can be modified to inhibit flight and reduce dispersal, we doubt that introduction and release will materially supplement local populations.

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