Coccinella septempunctata[1] in the United States: Recolonizations and Notes on Its Ecology[2]

GEORGE W. ANGALET, JOSEPH M. TROPP, AND ALISSA N. EGGERT

Beneficial Insects Research Laboratory, Agric. Res., SEA, USDA, Newark, DE 19713

ABSTRACT

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Despite repeated efforts to establish the Palearctic coccinellid *Coccinella septempunctata* L. in the United States, no recoveries of this aphid predator were made until 1973 when a large population was found in the Hackensack Meadowlands, Bergen County, NJ. This was the first record of the establishment of *C. septempunctata* in this country. The predator is now found in New York and Connecticut as a result of natural dispersion, and has become established in Delaware, Georgia, and Oklahoma through recolonization. Since the species dominates all native coccinellids in the Meadowlands, it could become a useful addition to our beneficial insect fauna.

Attempts to establish the Palearctic coccinellid *Coccinella septempunctata* L. in the United States began in 1956 with 2 shipments of this aphid predator to California from India by G. W. Angalet, USDA. From these shipments, 1000 adults and 1500 larvae were reared, and released at several locations in southern and northern California in 1957. Adults were recovered for a month after releases, but no eggs or larvae were found, and no subsequent recoveries of adults were made.

Between 1958 and 1973, further shipments of *C. septempunctata* were received at the USDA Beneficial Insects Research Laboratory (then located at Moorestown, NJ) from India, France, Italy, Norway, and Sweden. A rearing program was conducted sporadically at Moorestown during those years, and various stages of the beetle were sent to Arizona, Connecticut, Florida, Maine, Virginia, Washington, the Dominican Republic, and the Virgin Islands for possible assistance in controlling several species of aphids. Also, we released *C. septempunctata* in Delaware, Maryland, New Jersey, Ohio, and Pennsylvania. Twelve F_1 adults were recovered in New Jersey in 1970 and 27 in Ohio in 1966, but no establishment was confirmed in the areas where releases were made. However, studies by Shands et al. (1972a, b, c, d, e) and Shands and Simpson (1972a, b, c, d) between 1965 and 1969 showed that releases of immature stages of *C. septempunctata* controlled the potato aphids, *Myzus persicae* (Sulzer) and *Macrosiphum euphorbiae* (Thomas) during the season in which they were released in test plots at Presque Isle, ME.

Then on June 23, 1973, R. L. Jacques, Biology Department, Fairleigh Dickinson University, Rutherford Branch, collected several specimens of *C. septempunctata* at East Rutherford in the Hackensack Meadowlands region of Bergen County, NJ (Angalet and Jacques 1975). Dr. Jacques again collected the predator in the same area in 1974. These were the first records of the establishment of *C. septempunctata* in the United States. We conducted a survey in 1974 and found that this predator was abundant at several sites in the Meadowlands along the New Jersey Turnpike. Our attempts to establish this insect in new areas from material collected at East Rutherford began the same year and have continued to the present time. Here we report the results of attempted recolonization of *C. septempunctata* in the United States.

Biology

Ecology - Life History

The origin of *C. septempunctata* in the Meadowlands has not been determined and will probably never be known, but the possibility exists that the establishment may have been related with trash disposal sites in the Meadowlands where trash from Kennedy International Airport and other transportation sources was dumped (Angalet and Jacques 1975). The Hackensack Meadowlands consists of 8000 ha of tidal salt marsh and meadows surrounded by concentrated urban industrial and residential developments. Because the Hackensack River periodically floods the Meadowlands, the area has not been developed. An expanding landfill has recently covered some of the region but an area administered by the Hackensack Meadowlands Development Commission and the New Jersey Turnpike Commission will remain unchanged, and should prevent the complete destruction of this habitat for *C. septempunctata*.

In 1974, the largest concentration of *C. septempunctata* in the Meadowlands was found in a 5 ×3-km area bordered on one side by the landfill and on the other side by the New Jersey Turnpike. Populations diminished rapidly with distance from this area, though numerous small colonies were found as far as 20 km from the original discovery site. Surveys through 1978 showed that this area continued to contain the largest populations of *C. septempunctata* every year. Most of the Meadowlands appears to be an optimum habitat for *C. septempunctata* ecologically, and the beetle has been the dominant aphid predator there every year since our study began in 1974. Three factors that are consistent in the area and that appear necessary for the buildup of large beetle populations are: dense spring and early summer populations of aphids suitable for oogenesis; sufficient populations of suitable species of aphids in July and August enabling beetles to store body fat and glycogen for winter survival; and protected hibernation sites near or in the feeding area that reduce excessive winter mortality.

Twenty-six species of aphids were identified from the

[1] Coleoptera: Coccinellidae.

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Table 1.—Species of aphids collected in the Hackensack Meadowlands, NJ (1975–78).

Species	Host Plant
1. *Acyrthosiphon pisum* (Harris)	Yellow sweet clover (*Melilotus officinalis* Lam.)
2. *Aphis citricola* Van der Goot	Goldenrod (*Solidago* sp.)
3. *Aphis craccivora* Koch	Poor man's pepper (*Lepidium virginicum* L.)
4. *Aphis gossypii* Glover	Common milkweed (*Asclepias syriaca* L.)
5. *Aphis nerii* Boyer de Fonscolombe	Common milkweed
6. *Aphis rumicis* L.	Common burdock (*Arctium minus* Bernh.)
7. *Brachycaudus cardui* (L.)	Filed thistle (*Cirsium discolor* (Muhlenberg))
8. *Brachycaudus helichrysi (Kaltenbach)*	Yarrow (*Achillea millefolium* L.)
9. *Brevicoryne brassicae* (L.)	Field mustard (*Brassica rapa* L.)
10. *Cachryphora serotinae* (Oestlund)	Unknown
11. *Capitophorus* sp.	Mugwort (*Artemesia vulgaris* L.)
12. *Cavariella essigi* (Gillette and Bragg)	Wild parsnip (*Pastinaca sativa* L.)
13. *Cavariella* sp.	Yarrow
14. *Dactynotus ambrosiae* (Thomas)	Common ragweed (*Ambrosia artemisiifolia* L.)
15. *Dactynotus erigeronensis* (Thomas)	Daisy fleabane (*Erigeron annuus* (L.) Pers.)
16. *Hyadaphis erysimi* (Kaltenbach)	Unknown
17. *Hyadaphis foeniculi* (Passerini)	Wild parsnip
18. *Hyalopterus atriplicis* (L.)	Shepherd's purse (*Capsella bursapastoris* (L.) Medik.)
19. *Hyalopterus pruni* (Geoffroy)	Common reed grass (*Phragmites australis* (Cav.) Trin. ex Steud.
20. *Macrosiphoniella artemisiae* (Boyer de Fonscolombe)	Mugwort
21. *Macrosiphoniella frigidicola* (Gillette and Palmer)	Mugwort
22. *Myzocallis asclepiadis* (Monell)	Common milkweed
23. *Myzus persicae* (Sulzer)	Wild lettuce (*Lactuca canadensis* L.)
24. *Pemphigus brevicornis* (Hart)	Goldenrod
25. *Pleotrichophorus* sp.	Mugwort
26. *Therioaphis riehmi* (Börner)	Yellow sweet clover

East Rutherford region of the Meadowlands (Table 1). *Acyrthosiphon pisum, Aphis craccivora, Aphis gossypii, Hyalopterus pruni, Macrosiphoniella artemisiae,* and *Myzus persicae* were reported to be acceptable prey for *C. septempunctata* by Blackman (1965) and Iperti (1965). However, all species of aphids collected in the Meadowlands were found to be suitable food for both immature and adult beetles, and none was toxic.

Species of aphids that are most important for the commencement of oogenesis in the predator at East Rutherford are those found on mugwort (*Artemesia vulgaris* L.), a common plant at this site. This plant is heavily attacked each spring by *Capitophorus* sp., *Macrosiphoniella artemisiae, M. frigidicola* and *Pleotrichophorus* sp., and *C. septempunctata* begins feeding on these aphids soon after emerging from hibernation. Even when other aphid species were scarce on most hosts, as during the spring of 1978, *Artemesia* produced a large enough population of aphids to prevent reduction in the F_1 generation of *C. septempunctata*. As many as 233 *C. septempunctata* pupae were found on a single *Artemesia* bush. Other relatively abundant species of aphids found at the site during the spring were *Acyrthosiphon pisum, Aphis craccivora, Aphis rumicis, Brachycaudus cardui,* and *Therioaphis riehmi.*

In the Meadowlands, the mealy plum aphid (*H. pruni*) is the most suitable aphid species for pre-diapause feeding that is necessary for aphidivorous coccinellids to store reserves of body fat and glycogen to ensure survival during the winter (Hodek 1973). Shands et al. (1972e) found that improperly fed *C. septempunctata* entering hibernation did not survive the extremely cold winter temperatures in Maine. The mealy plum aphid migrates from its spring hosts to common reed grass *Phragmites australis* (Cav.) Trin. ex Steud., the plant most commonly encountered in the Meadowlands, and it is on this reed that it becomes the most abundant aphid in the area. Thus, the *H. pruni* is abundantly available to the F_1 generation of *C. septempunctata,* which feed on it until going into hibernation between mid-July and early September. By mid-August, *H. pruni* is usually gone from the *Phragmites,* and adults of *C. septempunctata* that have not gone into hibernation are found feeding on pollen and nectar from several species of flowering plants.

Three favored hibernating sites for *C. septempunctata* in or near the Meadowlands are tussocks of grass, *Agrostis gigantea* Roth, rosettes and leaves of common mullein, *Verbascum thapsus* L., and branches of small Scotch pine, *Pinus sylvestris* L., and red pine, *Pinus resinosa* Aiton. These sites are abundant in the area, and winter mortality is not excessive.

According to Hagen (1962), *C. septempunctata* has several types of voltinism. In the Meadowlands, it is almost entirely univoltine as it is in western Europe though an occasional female does produce a 2nd generation in July or August and on one occasion, 3 egg masses were found on Sept. 5. The species begin emerging from hibernation in early April, and emergence continues until mid-June. Mating occurs throughout the emergence period, often while the beetles are still in the grass tussocks. The earliest that eggs and pupae have been found is on April 27 and May 15, respectively. Adults emerge from pupae until the end of July. *Coccinella septempunctata,* unlike *Hippodamia convergens* Guérin-Méneville (Hagen 1962) does not make long distance migrations to hibernation sites, but aggregates within the breeding area (Hodek 1973). Some aggregation begins during the 2nd week in July, but the largest movement occurs during the 2nd week in August, by

which time few aphids are found in the Meadowlands. However, the last *C. septempunctata* adults feeding on pollen and nectar may not enter hibernation until flowering plants have died.

Large individual aggregations of *C. septempunctata* are not found in the Meadowlands. In pine trees, clusters contain from 5 to 250 beetles, although there may be as many as 50 aggregations in the same tree. The largest number of total beetles ever collected from one tree is 2493. In mullein, 1–50 beetles commonly occur in individual rolled up leaves, and the largest number ever found in one plant is 238. In grass, there may be from 3 to 7 beetles in small clumps and from 200 to 400 in large tussocks. The most beetles ever collected from one tussock is 512. The only other coccinellid that overwinters in this area in numbers is *Coleomegilla maculata* (De Geer), which may be found in the grass in aggregates of several hundred. However, *C. maculata* does not enter dormancy until the last week in August. Generally, aggregations of coccinellids are monospecific (McMullen 1967), but we find some heterospecific aggregations of *C. septempunctata* and *C. maculata* that is predominately one species with only a few specimens of the other species.

Coccinella septempunctata has outnumbered native coccinellids at the Meadowlands every year since 1974, though 17 species of coccinellids were collected (Table 2). Most of these species were scarce, with only *Coleomegilla maculata, Hippodamia convergens, Coccinella undecimpunctata,* and *Adalia bipunctata* being commonly encountered.

To determine the relative abundance of *C. septempunctata* and native aphidivorous coccinellids at East Rutherford during 1978, coccinellids were collected by sweep net from June to October on mixed vegetation in the Meadowlands, and relative abundance of the 4 most populous coccinellids was determined (Table 3).

Table 3.—Four most abundant species of coccinellids swept from mixed vegetation in the Hackensack Meadowlands, Bergen Co., NJ, 1978.

No. coccinellids/100 sweeps			
Area A		Area B	
June 6, 1978		June 20, 1978	
C. septempunctata	552	*C. septempunctata*	1240
H. convergens	21	*H. convergens*	52
C. maculata	14	*C. maculata*	31
C. 11 punctata	48	*C. 11 punctata*	59
July 19, 1978		August 1, 1978	
C. septempunctata	1529	*C. septempunctata*	586
H. convergens	146	*H. convergens*	34
C. maculata	54	*C. maculata*	26
C. 11 punctata	68	*C. 11 punctata*	47
Aug. 11, 1978		Aug. 23, 1978	
C. septempunctata	87	*C. septempunctata*	38
H. convergens	3	*H. convergens*	4
C. maculata	7	*C. maculata*	4
H. 11 punctata	18	*H. 11 punctata*	11
August 30, 1978		September 13, 1978	
C. septempunctata	32	*C. septempunctata*	37
H. convergens	2	*H. convergens*	1
C. maculata	4	*C. maculata*	4
C. 11 punctata	8	*C. 11 punctata*	2
September 19, 1978		September 29, 1978	
C. septempunctata	42	*C. septempunctata*	27
C. maculata	11	*C. maculata*	6
C. 11 punctata	4	*C. 11 punctata*	5
October 11, 1978		October 19, 1978	
C. septempunctata	38	*C. septempunctata*	26
C. maculata	3	*C. maculata*	2
C. 11 punctata	1	*C. 11 punctata*	1
October 25, 1978			
C. septempunctata	21		

Releases

Adults (501,209) of *C. septempunctata* have been released in several states (Table 4) since 1974. Beetles were collected from hibernating quarters from September through December and again in April and May in the Meadowlands, and also from pine trees along the New Jersey Turnpike in Bergen County, NJ. Three methods of release were used: (1) A cage 2.5×1.5×1.5 m covered with fine plastic screen except for a plyboard top to shield the contents from heavy rainfall was placed in an alfalfa field in October or November on blocks so the cage was 0.5 m off the ground. Into the cage (½-filled with dried mullein, excelsior, and artificial pine tree branches) was placed from 8000 to 27,000 *C. septempunctata*. The cover of the cage was removed when aphids appeared in the field, and the beetles were allowed to leave the cage at will. (2) Twelve cages, 28×28×20 cm, with 1.2-cm wire screen mesh on 5 sides and solid metal tops were ¾-filled with dry mullein leaves. These cages were placed 20 m apart at the edge of woodlots and thick hedgerows adjacent to an alfalfa field in the late fall or early winter, and received 1000 beetles each. The cages were covered with soil except for an 8-cm opening on one side through which the predators could leave. On winter days when the temperature rose above 20°C, many beetles did leave and buried themselves in trash near the cages. The remainder left the cages in the spring. (3) From 9000 to 27,000 diapausing coccinellids were released directly by hand along the edge of a woodlot or hedgerow (100 m) where there was sufficient duff to protect them during the winter. Also on a few occasions, 1200–7000 beetles were released directly in the spring.

Table 2.—Coccinellids collected in the Hackensack Meadowlands, NJ, 1974–78.

Adalia bipunctata (L.)
Brachyacantha albifrons (Say)
Coccinella novemnotata Herbst
Coccinella septempunctata L.
Coccinella transversoguttata richardsoni Brown
Coccinella undecimpunctata L.
Coleomegilla maculata (De Geer)
Hippodamia convergens Guérin-Méneville
Hippodamia parenthesis (Say)
Hippodamia quinquesignata (Kirby)
Hippodamia tredecimpunctata tibialis (Say)
Mulsantina picta (Randall)
Myzia pullata (Say)
Naemia seriata (Melsheimer)
Neoharmonia venusta venusta (Melsheimer)
Olla v-nigrum Mulsant
Subcoccinella vigintiquatuorpunctata (L.)

Recoveries

Since 1974, *C. septempunctata* has been recovered in 13 counties in New Jersey, 11 in New York, 4 in Con-

Table 4.—Releases of *C. septempunctata* (1974–78) from collections made in the Meadowlands, East Rutherford, NJ (Bergen Co.).

State	No. of beetles released				
	1974	1975	1976	1977	1978
Delaware	20,800	2,075	0	0	6,350
District of Columbia	0	0	0	0	500
Florida	0	0	0	0	1,200
Georgia	0	0	3,339	11,800	13,000
Illinois	0	0	1,960	17,000	7,000
Maine	0	0	0	0	15,000
Maryland	1,200	0	102	12,000	16,750
Nebraska	0	0	0	0	25,100
Nevada	0	0	0	0	17,700
New Jersey	0	500	0	0	5,000
New Mexico	0	0	0	24,200	36,400
New York	0	0	915	13,000	12,000
Ohio	600	3,500	3,191	19,800	7,000
Oklahoma	0	31,748	0	13,000	46,779
Pennsylvania	0	0	500	9,000	14,000
South Dakota	0	0	0	0	13,100
Texas	0	5,000	0	0	15,700
Virginia	1,200	4,000	0	0	0
Washington	0	5,400	0	0	0
Wisconsin	0	0	0	0	25,100
Utah	0	0	0	0	17,700
Total	23,800	52,223	10,007	119,800	295,379

necticut, 3 in Delaware, 2 in Georgia, one in Oklahoma, and one in Pennsylvania (Table 5). During 1978, F_1 adults were recovered in Florida, Illinois, Maryland, Ohio, Pennsylvania, and Ithaca, NY as a result of releases made during the fall and winter of 1977 and the spring of 1978. Whether successful establishment has occurred in these latter states will not be known until the spring of 1979. In Florida, state laws permitted the release of laboratory-reared adult *C. septempunctata* only, so the release in this state was made directly in an alfalfa field on Feb. 27, 1978. The Delaware, Georgia, and Oklahoma establishments resulted from liberations; the establishments in Connecticut, New York, and New Jersey resulted from natural dispersal by *C. septempunctata*, probably from Bergen County, NJ.

Table 5.—Distribution of *C. septempunctata* in the USA through 1978 as determined by our recoveries.

State	County	Year of 1st recovery
New Jersey	Bergen	1974
	Passaic, Essex, Union, Morris, Middlesex	1975
	Monmouth	1976
	Hunterdon, Somerset	1977
	Warren, Mercer, Salem, Gloucester	1978
New York	Queens, Brooklyn, Richmond	1975
	Bronx, Westchester, Putnam, Rockland, Orange, Ulster	1976
	Nassau, Suffolk	1978
Connecticut	Fairfield	1975
	New Haven	1976
	Middlesex, New London	1978
Delaware	New Castle	1975
	Kent, Sussex	1978
Georgia	Peach	1977
	Houston	1978
Oklahoma	Payne	1977
Pennsylvania	Philadelphia	1978

Dispersal

Since *C. septempunctata* does not migrate for long distances, it has extended its range from the Meadowlands slowly. In New Jersey, small colonies are now found at the Great Swamp Wildlife Refuge in Somerset County, near Crestmoor in Morris County, and in nearby Passaic, Union, and Middlesex Counties.

In 1974, isolated specimens of *C. septempunctata* were collected on Staten Island, Richmond County, NY and the beetle is now common at Great Kills Park on the eastern shore of the island. The habitat at Great Kills Park is similar to that at the Meadowlands, with extensive stands of *Phragmites*, *Artemesia*, and several species of grasses. In late August 1978, some of the grass tussocks examined had 3–70 overwintering beetles. A few beetles were found in 1975 in Brooklyn and Queens Counties, Long Island, NY as far east as John F. Kennedy Airport, but none was collected east of the airport until 1978 when 7 larvae and 4 adults were swept at Babylon in Nassau County and at Riverhead, Suffolk County. There has also been a limited migration of *C. septempunctata* north along the Hudson River in New York as far as Ulster County.

Since 1975, only occasional specimens of *C. septempunctata* have been collected in Fairfield County, CT but the beetle is slowly extending its range along the south coast of the state. For example, in Aug. 1976, 2 diapausing beetles were found in mullein leaves at Hammonasset State Park, New Haven County, CT which is ca. 150 km from the Hackensack Meadowlands. In June 1977, 12 larvae and 5 adults were obtained in 200 sweeps at this state park. A year later the park was again surveyed, and *C. septempunctata* was found to be well established in most of the area. At one location, 52 larvae and 7 adults were collected in 200 sweeps. A visual survey on Aug. 2, 1978 at Hammonasset, CT resulted in the following coccinellid counts: 415 *Coccinella undecimpunctata*, 175 *Coccinella septempunctata*, 132 *Hippodamia convergens*, 25 *Adalia bipunctata*, 16 *Coccinella novemnotata*, 14 *Coleomegilla maculata*, 3 *Coccinella transversoguttata*, 3 *Hippodamia tredecimpunctata tibialis*, and one *Coccinella trifasciata* L. These counts were made on several species of plants at 12 ca. one-ha sites one km apart. On the same date, one adult and one pupae of *C. septempunctata* were collected at Rocky Head State Park, New London County, CT 25 km east of Hammonasset. On July 25, 1978 one adult was found by R. J. Dysart at Norwich, CT. This was the farthest east of the Meadowlands that *C. septempunctata* was recovered.

Natural Enemies

Predators

Occasionally, *C. septempunctata* larvae and adults were observed being fed upon by the predaceous pentatomid, *Podisus maculiventris* (Say). However, this predator was not found in sufficient numbers to be consid-

ered important. Unidentified centipedes were found in some aggregations of beetles in the trash below pine trees, and in some cases, they had destroyed most of the beetles present. Several unidentified species of spiders are common in the Meadowlands and were observed feeding on *C. septempunctata*, but the impact on the beetle population was not determined. Rothschild (1961) reported that a secretion given off by coccinellids protects them from vertebrate and insect predators, and this seems to be confirmed by the scarcity of predators on *C. septempunctata*.

Parasites

No larval parasites of coccinellids were observed at East Rutherford, but the entire Meadowlands was not surveyed because of swampy conditions. However, the cosmopolitan parasite of adult coccinellids, *Perilitus coccinellae* (Schrank), was recovered each year. Random samples of adult *C. septempunctata* collected from different locations throughout the season averaged 2% parasitization in 1975, 6% in 1976, and less than 1% in 1977 and 1978. These parasitization rates are not high enough to have much effect on the populations of *C. septempunctata*.

Disease

Aggregations of *C. septempunctata* hibernating in low areas susceptible to flooding are often killed by the pathogenic fungus *Beauveria bassiana* (Balsamo). In the Meadowlands, mortality due to pathogens usually occurred in aggregations of beetles overwintering in low grass tussocks. Aggregations overwintering in pine branches and on mullein plants suffered less from pathogens as these plants are found in areas where flooding is minimal. During the severe winter of 1977–78, an estimated 25% of the coccinellids overwintering in grass clumps were destroyed by *B. bassiana*.

Conclusions and Discussion

Observations on the establishment of *C. septempunctata* resulting from releases in Delaware, Georgia, and Oklahoma are not complete and are not included here.

It is unfortunate that establishment of *C. septempunctata* did not occur in an agricultural region so its potential value against economically important species of aphids could have been determined. However, the abundance of *C. septempunctata* over native coccinellids in the Meadowlands indicates that in the future it could become a valuable addition to our beneficial insect fauna. Because the migration of *C. septempunctata* from the original area of establishment in New Jersey has been slow, the only method for establishing it in agricultural areas has been through continued releases in as many states as possible. In the Palearctic region, it is found in all types of climatic environments. Hence, it should be possible to establish, *C. septempunctata* in most regions of the United States where aphids are economically important.

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