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Overwintering and Aestivation Sites of *Coccinella septempunctata brucki* MULSANT (Coleoptera: Coccinellidae) and Its Migration to Alfalfa Fields

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Overwintering *Coccinella septempunctata brucki* adults were found in mounds and bunches of Japanese pampas grass in central Japan in February. Most adults were found in the south- and east-facing mounds, where the air temperature was 2°C–6°C higher and there were more aphids than in the north-facing mound. Adult beetles started to migrate to an alfalfa field infested with aphids in early spring, when daily maximum temperatures exceeded 12°C, but only few adults migrated to a field where the aphids had been eliminated. Some of the adults marked in their overwintering sites were recaptured in the alfalfa fields. In August, aestivating adults were found mainly in the bunches of Japanese pampas grass and some of the adults marked in August were recaptured in the alfalfa fields in the next spring.

Key words: *Coccinella septempunctata brucki* MULSANT, overwintering, aestivation, migration, alfalfa

INTRODUCTION

The aphid *Acyrthosiphon kondoi* SHINJI, an important pest of alfalfa, overwinters on this crop and begins to increase in numbers in April. There is a marked peak in population density of aphids from late April to mid-May (TAKAHASHI and NAITO, 1984). It is important to avoid aphid damage in the early growth stage of alfalfa (SHARMA and STERN, 1980). *C. septempuncatata brucki* MULSANT is more useful in aphid control than other coccinellid species because of its early occurrence in spring alfalfa fields. Both adults and larvae of *C. septempunctata brucki* feed on *A. kondoi*. Although they are not observed in the alfalfa fields in winter, they appear there in early spring when aphid density is still low (TAKAHASHI and NAITO, 1984). This suggests that the adult beetles migrate from elsewhere to the alfalfa fields after termination of their overwintering.

Aestivating *C. septempunctata brucki* adults are often found in the bunches of Japanese pampas grass (SAKURAI et al., 1981), and the relationship between their overwintering sites and aestivating sites is not well known.

This study surveyed the overwintering and aestivation sites of *C. septempunctata brucki* and its migration to the alfalfa fields.

SAMPLING AREA AND METHODS

All of the following surveys were done in fields of the National Grassland Research Institute in Nishinasuno in the northern part of Tochigi Prefecture in Japan.

1) *Overwintering and aestivation sites.* Number of lady beetles in 27 $l \times 1$ m frames/240 m^2 were counted in alfalfa (*Medicago sativa* L.), orchard grass (*Dactylis glomerata* L.) and Italian ryegrass (*Lolium multiflorum* LAM.) fields, and in Japanese pampas grass (*Miscanthus sinensis* ANDERSS) and mounds. The mounds faced north, east and south. Each mound was 0.5 to 1 m high with a slope of approximately 20° from horizontal, and covered mainly with gramineous plants such as *Anthoxanthum odoratum* L. And the Japanese pampas grass was about 200 m from the alfalfa fields, but the orchard grass field, Italian ryegrass field and mounds were located less than 20 m away.

Surveys were carried out in mid-February and mid-August of 1990. Adults collected in these surveys were released again after having their elytra marked with a pin hole. Number of aphids in ten 0.5×0.5 m frames were counted in each site. The air temperature was also recorded at each site. The number of adult beetles on the south facing mounds (100 m^2), about 20 m apart from the alfalfa fields, was recorded by direct counting every day from late February through May.

2) *Population density of adult beetles in the alfalfa fields.* Adult lady beetles in the alfalfa fields (400 m^2) were captured daily from February through May. The number of aphids in the same field was recorded once a week. The aphids in half of the alfalfa field area (200 m^2) were eliminated with disulfoton pesticide to obtain an aphid-free field.

RESULTS AND DISCUSSION

Overwintering sites

All of the lady beetles found in this survey were *C. septempunctata brucki*. They were found in mounds and in bunches of Japanese pampas grass (Table 1). The density of the adults differed in the mounds: beetles were found in south- and east-facing mounds, but none were found in the north-facing mounds. The beetles have

Table 1. Density of *C. septempunctata brucki* adults and aphids at their overwintering and aestivating sites

Site	Overwintering density/m^2 (Feb. 8, '90)	Density of aphids at overwintering sites/m^2 (Feb. 28, '90)	Aestivation density/m^2 (Aug. 7, '90)
Alfalfa	0 a	130.4±81.3 a b	0 a
Orchard grass	0 a	0 a	0 a
Italian ryegrass	0 a	1.6±2.6 a	—
Mounds			
North-facing mound	0 a	0 a	2.3±1.8 a
East-facing mound	3.2±5.0 b	14.4±15.1 a	0.6±1.7 a
South-facing mound	4.8±3.7 c	863.2±1523.2 b	1.0±1.4 a
Japanese pampas grass	2.2±2.8 b	0 a	10.5±9.6 b

Means followed by the same letter in each site are not significantly different at the 5% level (DUNCAN's multiple range test).

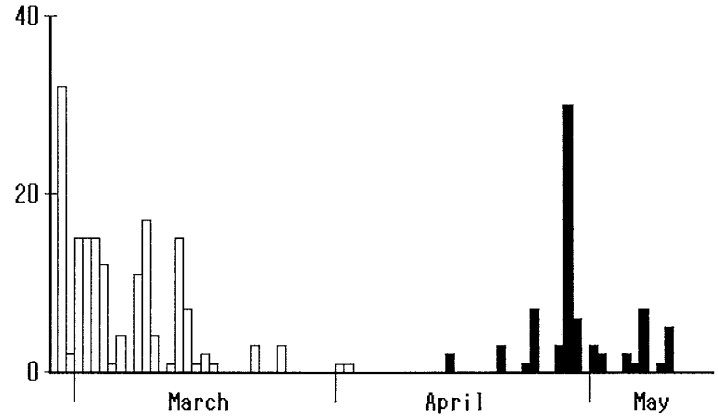

Fig. 1. Occurrence of adult *C. septempunctata brucki* in south-facing mounds (100 m^2) in 1989. □: Overwintered adults. ■: Newly emerged adults.

no diapause in the winter and their activity is suppressed by low temperature (SAKURAI and TAKEDA 1986a; SAKURAI et al., 1986b). The difference in density seemed to depend on the presence of aphids and the air temperature in our survey: aphids, mainly *Shizaphis graminum* (RONDANI), were found in the south- and east-facing mounds where the air temperature was more than 2°C–10°C higher than it was at the north-facing mounds. The beetles were active in the south- and east-facing mounds because the aphid population and the air temperature was high enough for them to feed. Radiant heat is important in winter (SAKURATANI et al., 1986). The radiant temperature in the south- and east-facing mounds also must have been higher than it was at the north-facing mounds.

In February and March, eggs of *C. septempunctata brucki* were found in the south- and east-facing mounds on the underside of dead leaves. The beetles can oviposit when the temperature is above 10°C (TAKAHASHI, in press).

The density of the adults in bunches of Japanese pampas grass was 2.2 beetles/m^2. No aphids and no eggs were found in this habitat, indicating that the populations in the Japanese pampas grass begin to feed and oviposit after their migration to other habitats.

No beetles were found in crop fields (Table 1), the main reason, apparently, being the lack of big bunches of plants. If crops were grown in big bunches, it is possible that these crop fields would also become overwintering sites for adult beetles.

Adults that overwintered in the mounds departed in March (Fig. 1). Newly emerged adults, with pale colored elytra (SAKURAI et al., 1983), appeared in the mounds from April and, soon after their emergence, they also left the mounds.

Population density of adults in alfala fields

Overwintered adults appeared in the alfalfa fields from March to May when daily maximum temperatures exceeded 12°C and there was no rainfall (Fig. 2). In late May their number decreased to zero. Newly emerged adults migrated from the overwintering sites to the alfalfa fields in the middle of April in 1989, but almost none were found there in 1990 and 1991. The aphid density in April was more than 40/alfalfa stem in 1989, but less than 10 in 1990, and less than 25 in 1991. Also, few adults

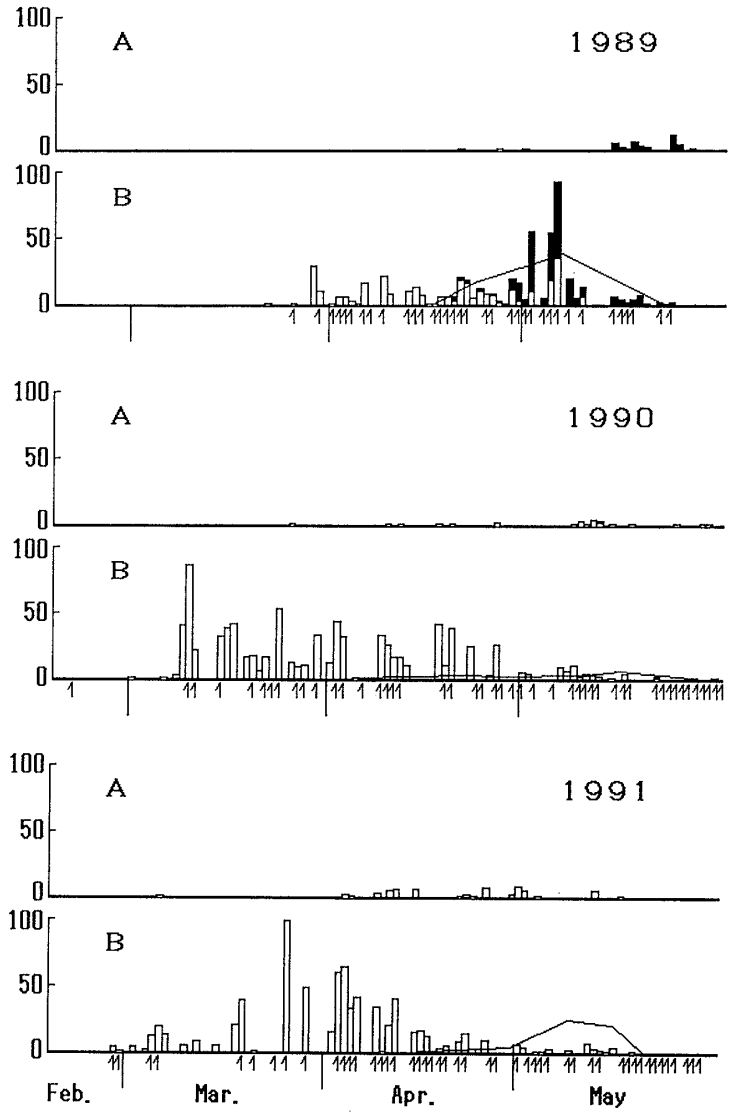

Fig. 2. Number of *C. septempuncta brucki* collected and occurrence of aphids in alfalfa fields (1989–1991). A: Aphid-free alfalfa field. B: Alfalfa field infested with aphids. □: Overwintered adults per 200 m². ■: Newly emerged adults per 200 m². —: Average number of aphids per alfalfa stem. ↑: Daily maximum air temperatures exceeded 12°C and there was no rainfall.

migrated to the aphid-free alfalfa field in any of these three years (Fig. 2). Relative adult density in different crops varies mainly as a consequence of the variation in aphid abundance (HONĚK, 1982), and many adults aggregated to the corn clump on which aphids appeared in high density (SAKURATANI et al., 1983). Although there is a possibility that the adults that had landed on the aphid-free fields moved out rapidly after their short stay, these results suggest that the migration of the adult beetles to crop fields strongly depends on the density of aphids, and that they visit the fields where there are more aphids.

Harvesting in the spring reduced coccinellid populations by more than 90%, but

Table 2. Mark and recapture of *C. septempunctata brucki* adults (1989–1990)

Date	Number released	Site	Date	Recapture number	Site
Marking in overwintering sites					
(1989)			(1989)		
Feb. 14	50	Mounds[a]	Mar. 26–Apr. 10	2	alfalfa
Feb. 21–Mar. 2	107		Mar. 26–Apr. 12	3	fields
Mar. 3–10	61		Apr. 3–Apr. 13	6	
Mar. 12–16	22		Apr. 13–Apr. 15	2	
(1990)			(1990)		
Mar. 6	200	Japanese pampas grass[b]	Apr. 2–Apr. 20	2	alfalfa fields
Marking in aestivating sites					
(1989)			(1990)		
Sep. 12	379	Japanese pampas grass[b]	Apr. 2–Apr. 27	2	alfalfa fields

[a] Distance between the mounds and alfalfa fields was less than 20 m.

[b] Distance between Japanese pampas grass and alfalfa fields was about 200 m.

spring cereals planted near alfalfa fields can be a safe harbour for the largest populations of *C. septempunctata* (Honěk, 1982). Neighboring plants are important for the conservation of adult beetles.

Recapture of the marked beetles

Some of the adult beetles marked in their overwintering sites were recaptured in the alfalfa fields (Table 2) confirming the idea that the adults migrate from their overwintering sites to the fields in the spring. The proportion of the recaptured beetles that were marked in the mounds some 20 m away from the alfalfa fields in early srping amounted to 5.4% (0.12%/day), whereas only 1% (0.06%/day) of those marked in the Japanese pampas grass 200 m away were recaptured.

The ratio of recapture thus seemed to depend on the distance between the overwintering site and the crop field: the shorter the distance, the greater the recapture ratio. Overwintering sites a short distance from the crop fields are therefore important to attract more coccinellid migrations in early spring.

Aestivation sites

The density of aestivating beetles in Japanese pampas grass was highest among the surveyed fields (Table 1). The temperature in this grass in August was constant and more than 10°C lower than the ambient daytime temperature. Low temperature in Japanese pampas grass is one of the reasons for the high density of aestivating beetles (Sakuratani and Kubo, 1985).

Beetles marked in the summer were recaptured the next spring in alfalfa fields, indicating that some of the newly emerged spring beetles overwinter until the next spring. These overwintering and aestivation sites are important for the *C. septempuntata brucki* population to remain near the fields and maintain the population of aphids at low levels.

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