Survey of Lady Beetles (Coleoptera: Coccinellidae) in Sweet Corn Using Yellow Sticky Cards[1]

Michael P. Hoffmann, Michael S. Orfanedes[2], Laura H. Pedersen[3], Jonathan J. Kirkwyland[4], E. Richard Hoebeke and Ramesh Ayyappath

Department of Entomology
Cornell University
Ithaca, NY 14853 USA

J. Entomol. Sci. 32(3): 358-369 (July 1997)

ABSTRACT Yellow cards coated with adhesive were used to survey for the presence, relative abundance and seasonal patterns of lady beetles in research and commercial fields of processing sweet corn in central and western New York in 1992 and 1993. The lady beetles species recorded, in order of abundance were: *Coleomegilla maculata lengi* Timberlake, *Coccinella septempunctata* L., *Psyllobora vigintimaculata* (Say), *Hippodamia parenthesis* (Say), *Propylea quatuordecimpunctata* (L.), *Cycloneda munda* (Say), *Hippodamia glacialis glacialis* (F.), *Adalia bipunctata* (L.), *Coccinella trifasciata perplexa* Mulsant, and *Coccinella transversoguttata richardsoni* Brown. *Coleomegilla maculata lengi* was in sufficient number to reflect seasonal patterns. *Coleomegilla maculata lengi* populations rapidly increased in early July, peaked in late July or early August and then rapidly declined. The timing of *C. maculata lengi* peak abundance was more closely related to day-of-year than to stage of crop development based on accumulated degree days from planting. The pattern of capture of *C. maculata lengi* at incremental distances into the field did not indicate colonization from the field edge.

KEY WORDS Insecta, Coleoptera, Coccinellidae, lady beetles, sweet corn, biological control, *Coleomegilla maculata lengi*

Sweet corn, either fresh-market or processed, is a valuable commodity in New York and the northeastern U.S. In 1993, 22,800 ha of sweet corn was produced in New York (Anonymous 1994). Despite its importance, little effort has been made to survey or assess the importance of naturally occurring populations of lady beetles which are among the many natural enemies found in fields of sweet corn (Bartholomai 1954). Reported prey of lady beetles includes sweet corn pests such as the European corn borer, *Ostrinia nubilalis* (Hübner) (Baker et al. 1949, Bartholomai 1954), corn earworm, *Helicoverpa zea* (Boddie) (McKinlay 1992), and

[1] Received 17 May 1996; Accepted for publication 13 April 1997.
[2] Cornell Cooperative Extension, 420 E. Main St., Batavia, NY 14020
[3] Ontario Co. Cooperative Extension, 21 South Grove St., East Aurora, NY 14052.
[4] Department of Fruit & Vegetable Science, Cornell University, Ithaca, NY 14853.

corn leaf aphid, *Rhopalosiphum maidis* (Fitch) (Gordon 1985, Obrycki and Orr 1990, Wright and Laing 1982).

The species diversity and seasonal abundance of lady beetles has been studied in other geographic regions. For example, Smith (1971) reported that the most common species in sweet corn grown in Ontario, Canada, are in descending order: *Hippodamia tredecimpunctata tibialis* (Say), *Coccinella transversoguttata richardsoni* Brown, *Coccinella novemnotata* Hbst., *Coleomegilla maculata lengi* Timberlake, *Coccinella trifasciata perplexa* Mulsant, and *Hippodamia parenthesis* (Say). Lady beetles are more abundant on early than on late-planted corn (Smith 1971). Maredia et al. (1992) reported that both cultivated and uncultivated habitats play an important role in supporting populations of seven-spotted lady beetle. Lady beetle abundance is influenced by overwintering success (Smith 1965, Wright and Laing 1982), timing of pesticide applications (Whitford and Showers 1988) and timing of aphid infestations (Foott 1973).

Sweet corn fields are typically surrounded by mixed agricultural and natural habitats including annual and perennial crops and woodlots. Knowledge of field colonization patterns by lady beetles could be useful in identifying sources of populations and possibly identify ways to manipulate surrounding habitats to enhance beetle populations. The colonization of a corn field by some species of lady beetles is dependent upon food availability, light exposure, elevation of field, plant density and planting date (Smith 1971).

Our primary objective was to determine the species of lady beetles present, and their relative abundance and temporal population patterns in sweet corn in central and western New York, using an indirect sampling method (sticky cards). We also wanted to assess field colonization patterns. A final objective was to determine if the multicolored Asian lady beetle, *Harmonia axyridis* (Pallas), was present in sweet corn in New York. Establishing baseline information on this species, which is moving northward from southern states (Kidd et al. 1995), would allow a reassessment of species diversity in the future and possible provide evidence of displacement of native species. Although considered a semi-arboreal species, the Asian lady beetle has been recorded from field crops such as alfalfa and mint (LaMana and Miller 1996).

Materials and Methods

Six commercial fields of processing sweet corn in Orleans Co, NY and three experimental fields at the Cornell Univ. Department of Entomology Research Farm, Freeville, NY, were surveyed for lady beetles in 1992 and 1993. Commercial fields ranged in size from 13 to 60 ha, were planted with the varieties 'More' or 'Challenger', and were selected to represent a range of planting dates. The insecticides chlorpyrifos or carbofuran were applied to commercial fields at planting to control corn flea beetle, *Chaetocnema pulicaria* (Melsheimer); and several fields were treated with one or two applications of permethrin and/or esfenvalerate after tasseling for control of lepidopteran pests. At Freeville, three contiguous plots (≈0.12 ha each) of processing sweet corn var. 'Terminator' were planted on 14 and 15 May, 5 and 7 June, and 26 and 28 June, 1992 and 1993, respectively. No insecticides were applied to sweet corn at Freeville.

Yellow cards (15 × 15 cm) coated with adhesive (Olson Products, Inc., Medina, OH), were used to capture lady beetles. Cards were attached to wooden stakes at a height of 4.7 to 7.1 cm above ground, placed in the field between planting and emergence. Cards were changed weekly until harvest. When removed from the field, cards were wrapped with cellophane and taken to the laboratory where they were examined. A dissecting microscope was used, as needed, to aid in identification. Lady beetle counts, by species, were recorded.

To monitor abundance and colonization of commercial fields by lady beetles, five rows of yellow sticky cards were placed parallel to a field edge. Each row consisted of four cards spaced 30 m apart. The first row was located just outside the field in the weedy border or hedgerow. The second, third and fourth rows were located 30, 60, and 90 m, respectively, into the field from the field edge, and the fifth row was located at the center of the field, regardless of field size. Placement of the cards in each field was based on accessibility. Cards at the end of the rows were at least 100 m from another field edge. All cards, except those in the weedy border and the first row within the field, were removed at mid-season. In the research fields, four cards were positioned in a 10 × 25 m rectangle centered in each planting on 19 May of both years.

At Freeville, sweet corn development was recorded weekly (number of leaves/plant and reproductive stages). In commercial fields, where plant growth was not monitored, the 50% silking stage was estimated based on degree day (DD) accumulation (J. Ballerstein, pers. comm).

To determine if there was a pattern of colonization by lady beetles in commercial fields, we used χ^2 analysis to test for differences in the number of specimens at the incremental row locations. To determine whether DD or day-of-year was the better predictor of peak *C. maculata lengi abundance*, we compared the coefficient of variation (CV) for the means of each. Daily DD values were obtained from local weather recording stations.

Results and Discussion

Species recorded. *Coleomegilla maculata lengi* was by far the most abundant species recorded in both years (Table 1). Of 1,539 beetles caught in 1992 in all fields, 90% were *C. maculata lengi,* 8.3% were *Coccinella septempunctata,* and 0.7% were *H. parenthesis.* Of 4,630 beetles caught in 1993, 95.3% were *C. maculata lengi,* 1.9% were *C. septempunctata,* and 1.8% were *Psyllobora vigintimaculata. Psyllobora vigintimaculata* was the third most abundant species found in commercial fields in 1993, but was not recorded in 1992. *Coccinella trifasciata perplexa, Propylea quatuordecimpunctata,* and *P. vigintimaculata* were recorded in 1993, but not in 1992.

The relatively high number of *C. maculata lengi* recorded could be a function of the attraction of this species to yellow sticky cards; *C. maculata lengi* prefer yellow in their dispersal stage (Benton and Crump 1981). Udayagiri (pers. comm.) compared red, green, white and yellow sticky cards for capture of lady beetles in sweet corn and found *C. septempunctata* and *C. maculata lengi,* to be most abundant on yellow cards. Differences in mobility may also affect trap capture. Mack and Smilowitz (1979), using white sticky traps to monitor green peach aphid predators in potatoes, found that the highly mobile *Hippodamia convergens* Guerin-Meneville

Table 1. Species of lady beetles recorded on yellow sticky cards in sweet corn fields in New York in 1992 and 1993.

	1992				1993				1992 and 1993 Combined	
SPECIES	Research*	Commercial†	Total	%	Research*	Commercial†	Total	%	Total	%
Coleomegilla maculata lengi	627	758	1,385	90.0	1,107	3,305	4,412	95.3	5,797	94.0
Coccinella septempunctata	73	55	128	8.3	18	71	89	1.9	217	3.5
Psyllobora virgintinmaculata	0	0	0	0.0	0	83	83	1.8	83	1.3
Hippodamia parenthesis	0	11	11	0.7	0	7	7	0.2	18	0.3
Propylea quatuorde-cimpunctata	0	0	0	0.0	0	17	17	0.4	17	0.3
Cycloneda munda	2	0	2	0.1	0	13	13	0.3	15	0.2
Hippodamia glacialis glacialis	1	8	9	0.6	0	3	3	0.1	12	0.2
Adalia bipunctata	2	0	2	0.1	0	2	2	0.1	4	0.1
Coccinella trifasciata perplexa	0	0	0	0.0	0	4	4	0.1	4	0.1
Coccinella transversoguttata richardsoni	2	0	2	0.1	0	0	0	0.0	2	0.0
Totals	707	832	1,539	100.0	1,125	3,505	4,630	100.0	6,169	100.0

* Research plantings at Department of Entomology Farm, Freeville, NY.
† Commercial sweet corn fields in western NY.

is the most abundant species caught, even when *C. maculata lengi* was four times more abundant on potato stem counts. Using drumshaped sticky traps, Ewert and Chiang (1966) found *H. convergens* and *H. tredecimpunctata* more often and at greater heights than *C. maculata lengi,* even with *C. maculata lengi* more abundant on corn plants in the immediate area of the traps. Although the capture of lady beetles on yellow sticky cards is a relative measure of the abundance of lady beetles in a system, it is consistent and simple to use. Because of its consistency, future surveys will have the same relative attractiveness to this beetle species, allowing for comparison with this initial survey.

Six of the lady beetle species we recorded are predators of the corn leaf aphid, *R. maidis,* and *C. maculata lengi* feeds on larvae and eggs of lepidopteran pests of sweet corn (Gordon 1985, Obrycki and Orr 1990, Wright and Laing 1982). *Psyllobora vigintimacululata,* feeds on mildew fungus (Davidson 1921) and presumably mildew-supporting weeds occur in fields of sweet corn. Two Coccinella species are predators of aphids occurring in sweet corn (McKinlay 1992). *Adalia bipunctata* is a predator of the pea aphid, *Acyrthosiphon pisum* (Harris), which apparently does not feed on corn, but may be infesting leguminous weeds in sweet corn (Metcalf and Metcalf 1993).

A survey (1980–1981) of lady beetles on potatoes at the Freeville Entomology Farm (Obrycki and Tauber 1985) showed the most abundant species to be *C. transversoguttata richardsoni, C. maculata lengi, Hippodamia glacialis, H. convergens,* and *H. tridecimpunctata.* The latter two species were not recorded in our survey in sweet corn.

The multicolored Asian lady beetle, *H. axyridis*, was not found in this survey. However, the first official record of Asian lady beetle in New York was in Feb 1994 (E. Richard Hoebeke, pers. comm.). Since 1994, this species has been common in sweet corn and other vegetables such as peppers, squash, melons, and tomatoes grown in Maine (Allan Eaton, pers. comm.). In 1995 and 1996, *H. axyridis* was common in sweet corn and pumpkins in New York (Hoffmann, unpubl. data).

Temporal patterns. Overall, *C. maculata lengi* was the only species abundant enough to characterize temporal patterns. In 1992, captures of *C. maculata lengi* in commercial fields were too few (generally <0.5 per card per day) to characterize seasonal abundance. In research fields in 1992 and 1993, and the commercial fields in 1993, *C. maculata lengi* was abundant, exceeding 12 beetles per card per day during peak abundance (Fig. 1).

Coleomegilla maculata lengi were captured in fields from shortly after planting through harvest (Figs. 1 and 2). At Freeville, beetles were captured over bare soil in unplanted plots from mid-May to late June. Starting in early July, populations in most fields rapidly peaked in late July or early August with rapid decline thereafter. The patterns recorded for *C. maculata lengi* at Freeville, NY, agree with what Obrycki and Tauber (1985) for potatoes at the same location. The rapid decline of populations in commercial fields was not in direct response to insecticide sprays for lepidopteran pests, because populations were in decline before the applications were made (Fig. 1). In addition, populations also declined at about the same time in Freeville plots, where no insecticides were applied (Fig. 2). *Coleomegilla maculata lengi* activity was recorded into Oct at Freeville because fields were not physically harvested, but monitored until crop growth was terminated by frosts.

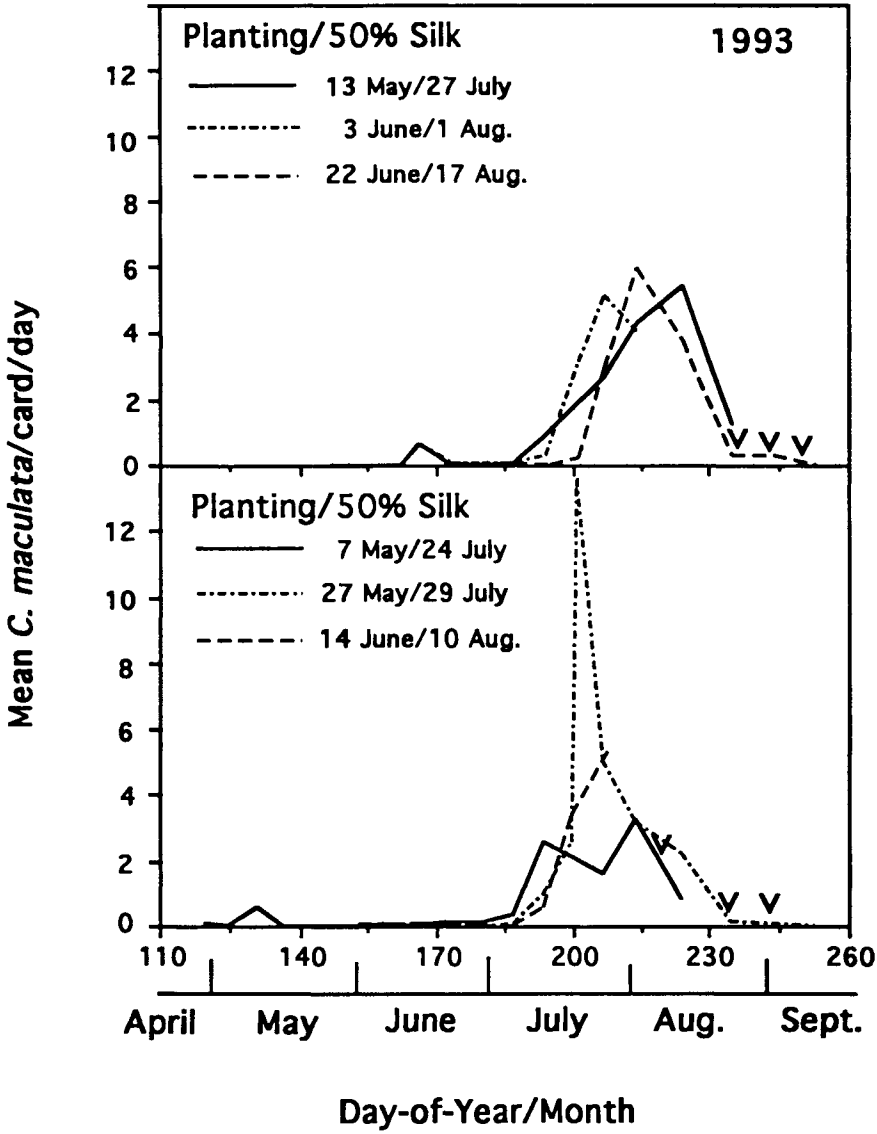

Fig. 1. Seasonal abundance of *C. maculata lengi* in six commercial fields of processing sweet corn, western New York, 1993. Two fields were not monitored to harvest. Insecticide (permethrin or esfenvalerate) applications made during time fields were monitored with cards, indicated with arrow.

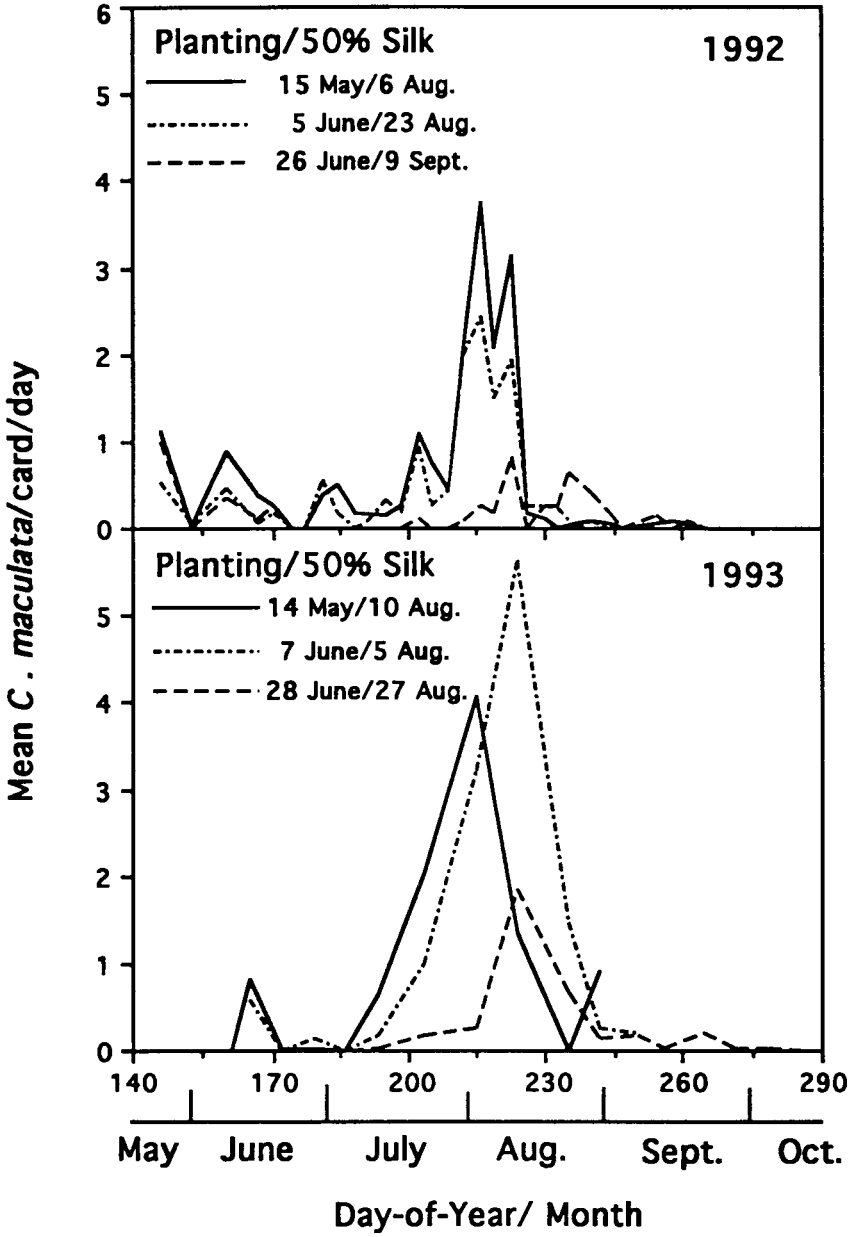

Fig. 2. Seasonal abundance of *C. maculata lengi* in sweet corn, Freeville, NY, 1992 and 1993. No insecticides applied.

Coleomegilla maculata lengi peak abundance varied more with degree days (DD) from planting (above a base temperature of 10°C for corn) than day-of-year. However, *C. maculata lengi* peak abundance (catch/card/day) (Figs. 1 and 2) was better associated with day-of-year (CV = 3.6%, n = 10) than accumulated DD (>10°C) from planting (CV = 23.5%, n = 10). Commercial fields planted 27 May and 14 Jun were not used in this comparison because date of peak abundance was not apparent. This lack of association between DD from planting and abundance of *C. maculata lengi* is further supported by the lack of association with the observed (Freeville) and estimated (commercial fields) 50% silk stage (peak pollen shed) and beetle abundance (Figs. 1 and 2). In most instances peak abundance of *C. maculata lengi* and 50% silk stage did not coincide.

Coleomegilla maculata lengi are not attracted to corn fields at pollination and moderate to large numbers of *C. maculata lengi* larvae and adults are not present until after pollination (Foott 1973). Others, however, have shown a general relationship between *C. maculata lengi* abundance and availability of pollen (Benton and Crump 1981, Groden et al. 1990). Smith (1971) reported that *C. maculata lengi* populations remained relatively constant throughout the corn growing season, a pattern distinct from our findings.

Field colonization. The full complement of cards, except for the hedgerow and 30 m row of cards, was removed mid-season and before the major increase in *C. maculata lengi* abundance. Thus, if a colonization pattern occurred during this rapid population buildup, we were not able to record it. Captures of *C. maculata lengi* were generally too low (<5) per card) for analyses by date. Therefore, captures for the entire time the cards were in the field were totaled across all rows and dates and used in the analyses. Cards in the hedgerow had too few beetles to include in these analyses.

In two and three of the fields monitored in 1992 and 1993, respectively, adequate counts of *C. maculata lengi* were made to permit χ^2 tests for differences in beetle abundance among cards at the incremental site into the fields (Fig. 3). Except for one field, *C. maculata lengi* captures at hedgerows were always fewer than at in-field sites. The reason for this exception is not clear.

The respective χ^2 value and count of *C. maculata lengi* (n) for each planting date were: 12 May 1992, 7.5 (249); 8 May 1992, 3.4 (96); 7 May 1993, 10.6 (129) ($P < 0.05$); 2 Jun 1993, 11.2 (101) ($P < 0.05$); and 22 Jun 1993, 3.6 (108). The two fields with statistically significant differences, had a trend of greater to fewer catches with distance into the field. Among the other fields, colonization trend was not apparent. If fields are colonized from the edge, it may occur rapidly or later in the season when *C. maculata lengi* are more abundant.

A complex of lady beetles occur in New York sweet corn. *Coleomegilla maculata lengi* is the most abundant and its distinct seasonal abundance pattern was not related to sweet corn phenology. Our study provides a baseline of information for long-term investigation of changes in lady beetle species diversity which may occur subsequent to the establishment of the multicolored Asian lady beetle in the northeastern U.S.

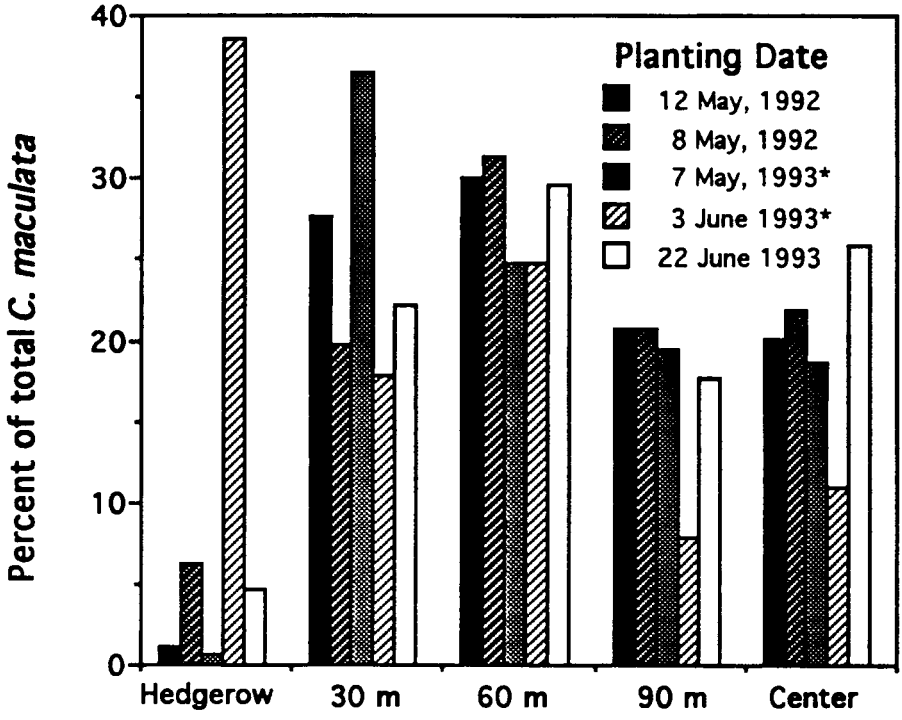

Fig. 3. Percentage of total number of *C. maculata lengi* captured on yellow sticky cards at different distances into fields of sweet corn and in hedgerow. Asterisk indicates significant difference in lady beetle abundance among distances (χ^2 test, $P < 0.05$). Hedgerow not included in χ^2 analysis.

Table 2. Reported prey of lady beetles found in sweet corn in New York, 1992 and 1993.

SPECIES	*A. pisum*	*R. maidis*	*R. padi*	*S. graminum*	*S. avenae*	O. nubilalis eggs	*H. zea* eggs
Coleomegilla maculata lengi	*	‡	-	-	+	$	$$
Coccinella septempunctata	**	**	+	+	+	-	-
Psyllobora vigintimaculata	-	-	-	-	-	-	-
Hippodamia parenthesis	+,++	+	-	++	+	-	-
Propylea quatuordecimpunctata	**,+	**	-	-	+	-	-
Cycloneda munda	+	+	-	-	+	-	-
Hippodamia glacialis	+	+	-	+	+	-	-
Adalia bipunctata	†	-	-	-	-	-	-
Coccinella trifasciata perplexa	+	-	+	+	+	-	-
Coccinella transversoguttata	+	-	+	+	+	-	-

*Baker (1949)

**Obrycki and Orr (1990)
+Gordon (1985)
++Orr and Obrycki (1990)
†Brodsky and Barlow (1985)
‡Wright and Laing (1982)
$Bartholomai (1954)
$$McKinlay (1992)

Acknowledgments

We thank M. Kirkwyland for assistance with preparation of this manuscript. This research was supported in part by the New York State Integrated Pest Management Group.

References Cited

Anonymous. 1994. New York agricultural statistics. New York State Department of Agriculture and Markets Division of Statistics. Albany, NY.

Baker, W. A., W. G. Bradley and C. A. Clark. 1949. Biological control of the European corn borer in the United States. US Dept. Agric. Tech. Bull. 983: 179-180.

Bartholomai, C. W. 1954. Predatism of European corn borer eggs by arthropods. J. Econ. Entomol. 47: 295-299.

Benton, A. H. and J. Crump. 1981. Observations on the spring and summer behavior of the 12–spotted ladybird beetle, *Coleomegilla maculata* (De Geer) (Coleoptera: Coccinellidae). J. New York Entomol. Soc. 89: 102-108.

Brodsky, L. and C. A. Barlow. 1985. Escape responses of the pea aphid, *Acyrthosiphon pisum* (Harris) (Homoptera: Aphididae): influence of predator type and temperature. Can. J. Zool. 64: 937-939.

Davidson, W. M. 1921. Observations on *Psyllobora taedata* LeConte, a coccinellid attacking mildews. Entomol. News. 32: 83–89.

Ewert, M. A. and H. C. Chiang. 1966. Dispersal of three species of coccinellids in corn fields. Can. Entomol. 98: 999-1003.

Foott, W. H. 1973. Observations on Coccinellidae in corn fields in Essex County, Ontario, Proc. Entomol. Soc. Ont. 104: 16–21.

Gordon, R. D. 1985. The Coccinellidae (Coleoptera) of America North of Mexico. J. New York Entomol. Soc. 93: 1-912.

Groden, E., F. A. Drummond, R. A. Casagrande and D. L. Haynes. 1990. *Coleomegilla maculata* (Coleoptera: Coccinellidae): Its predation upon the Colorado potato beetle (Coleoptera: Chrysomelidae) and its incidence in potatoes and surrounding crops. J. Econ. Entomol. 83(4): 1306-1315.

Kidd, K. A., C. A. Nalepa, E. R. Day and M. G. Waldvogel. 1995. Distribution of *Harmonia axyridis* (Pallas) (Coleoptera: Coccinellidae) in North Carolina and Virginia. Proc. Entomol. Soc. Wash. 97 (3): 729-731.

LaMana, M. L. and J. C. Miller. 1996. Field observations on *Harmonic axyridis* Pallas (Coleoptera: Coccinellidae) in Oregon. Biol. Con. 6: 232-237.

Mack, T. P. and Z. Smilowitz. 1979. Diel activity of green peach aphid predators as indexed by sticky traps. Environ. Entomol. 8: 799-801.

McKinlay, R. G. 1992. Vegetable crop pests. CRC, Boca Raton, FL.

Metcalf, R. L. and R. A. Metcalf. 1993. Destructive and useful insects: Their habits and control. 5th Edition. McGraw Hill Inc.

Obrycki, J. J. and C. Orr. 1990. Suitability of three prey species for nearctic populations of *Coccinella septempunctata, Hippodamia variegata* and *Propylea quatuordecimpunctata* (Coleoptera: Coccinellidae). J. Econ. Entomol. 83 (4): 1292-1297.

Obrycki, J. J. and M. J. Tauber. 1985. Seasonal occurrence and relative abundance of aphid predators and parasitoids on pubescent potato plants. Can. Entomol. 117: 1231-1237.

Orr, C. J. and J. J. Obrycki. 1990. Thermal and dietary requirements for development of *Hippodamia parenthesis* (Coleoptera: Coccinellidae). Environ. Entomol. 19 (5): 1523-1527.

Smith, B. C. 1965. Differences in *Anatis mali* Auct. and *Coleomegilla maculata lengi* Timberlake to changes in the quality and quantity of the larval food (Coleoptera: Coccinellidae). Can. Entomol. 97: 1159-1166.

1971. Effects of various factors on the local distribution and density of coccinellid adults on corn (Coleoptera: Coccinellidae). Can. Entomol. 103: 1115-1120.

Whitford, F. and W. B. Showers 1988. Abundance of nontarget foliage–dwelling insects after insecticide treatment for adult European corn borer (Lepidoptera: Pyralidae). J. Econ. Entomol. 81: 1323-1327.

Wright, J. E. and J. E. Laing. 1982. Stage-specific mortality of *Coleomegilla maculata lengi* Timberlake on corn in southern Ontario. Environ. Entomol. 11: 32-37.