AGGREGATIONS AND WINTER SURVIVAL IN SOUTHERN ALBERTA OF *HIPPODAMIA QUINQUESIGNATA* (COLEOPTERA: COCCINELLIDAE), A PREDATOR OF THE PEA APHID (HOMOPTERA: APHIDIDAE)

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Abstract

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Aggregations of the ladybird beetle *Hippodamia quinquesignata* Kirby were found at several sites on the eastern edge of the Rocky Mountains in southern Alberta at altitudes of 1250-2439 m, and also in the Porcupine Hills (1780 m), just east of the Rockies. The beetles apparently migrate from the prairie region where they feed on pea and grain aphids to the aggregation sites in fall, and return to the prairie in spring.

H. quinquesignata can survive southern Alberta winters, but some protection is needed as high mortality sometimes occurs in localized areas of the aggregation sites. Supercooling data indicate that the greatest protection against cold occurs during mid-winter but a considerable amount of cold hardening occurs during the fall. The most critical period for survival appears to be April and May when the beetles have lost much of their cold resistance, and a late spring cold period could cause high mortality.

Résumé

On a observé des rassemblements de la coccinelle *Hippodamia quinquesignata* Kirby à plusieurs endroits du versant est des Rocheuses du sud de l'Alberta, à des altitudes variant de 1 250 à 2 439 m, et également dans les Porcupine Hills (1 780 m), juste à l'est des Rocheuses. Il semble que les coccinelles migrent de la région des Prairies où elles se nourrissent de pucerons du pois et du grain aux lieux de rassemblement à l'automne et retournent dans les Prairies le printemps venu.

H. quinquesignata peut survivre aux hivers du sud de l'Alberta, mais elle a besoin d'une certaine protection car la mortalité est parfois élevée dans certaines aires des lieux de rassemblement. Les données de surfusion révèlent que la meilleure protection contre le froid se rencontre au milieu de l'hiver, mais qu'une bonne partie de l'acclimatation au froid se fait à l'automne. La période la plus critique de survie semble être avril et mai lorsque les coccinelles ont perdu une grande partie de leur résistance et qu'une vague de froid à la fin du printemps peut causer une forte mortalité.

Introduction

The ladybird beetle *Hippodamia quinquesignata* Kirby is a common predator of the pea aphid, *Acyrthosiphon pisum* (Harris), on alfalfa in Alberta. It is also frequently found on cereals where it feeds on four grain aphids, *Rhopalosiphum padi* Linnaeus, *R. maidis* (Fitch), *Metopolophium dirhodum* (Walker), and *Macrosiphum avenae* (Fabricius). In autumn, the beetles move from the forage and grain fields and are usually not found in the debris either in the field or in the headlands.

The beetle had been reported in the mountains of western United States by Edwards (1957), who found some *H. quinquesignata* with swarms of *H. oregonensis* Crotch on Mount Rainier, Washington at a height of 2134 m on 19 June 1952. He also stated that *H. quinquesignata* had been reported from Mount Logan, Utah (2957 m), on 13 May 1939; at Peavine Peak, Nevada (2521 m), on 16 January 1923; in the Argus Mountains (1677 m), Death Valley, California on 30 May 1933; and on Telescope Mountain (3354 m), Death Valley, California on 26 March 1956.

This paper reports on aggregation sites of *H. quinquesignata* in southern Alberta, winter survival, and supercooling points.

Glycerol and sorbital contents of the beetles were determined as these polyhydric alcohols were reported to accumulate in fall in some insects and appear to be involved in cold tolerance (Dubach *et al.* 1959; Salt 1961; Sømme 1964; Takehara and Asahina 1960).

Methods

Aggregation sites. Foothill and mountain areas of southern Alberta were examined for aggregation sites. Beetles were observed at a site in the south western portion of the Porcupine Hills to determine the characteristics of the aggregation site, whether the beetles returned to the same sites each year, whether they hibernated at the site, and whether they mated before leaving the site.

Low temperature tolerance. In April and May 1974, four areas of the aggregation site in the Porcupine Hills were examined to determine winter mortality of *H. quinquesignata*.

The supercooling points of ladybird beetles were determined from specimens collected during 1973 to 1975 from aggregation sites in southern Alberta and also from one alfalfa field near Lethbridge. As the Porcupine Hills and mountain sites were not readily accessible during the winter, beetles were collected at the Porcupine Hills site on 5 September 1973. They were brought to Lethbridge and some were placed under a flat rock, some in a small screen cage, and some in a 0.5-l. cardboard container at the base of shelterbelt trees near the Lethbridge Agriculture Center (914 m). The area with the beetles was covered by an inverted wooden box 12×122×122 cm. Supercooling points of the beetles were determined 23 Jan. and 24 April, 1974. On 2 June 1975, beetles were collected from the Porcupine Hills and their offspring were reared in the laboratory (20°C) on aphids. On 26 August, supercooling points of these laboratory-reared beetles were determined.

To measure supercooling points, 10 to 25 of the beetles collected on each sampling date were used. Each insect was placed in contact with a 40-gauge copper-constantan thermocouple, which was connected to a recording potentiometer. The thermocouple was kept in a fixed position inside a glass tube, which was closed at the end with cotton after the insect was inserted. To slow down the rate of cooling to 1°–3°C/min, the glass tube was placed inside a larger tube before being cooled in a freezer.

Ten or more beetles from those collected on each date of sampling were prepared for glycerol and sorbitol analysis by a method described by Sømme (1964). The concentrations of the polyhydric alcohols were expressed as percentages of fresh body weights.

Results and Discussion

Aggregation sites. In the spring of 1971, overwintering adults of *H. quinquesignata* were found at an aggregation site near the summit of the highest peak in the Porcupine Hills (1780 m, lat. 50°, long. 114°) ca. 90 km north west of Lethbridge, Alberta.

At this site, the beetles were under rocks and debris on a west-facing slope with sparse vegetation. No beetles were found on the north-, east-, or south-facing slopes, which were covered with dense vegetation. In the springs of 1972 to 1975, aggregations of the beetles were again found at the same site where they were discovered in 1971. When adults from the aggregation site were brought into the laboratory in the spring of 1972, the females laid eggs that hatched. The resulting larvae and adults were fed pea aphids and a culture was maintained in large petri dishes at 20°C for several generations.

The same species was subsequently found by the author (AMH) or by Chinook Hiking Club members in other aggregation sites in Alberta: in Waterton National Park, Bellevue Hill (2043 m), Mount Blakiston (2744 m), Crandell Mountain (2378 m), Glendowan Mountain (2474 m), Lakeview Ridge (1768 m), and Sofa Mountain (2439 m); near Beaver Mines, on a ridge 3 km south east (1250 m) and Table Mountain (2230 m); near Blairmore, Turtle Mountain (2134 m); near the Kananaskis Highway, north of Coleman, Lightning Peak (Livingston Range) (1829 m) and Plateau Mountain (2043 m). Another ladybird beetle, *Hippodamia caseyi* Johnson, was also found in small numbers at the Porcupine Hills site and on Turtle Mountain.

The aggregation sites were usually located on upper, exposed slopes that contained little vegetation and were covered with flat rocks that were lying on the surface but had open areas beneath into which the beetles could crawl. The sites were generally more exposed, and were usually free of snow earlier in the spring than the surrounding areas. The beetles were nearly always under rocks, tree branches, or bark, in crevices in rocks, logs, or pine cones, or at the base of junipers.

In spring, mating activity occurred before dispersal of the beetles from the aggregation sites. Hagen (1962) noted similar activity of ladybird beetles at aggregation sites in California. At the Porcupine Hills site, as the temperature increased during the day, the beetles moved to the summit from their aggregation sites and sunned themselves, but returned to the aggregation sites as the temperature dropped in the evening. In June 1975, after several days of increased activity and warm weather, the beetles swarmed at the summit of the hill near the Alberta Forestry Lookout Tower. The number swarming was far greater than the number found under rocks, dead branches, and in juniper bushes just below the summit, so it is probable that beetles moved in from other aggregation sites in surrounding areas. The time of the swarming, before dispersal, appears to vary considerably from one year to the next because of variations in snowcover and spring temperatures.

Observations of the beetles at the aggregation sites in the Porcupine Hills in September, October, and November, and again in April and May, indicated that the species remains in the area throughout the winter, as they could be readily found in an inactive state under rocks in the late autumn and early spring. The species uses the same aggregation sites each year. Hodek (1973) reported that, in Europe, the ladybird beetles *Semiadalia undecimnotata* (Schneider) and *Harmonia oxyridis* Pallas use the species-specific aggregation sites year after year.

Aggregations of other species of ladybird beetles have been found in Canada. Fields and McMullen (1972) found *H. caseyi* and *H. oregonensis* near the Okanagan Valley of British Columbia on mountains ranging in height from 1975 to 2303 m.

In the United States, Chapman *et al.* (1955) found several species of ladybird beetles aggregating in western Montana in 1952: *Coccinella nivicola monticola* Mulsant, *C. transversoguttata quinquenotata* Kirby, and *H. oregonensis oregonensis* Crotch and *H. caseyi*. They also reported that, in western Montana on Mount McDonald (2743 m), grizzly bears (*Ursus horribilis*) turned over rocks and ate the ladybird beetles beneath. Edwards (1957) found aggregations of ladybird beetles on top of Mount Allen in Glacier National Park in Montana, *H. oregonensis* near Yakima Peak, Washington (1900 m), and *H. convergens* Guerin at Tyrone, New Mexico. He stated that ladybird beetles aggregate in Oregon, Idaho, Utah, Arizona, and California.

Elsewhere in the world, Chapin (1946) reported on aggregations of *Coccinella septempunctata* Linnaeus on a glacier near Lakka Pass (4573 m) in the Himalaya Mountains and other aggregations on mountains in Turkestan. Hodek (1973) discussed

aggregations in Czechoslovakia, U.S.S.R., Poland, and France. Farrell (1968) reported aggregations of coccinellids on mountain tops in Malawi, Africa.

Aggregations of ladybird beetles have also been found on the shore of lakes (Lee 1980).

Winter survival and supercooling points. Many dead *H. quinquesignata* were found in the four areas of the Porcupine Hills aggregation site that were examined in the spring of 1974. Overwinter mortality varied in different areas of the site and ranged from 20 to 70%. Similarly, Edwards (1957) and Chapman (1954) also reported finding dead ladybird beetles beneath rocks in the Montana mountains. The mortality may be related to the amount of snowcover in the aggregation sites.

The data on supercooling points indicate that the greatest protection against cold occurred during mid-winter with a considerable amount of cold hardening occurring during the autumn. The most susceptible time to low temperature appears to be April and May when the beetles have lost much of their cold resistance, and a late spring cold period could cause high mortality.

Mean weights and mean supercooling points of the beetles from the various locations (Table I) were not related ($r = 0.01$). The mean weight of each sample of beetles, except those that were laboratory-reared, was close to the mean weight of all the beetles tested which was 21.6 mg. The laboratory-reared adults were much smaller than those collected on alfalfa or in the aggregation sites and had a mean weight of 15.9 mg. The beetles collected from alfalfa had a wider range of weights than those collected at the aggregation sites, but the mean weight was close to the mean weight of the hibernating beetles.

The maximum supercooling points of the 14 samples varied from −27.0° to −16.1°C, the minimum ranged from −13.0° to −7.0°C, and the mean from −22.2° to −9.0°C. The data indicate that, at all times of the year, the beetles have considerable ability to withstand cold weather. Part of the population can withstand lower temperatures at all times than the most susceptible part of the population can withstand during mid-winter.

Pantyukhov (Hodek 1973, p. 167) found mean supercooling points of the ladybird beetle *Chilocorus rubidis* Hope were: September −8.3°C (−2.7° to −14.2°), December −13.3°C (−4.9° to −17.4°), January −12.9°C (−4.3° to −17.2°), February −13.5°C (−5.6° to −17.8°), and April −3.4°C (−0.2° to −5.5°). He measured temperatures under the snow in the Leningrad area and found that the minimum was −2.5°C in 1964-65 and −7.0°C in 1965-66; the survival of the beetles was 67-82% and 52-70%, respectively. In two other regions of the U.S.S.R., the survival was 10% and 21%. His data indicate that *C. rubidis* in Russia supercooled less than *H. quinquesignata* in Alberta and was more susceptible to either late spring or early autumn frosts. In both species of ladybird beetles, the greatest supercooling occurred in mid-winter.

In southern Alberta there are often warm "chinook" winds in winter that melt the snow and cause wide fluctuations in air temperature (Table II). Temperatures of the air, and of the soil 5 cm below the soil surface were recorded at the Agriculture Canada Research Station at Lethbridge (pers. comm. H. Hobbs). The Station is about 90 km east of the Porcupine Hills and has a similar temperature pattern, but warms up sooner in spring and cools off later in autumn.

During the main study period, 1972-1975, the range of the lowest air temperatures during the five coldest months were: November −12.2° to −30.0°C, December −22.8° to −36.1°C, January −31.1° to −39.4°C, February −25.0° to −34.4°C, and March −11.1° to −31.1°C. The range of the lowest temperatures at 5 cm below the soil surface during the same months were: November −1.1° to −5.0°C, December

Table I. Supercooling points of *Hippodamia quinquesignata* collected in southern Alberta

			Weight (mg)				Supercooling point (°C)				Glycerol		Sorbitol	
	Date	*N*	Mean	SE	Min	Max	Mean	SE	Min	Max	Mean	SE	Mean	SE
Lethbridge (alfalfa field)	29.8.73	20	22.4	1.53	12.5	35.4	−10.1	0.72	−7.0	−16.1	0.07	0.02	T*	–
Porcupine Hills (under rocks)	6.9.73	20	22.7	0.59	19.4	29.5	−14.2	1.12	−8.3	−25.0	0.19	0.02	0.08	0.03
Lethbridge (in screen cage)	23.1.74	10	21.0	1.02	16.9	27.2	−20.5	1.44	−12.0	−27.1	0.25	0.03	T	–
Lethbridge (under rocks)	23.1.74	10	21.6	0.95	15.6	25.1	−21.0	1.87	−10.5	−27.0	0.42	0.04	T	–
Lethbridge (cardboard container)	24.4.74	20	21.7	0.58	18.0	26.0	−9.0	0.66	−7.5	−17.5	0.05	0.02	T	–
Porcupine Hills (under rocks)	24.4.74	20	20.6	0.70	16.5	27.0	−12.5	0.97	−8.0	−23.9	0.13	0.03	T	–
Lakeview Ridge (under rocks)	14.5.74	10	20.9	1.06	14.7	26.3	−12.1	1.88	−7.4	−24.4	0.08	0.03	T	–
Porcupine Hills (under rocks)	25.5.75	25	21.0	0.69	14.5	27.1	−13.0	0.71	−8.5	−20.1	0.08	0.01	T	–
Porcupine Hills (base of juniper)	2.6.75	25	20.9	0.56	15.0	25.7	−12.4	0.81	−7.5	−21.0	0.14	0.01	T	–
Porcupine Hills (base of juniper)	19.8.75	20	23.4	0.68	17.5	29.7	−10.3	0.59	−7.0	−16.9	0.08	0.01	T	–
Laboratory-reared (at 20°C)	26.8.75	8	15.9	0.88	12.9	19.4	−12.5	1.35	−8.5	−18.5	0.00	0.00	0.00	–
Porcupine Hills (under rocks)	16.9.75	20	21.7	0.78	13.9	28.3	−17.7	0.95	−8.5	−25.8	0.16	0.02	T	–
Porcupine Hills (under rocks)	22.10.75	20	22.1	0.61	17.2	27.9	−18.5	0.99	−10.0	−26.5	0.16	0.01	T	–
Beaver Mines Ridge (under rocks)	4.11.75	20	21.0	0.66	14.5	25.3	−22.2	0.98	−8.2	−27.0	0.18	0.03	T	–

*T, trace.

Table II. Monthly temperatures of air, and soil 5 cm below the surface, at Lethbridge, Alberta, 90 km east of the Porcupine Hills aggregation site

Temp. (°C)	Year	Month											
		Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
		Air temperatures											
Min.	1972	−39.4	−28.9	−31.1	−18.9	−3.3	4.4	4.4	3.9	−10.6	−18.9	−13.3	−36.1
	1973	−31.1	−26.1	−11.1	−11.7	−5.6	0.6	4.4	1.7	−4.4	−8.9	−28.9	−27.8
	1974	−36.1	−25.0	−26.1	−5.6	−1.7	2.2	3.9	5.0	−4.4	−5.0	−12.2	−22.8
	1975	−31.7	−34.4	−21.1	−21.7	−1.1	3.3	8.9	3.9	−1.7	−7.2	−30.0	−27.2
		Soil temperatures 5 cm below surface											
Min.	1972	−10.6	−8.9	−6.1	0.6	5.0	12.8	12.8	15.6	2.2	1.7	−1.1	−4.4
	1973	−13.3	−6.7	0.6	1.7	2.8	11.1	12.8	16.6	6.7	3.3	−3.3	−6.1
	1974	−8.9	−5.6	−0.6	1.7	6.1	11.1	13.3	11.1	6.7	3.9	−4.4	−3.9
	1975	−8.9	−8.9	−1.7	0	5.0	11.1	16.7	13.9	7.2	0.6	−5.0	−2.8
		Air temperatures											
Max.	1972	7.2	10.0	18.9	25.6	31.1	32.2	29.4	34.4	26.1	25.0	12.8	10.0
	1973	12.2	18.3	17.2	19.4	30.0	32.8	37.8	33.9	31.1	21.7	8.9	10.6
	1974	8.3	9.4	16.1	25.6	22.8	33.9	32.8	35.0	29.4	27.8	18.9	10.6
	1975	10.6	8.9	10.6	14.4	25.6	28.3	35.6	28.3	30.0	26.7	22.2	11.1
		Soil temperatures 5 cm below surface											
Max.	1972	−2.8	0.0	10.0	14.4	22.2	26.7	27.8	29.4	23.3	14.4	7.2	0.0
	1973	−0.6	2.2	8.9	13.9	24.4	27.2	29.4	30.0	22.2	12.8	28.0	0.0
	1974	0.0	0.0	6.7	19.4	18.3	30.6	30.6	28.9	21.1	14.4	8.3	2.2
	1975	1.7	0.0	4.4	10.6	18.9	23.3	29.4	25.6	21.1	17.8	9.4	0.0

−2.8° to −6.1°C, January −8.9° to −13.3°C, February −5.6° to −8.9°C, March 0.6° to −6.1°C (Table II).

As the beetles tested supercooled to a maximum of −27°C and yet survived when the air temperature was −39.4°C, they must have been protected at critical times in their aggregation sites by the rocks, debris, and/or snow. Possibly the protection permitted the beetles to live at a temperature closer to that recorded below the soil surface than that recorded for the air.

Glycerol and sorbitol contents. The glycerol content of the beetles (Table I) reached its highest level in January 1974, and was also high in September 1973, and September, October and November 1975. Lower levels of glycerol were recorded in April, May, and August. The beetles on most dates contained little or no sorbitol. The beetles reared in the laboratory contained no glycerol or sorbitol but supercooled to a mean of −12.5°C (−8.5° to −18.5°C), indicating that a considerable level of supercooling is due to factors other than glycerol or sorbitol, and that the beetles could survive a fairly severe frost at all times of the year.

Conclusions

Adults of *H. quinquesignata* hibernate at several aggregation sites on the eastern edge of the Rocky Mountains in Alberta at heights of ca. 1250 to 2439 m, and also in the Porcupine Hills area just east of the Rocky Mountains.

The beetles appear to move from the prairie area where they feed on pea and grain aphids to the aggregation sites in fall, and back to the prairie in spring. Their maximum supercooling point was −27°C and the mean supercooling points of samples of beetles varied from −9.0° to −22.2°C with maximum supercooling points occurring in mid-winter. *H. quinquesignata* can survive Alberta winters, but some protection is needed as high mortality occurs in localized areas of the aggregation sites.

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