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SHORT COMMUNICATION

Citizen scientist rediscovers rare nine-spotted lady beetle, *Coccinella novemnotata*, in eastern North America

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Abstract A single adult *Coccinella novemnotata* (the nine-spotted lady beetle) was recently discovered by a Cornell University student amongst a series of specimens collected in early October 2006 in Arlington, Virginia. The specimen is the first individual collected in eastern North America in over fourteen years and is only the sixth of its species known to be collected anywhere in North America in the last ten years. This discovery reopens questions regarding the current status of this once common species. Interactions with exotic species, global climate change, and shifting land use patterns have all been postulated as possible factors in this species decline. This discovery is the first in a new program in the USA designed to educate the public regarding biodiversity and conservation and to engage them in a survey of native and exotic lady beetle species.

Keywords Rare ladybeetle · Invasive species · Biodiversity · Conservation · Citizen science

Beetles in the family Coccinellidae, known as ladybugs, lady beetles, or ladybird beetles, are common, charismatic, and rightfully revered for their role in the suppression of pest insects (Gordon 1985). Approximately 475 species of Coccinellidae occur in America north of Mexico and *Coccinella novemnotata* (the nine-spotted lady beetle, referred to hereafter as ''C9'') was historically one of the most prevalent (Gordon 1985). Designating the beginning of C9's decline is difficult. In a large four-year study from 1967–1970, Foot (1974) found no C9 in corn in Ontario although they made up a substantial portion of the lady-beetle complex in Ontario corn in 1963 (Table 1) and were present, albeit ''never numerous'', as late as 1977. Before 1967 the nine-spotted lady beetle ranged across most of North America and comprised a substantial percentage of lady beetles collected in the northeastern US and southeastern Canada. Between 1967 and 1985 some surveys found substantial populations but these occurrences became increasingly rare (Table 1). Several reports that did not provide quantifiable C9 densities during this period describe them as ''high'' or ''common'' while others describe them as ''scarce'' (Wheeler and Hoebeke 1995). Collections after 1985 were very rare and consisted of few individuals although notably one study describes C9 as common in potatoes in Maine as late as 1992 (Wheeler and Hoebeke 1995). In the last ten years, we know of only six individuals that have been collected anywhere in North America (two in Wisconsin in 2000 and four in Washington in 2001). On October 28, 2006, an adult nine-spotted lady beetle was found among a series of specimens collected on October 2, 2006 in a home in Arlington, Virginia, making it the only specimen of this species collected in eastern North America in over fourteen years. This specimen has been deposited in the Cornell University Insect Collection (Ithaca, New York). We hope that further surveys in the same area will lead to the discovery of a viable population in the same way that the five-spotted ladybeetle, *Coccinella quinquepunctata* was rediscovered in Britain (Majerus and Fowles 1989).

The question as to why the nine-spotted lady beetle became so rare remains a puzzling one. Most insect species that become endangered are initially rare because of either narrow range of conditions in which they can survive (e.g. cave insects) or because their diet is restricted to other

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Table 1 Percentage of lady beetles (among all coccinellid species collected in documented surveys) comprised by *C. novemnotata* in the northeastern USA and southeasten Canada[a]

Year	Percent *C. novemnotata*	Location	System
1924	13	New York	Alfalfa
1956–1958	19	New York	Potatoes
1957	13	Ontario	Forage and trees
1963	20	Ontario	Corn
1967–1970	0	Ontario	Corn
1968	19	Ontario	Red pine
1978	2	New Jersey	Natural
1979	14	Pennsylvania	Weeds
1980–1982	11	Pennsylvania	Soybean
1993	0	11 NE States	Forage and grains
1992–1993	0	New York	Sweet corn
1994	0	New Brunswick	Natural
1998	0	Nova Scotia	Natural
1999–2001	0	New York	Sweet corn
2000–2001	0	New York	Alfalfa and Natural

[a] Adapted from Harmon et al. (2007) and Wheeler and Hoebeke (1995)

organisms which are also rare (e.g. herbivores that specialize on rare plant species) (New 1995). In contrast, the nine-spotted lady beetle was known to thrive on a wide variety of prey in a wide range of habitats. With this broad niche it was one of the most dominant ladybeetles across the US and southern Canada until 20 years ago (Wheeler and Hoebeke 1995; Harmon et al. 2007). Most cases of rapid, sustained diminishing densities can be traced back to either habitat degradation or the impact of invasive species (New 1995). Changes in land-use and cropping patterns, decline in aphid densities, parasitism, disease, or even global warming have been postulated as possible causes of the decline of the nine-spotted lady beetle (Wheeler and Hoebeke 1995). Although there have been major shifts in the landscape of North America and some of these changes have accelerated in the past few decades, it still remains unclear why this particular lady beetle with its wide diet and habitat range dwindled while other species thrived. Several exotic lady beetle species have been implicated as potential factors in its decline (Harmon et al. 2007; Wheeler and Hoebeke 1995). Two species in particular, the seven-spotted lady beetle (*Coccinella septempunctata*, a congeneric species introduced from Europe) and the multi-colored Asian lady beetle (*Harmonia axyridis*) have become established in North America and both have reached very high densities. Populations of *C. novemnotata*, at least in the Northeast, seem to have declined precipitously following establishment and expansion of the introduced Old World *C. septempunctata* (Wheeler and Hoebeke 1995). Although the exact origins of the current populations of *C. septempunctata* remain the focus of some debate, classical biological control releases were made in eastern North America between 1958 and 1973 and established populations were detected in the early 1970's. Based on the similar appearance of *C. septempunctata* and C9, it seems possible that it *C. septempunctata* was established and having an impact on C9 as early as 1967. The first decade following establishment of *C. septempunctata* saw C9 collections become rarer and more variable while the second and third decades saw almost no collections at all.

The dilemma facing anyone concerned with lady beetle decline is that of gathering accurate data on the current locations of species that are now rare but in the recent past had extremely broad spatial and habitat ranges. Highly trained specialists are very adept at determining the distribution of species in defined ranges but there are not nearly enough specialists available to adequately survey the former ranges of the now rare native lady beetles in North America. To meet this challenge a new effort that has been launched at Cornell University incorporating non-lethal survey and reporting of Coccinellidae through a ''citizen science'' program (http://instruct1.cit.cornell.edu/courses/icb344/Lost_Ladybugs.htm). Rediscovery of C9 represents the fledgling program's first success. The non-specialist collectors attended a program describing the decline of C9 and they collected it among less than 100 beetles while it has not turned up in the 1000s collected recently by specialists at Cornell. Over the next 2 years researchers at Cornell will launch a web-based lady beetle survey similar to Canada's ''Spot the Ladybug'' and the United Kingdom's ''Ladybird Survey''. Citizen science is particularly well suited to track potentially widespread rare species since a successful program can receive data from thousands of locations while specialist studies seldom cover more than one hundred. Even if specialists are twice as likely to find a species in an occupied site this advantage is more than offset by one or two orders of magnitude greater number of observations that can be made by citizen scientists. To minimize identification errors, each data point utilized in our database will be ''virtually vouchered'' with a digital image. Our preliminary projects have demonstrated that lady beetles are charismatic and make excellent examples for teaching principles of biodiversity and conservation and that non-specialist citizens can effectively capture and produce digital images of lady beetles that are identifiable to species.

Unfortunately, C9 has not been alone in its decline. The past two decades have seen an unprecedented decrease in absolute and relative density of several formerly abundant native lady beetle species (e.g. the two-spotted lady beetle *Adalia bipunctata* and the convergent lady beetle *Hippodamia convergens*) and a corresponding increase of several introduced species in North America (Harmon et al. 2007). This pattern of potential displacement of native by invasive coccinellid species may be occurring in other parts of the world as well with *H. axyridis* suspected as one of the primary culprits (Adriaens et al. 2003). Based on the extremely rapid decline and present rarity of the nine-spotted lady beetle, a strong case could be made for listing it and possibly some other native lady beetles as federally endangered species in the USA. The process for conferring federal protection in the USA is rigorous and requires a great deal of data to substantiate that a species is truly in peril. Our goals with this new program are to (1) gather data regarding the current range and status of native lady beetle species, (2) facilitate the collection of specimens to establish captive colonies and investigate the causes of decline, and (3) to educate the public regarding the importance of insect biodiversity and to build support for the conservation of native lady beetles and other threatened groups.

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