Vermont Lady Beetle Atlas: Progress Report

Julia Pupko[1,2] and Kent McFarland[1]

1 Vermont Center for Ecostudies. PO Box 420, Norwich, Vermont 05055
2 ECO AmeriCorps, One National Life Dr., Montpelier, Vermont 05620

January 2022

Three-banded Lady Beetle © Kent McFarland

VERMONT CENTER FOR ECOSTUDIES
VERMONT ATLAS OF LIFE

Background

A 1976 annotated county checklist of Vermont lady beetles (Coccinellidae) reported 35 species from the state, listing the county and date of first and last collections (Parker et al. 1976). Following the digitization of these data by the Vermont Atlas of Life (VAL), we found that many species once considered common in Vermont were now missing or rarely recorded in Vermont. We compiled data from museum collections, published records, Lost Ladybug Project data for Vermont, and observations reported to iNaturalist to confirm this.

Apparent declines and extirpations of multiple native Lady Beetle species in Vermont was alarming. Declines in Vermont generally followed similar findings from other states and provinces across North America (Marriott 2014). Some species have declined so dramatically in parts of their range that they received special conservation status. In 2015, the Two-spotted Lady Beetle (*Adalia bipunctata*), Nine-spotted Lady Beetle (*Coccinella novemnotata*), and Transverse Lady Beetle (*C. transversoguttata*) were designated as “Species of Greatest Conservation Need" in New York. The Nine-spotted Lady Beetle was recently declared “Endangered” in Canada. Several studies have provided evidence linking these declines to a variety of factors, including introduction of non-native Lady Beetle species (Ducatti et al. 2017; Lamb et al. 2019) and land-use change (Diepenbrock et al. 2016), along with potential declines caused by pesticide use (Jiang et al. 2014). Introduction of non-native lady beetles is often cited as a primary cause of native species declines, but even with multiple long term dataset, proving this link has proven difficult (Harmon et al. 2006). Loss of native Lady Beetles may lead to increased risk of pest outbreaks in agriculture crops, forests, meadows, and other terrestrial landscapes (Hodek et al. 2012; Losey et al. 2014).

Given the lack of recent survey data in Vermont and concerns over region-wide declines in many native Lady Beetle species (Losey et al. 2007), we started the Vermont Lady Beetle Atlas in 2019, and expanded it throughout the state in 2021. This project is modeled after other successful atlas projects conducted by VAL that rely on community scientist involvement, along with the Lost Ladybug Project at Cornell University, which found two species of Lady Beetle previously thought to be extinct in New York (Losey et al. 2007; Losey et al. 2014). Using volunteer naturalists allowed for a greater chance of discovering missing Lady Beetle species while engaging Vermonters of all ages in science, natural history, and conservation.

The goal of the Vermont Lady Beetle Atlas is to survey Vermont’s current Lady Beetle fauna, encouraging community scientists to join us in our search. We wanted to know whether species that are currently missing might still remain in low numbers or if they are truly extirpated from Vermont. Through a combination of systematic surveys and encouraging people to upload all incidental sightings, we hoped to complete ample surveys in all 9 biophysical regions in Vermont. This atlas will enable us to better understand how Vermont’s Lady Beetle fauna has changed over time and what species remain extant and in need of conservation.

Methods

Historical Occurrences (pre-2019)–We identified and digitized Lady Beetle specimens from the University of Vermont Zadock Thompson Natural History Collection, Middlebury College

Collection, Fairbanks Museum, and the Vermont Forests, Parks, and Recreation collection. We also obtained records from the Lost Ladybug Project at Cornell University, crowd-sourced data from the Vermont Atlas of Life iNaturalist project, published records, and data shared with the Global Biodiversity Information Facility (GBIF).

Vermont Lady Beetle Atlas (2019-2021)–To compare the current fauna with historical records, we began the Vermont Lady Beetle Atlas in 2019. We used our large base of community naturalists to help us conduct Lady Beetle surveys across the state. In 2020, the Vermont Lady Beetle Atlas website was created, along with the Vermont Lady Beetle Atlas Project on iNaturalist, to increase community naturalist participation. In 2021, the Vermont Lady Beetle Atlas was expanded. In addition to the Vermont Lady Beetle Atlas on iNaturalist, we added a week-long Lady Beetle Bioblitz in June. We also partnered with other organizations across Vermont to co-host webinars that informed and trained community naturalists on how to participate in the Vermont Lady Beetle Atlas.

Results

From 1890 through 2021, 43 lady beetle species have been recorded in Vermont, with 36 native and seven introduced species (Table 1). We compiled 1,978 historic records (pre-2019) into Darwin Core Standard biodiversity datasets stored at the Vermont Atlas of Life (updated quarterly at https://biocache.vtatlasoflife.org/occurrences/search?q=lsid%3A7782&lang=en) and shared with the Global Biodiversity Information Facility (https://www.gbif.org/occurrence/search?taxon_key=7782&advanced=1&occurrence_status=present&gadm_gid=USA.46_1). Additionally, there were 485 historic research grade observations (pre-2019) shared with iNaturalist and contributed some unique Vermont records just prior to the start of the Vermont Lady Beetle Atlas.

- Undoubtable Lady Beetle (*Brachiacantha indubitabilis*) – the first and only state record was found in 2014.
- *Hyperaspis binotata* – 2014
- Hieroglyphic Lady Beetle (*Coccinella hieroglyphica kirbyi*) – the first record in Vermont was reported in 1969 until one was reported on iNaturalist in 2017.
- Mountain Lady Beetle (*Coccinella monticola*) – the first and only state record was reported on iNaturalist in 2017.
- Convergent Lady Beetle (*Hippodamia convergens*) – a native species that has been declining across its range and was rediscovered in Vermont in 2017,

By the end of 2018, we found that 13 of Vermont's 36 native species had not been seen in decades, some of which had not been detected for over 40 years (Table 1).

Since the start of the Vermont Lady Beetle Atlas in 2019, five species have been rediscovered and one new species has been discovered (Table 1):

- Bigeminate Sigil Lady Beetle (*Hyperaspis bigeminata*) – 2019
- Four-spotted Spurleg Lady Beetle (*Brachiacantha quadripunctata*) – 2020

- Octavia Lady Beetle (*Hyperaspis octavia*) – recorded for only the second time in Vermont in 2020
- Ten-spotted Spurleg Lady Beetle (*Brachiacantha decempustulata*) – 2021
- Hudsonian Lady Beetle (*Mulsantina hudsonica*) – 2021.
- Disk-marked Lady Beetle (*Hyperaspis disconotata*) – Native to eastern North America, first discovered in Vermont in 2021.

Additionally, the third state record of the Hieroglyphic Lady Beetle was uploaded to iNaturalist in 2021.

Since the start of the Vermont Lady Beetle Atlas, there has been a large increase in the number of observers and verified records of lady beetles in Vermont on iNaturalist (Table 2; Figure 1), which we attribute to outreach and education to community naturalists by Atlas coordinators. Prior to 2019, 117 iNaturalist users uploaded research grade lady beetle observations. In 2019, 2020, and 2021, there were 114, 316, and 360 lady beetle observers, respectively and 84, 251, and 224 of these observers were uploading research grade lady beetle observations for the first time (Table 2). Only 435 research grade lady beetle observations were uploaded to iNaturalist prior to the start of the Atlas. There were 329, 996 and 1382 new research grade observations uploaded to iNaturalist in 2019, 2020, and 2021, respectively. In total, 2,700 research grade observations of lady beetles have been uploaded to iNaturalist since the start of the Atlas (2,929 total observations).

With the possible correlation between the introduction of exotic lady beetle species and the decline of several native species (Figure 2), we have been monitoring observations of nonnative lady beetle species closely. Five non-native lady beetle species have been reported to iNaturalist since the start of the Atlas—Asian Lady Beetle (*Harmonia axyridis*), Fourteen-spotted Lady Beetle (*Propylea quatuordecimpunctata*), Seven-spotted Lady Beetle (*Coccinella septempunctata*), Variegated Lady Beetle (*Hippodamia variegata*), and Mexican Bean Beetle (*Epilachna varivestis*). There were 274, 740, and 957 research grade observations of these 5 species in 2019, 2020, and 2021, respectively (Table 3). In total, there were 1,971 observations of these five species, which is 73% of the total lady beetle observations uploaded to iNaturalist from 2019 to 2021.

Next Steps

There are several steps that we are taking to continue and expand community engagement and data collection in 2022. We will continue hosting training webinars prior to the start of the field season. We will host two week-long lady beetle bioblitzes, one in June and another in August.

We will also have a special focus in 2022 on four species that are missing we consider to be most wanted: Nine-spotted Lady Beetle (*Coccinella novemnotata*), Two-spotted Lady Beetle (*Adalia bipunctata*), Transverse Lady Beetle (*Coccinella transversoguttata*), and Thirteen-spotted Lady Beetle (*Hippodamia tredecimpunctata*).

The Nine-spotted, Two-spotted, and Transverse Lady Beetle species were designated as “species of greatest conservation need” in 2015 in New York, and the Nine-spotted also recently

being declared Endangered in Canada. The Thirteen -spotted Lady Beetle is listed as Imperiled in Nova Scotia and has been in sharp decline across much of its range (COSEWIC 2012).

A survey in 1993 failed to find any Nine-spotted Lady Beetles in 11 Northeastern states, including Vermont (Ellis et al. 1999). Biologists thought that both the Two-spotted and the Nine-spotted lady beetles were extinct in New York until citizen scientists rallied to help Cornell University's Lost Ladybug Project search for them. In 2009 the Two-spotted was reported from western New York and in 2011 citizen scientists discovered several Nine-spotted lady beetles on Long Island (Losey et al. 2014).

Community naturalists will be asked to survey in areas where these missing species were historically reported and in areas where there have been few to no lady beetle observations recently reported. We hope that with this increased focus, the chances of finding a remaining population of these missing species will be greatly increased.

Conclusions

During the first three years of the Vermont Lady Beetle Atlas, we have had great success in gathering occurrence records by engaging community naturalists. There were large increases in both the number of research grade lady beetle observations uploaded to iNaturalist, and in the number of iNaturalist users uploading research grade observations of lady beetles. To date, there have been six lady beetle species rediscovered and three species recorded in Vermont for the first time.

While there are six species that have been recorded in recent years for the first time in decades, there are still 11 native species that have not been reported since the 1990s. While we still have hope for finding more missing species, there is a good chance some of these species have been extirpated from Vermont, which may be connected to the high numbers of non-native lady beetles (specifically the Asian Lady Beetle, Fourteen-spotted Lady Beetle, and Seven-spotted Lady Beetle).

Tables and Figures

Table 1. Lady Beetle (Coccinellidae) faunal list for Vermont, USA based on verified records. Historic are those recorded prior to our atlasing efforts from 2019 through 2021.

Common Name	Scientific Name	Last Historic Report	Most Recent Record	Status
Two-spotted Lady Beetle	*Adalia bipunctata*	1992	1992	NY SGCN
15-spotted Lady Beetle	*Anatis labiculata*	2018	2021	
Eye-spotted Lady Beetle	*Anatis mali*	2018	2021	
Marsh Lady Beetle	*Anisosticta bitriangularis*	2018	2021	
Ten-spotted Lady Beetle	*Brachiacantha decempustulata*	1973	2021	
	Brachiacantha felina	1973	1973	
Undoubtable Lady Beetle	*Brachiacantha indubitabilis*		2014	
Four-spotted Lady Beetle	*Brachiacantha quadripunctata*	1976	2021	
Ursine Spurleg Lady Beetle	*Brachiacantha ursina*	1996	2021	
Cream-spotted Lady Beetle	*Calvia quatuordecimguttata*	2017	2020	
Twice-stabbed Lady Beetle	*Chilocorus stigma*	2018	2021	
Hieroglyphic Lady Beetle	*Coccinella hieroglyphica*	1969	2021	
Mountain Lady Beetle	*Coccinella monticola*	2017	2017	
Nine-spotted Lady Beetle	*Coccinella novemnotata*	1996	1996	NY SGCN, Canada-Endangered
Seven-spotted Lady Beetle	*Coccinella septempunctata*	2018	2021	Introduced
Transverse Lady Beetle	*Coccinella transversoguttata*	1986	1986	NY SGCN
Three-banded Lady Beetle	*Coccinella trifasciata*	2018	2021	
11-spotted Lady Beetle	*Coccinella undecimpunctata*	1971	1971	Introduced
Spotted Lady Beetle	*Coleomegilla maculata*	2018	2021	
Polished Lady Beetle	*Cycloneda munda*	2018	2021	
Firefly Duskyling	*Diomus terminatus*	1976	1976	
Mexican Bean Beetle	*Epilachna varivestis*	2018	2020	Introduced
Asian Lady Beetle	*Harmonia axyridis*	2018	2021	Introduced
Convergent Lady Beetle	*Hippodamia convergens*	2017	2021	
Glacial Lady Beetle	*Hippodamia glacialis*	1997	1997	
Parenthesis Lady Beetle	*Hippodamia parenthesis*	2018	2021	
Five-spotted Lady Beetle	*Hippodamia quinquesignata*	1890	1890	
13-spotted Lady Beetle	*Hippodamia tredecimpunctata*	1986	1986	
Variegated Lady Beetle	*Hippodamia variegata*	2018	2021	Introduced
Bigeminate Lady Beetle	*Hyperaspis bigeminata*	1976	2021	

	Hyperaspis binotata	1993	2014	
Disk-marked Lady Beetle	*Hyperaspis disconotata*		2021	
Octavia Lady Beetle	*Hyperaspis octavia*	1979	2021	
Esteemed Lady Beetle	*Hyperaspis proba*	1972	1972	
Undulate Lady Beetle	*Hyperaspis undulata*	1976	1976	
Hudsonian Ladybird	*Mulsantia hudsonica*	1992	2021	
Painted Lady Beetle	*Mulsantina picta*	2018	2021	
Streaked Lady Beetle	*Myzia pullata*	2017	2021	
Tiny Lady Beetle	*Nephus flavifrons*	2014		
14-spotted Lady Beetle	*Propylea quatuordecimpunctata*	2018	2021	Introduced
20-spotted Lady Beetle	*Psyllobora vigintimaculata*	2018	2021	
	Scymnus fraternus	1973	1973	
Pine Lady Beetle	*Scymnus suturalis*	1976	1976	Introduced

Table 2. Statistics for lady beetle data shared with the Vermont Atlas of Life on iNaturalist since it began in 2013 (research grade only). Users more than tripled during our atlasing efforts.

Year	Number of Observations	Number of Verified Species	Number of Observers
2021	1382	24	360
2020	996	21	316
2019*	329	17	114
2018	131	15	63
2017	103	13	40
2016	79	11	28
2015	61	9	19
2014	40	7	18
2013	50	10	19

*Start of the Vermont Lady Beetle Atlas

Table 3. Total number of research grade lady beetle observations in iNaturalist for each species by year.

Species Name	2008	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Total by Species
Asian Lady Beetle		1	5	31	24	40	47	75	85	236	613	769	1926
Spotted Pink Ladybeetle			2	4	5	1	5	7	13	21	106	89	253
Fourteen-spotted Lady Beetle	1		2	3	2	4	2	6	6	13	71	88	198
Twice-stabbed Lady Beetle				1			1		2	2	36	120	162
Seven-spotted Lady Beetle			3	1	5	5	7	2	4	13	31	50	121
Parenthesis Lady Beetle			1						2	3	26	62	94
Variegated Lady Beetle			1		2		1		4	12	19	44	83
Ursine Spurleg Lady Beetle				4	1	2	3	1	3	4	28	34	80
Polished Lady Beetle			1	2	1	1	5	2	3	4	19	38	76
Three-banded Lady Beetle				2		2	2		1	2	11	12	32
Eye-spotted Lady Beetle						2	4	3	2		5	14	30
Twenty-spotted Lady Beetle			1			3	1	1	3	5	6	10	30
Marsh Lady Beetle			1							4	5	9	19
Bigeminate Sigil Lady Beetle										3	1	14	18
Painted Ladybird									1	3	2	5	11
Mexican Bean Beetle				1					1	1	6		9
Octavia Lady Beetle											2	7	9
Convergent Lady Beetle								1			6	2	9
Cream-spotted Ladybird								2		1	1		4
Streaked Lady Beetle				1				1				1	3
Four-spotted Spurleg Lady Beetle											1	1	2
Fifteen-spotted Lady Beetle									1			1	2
Ten-spotted Spurleg Lady Beetle										1		1	2
Hieroglyphic Lady Beetle								1				1	2
Hudsonian Ladybird												1	1
Mountain Lady Beetle								1					1
Total by Year	**1**	**1**	**17**	**50**	**40**	**60**	**78**	**103**	**131**	**328**	**995**	**1373**	**3177**

Figure 1. The total number of lady beetle records (historic and modern) over time.

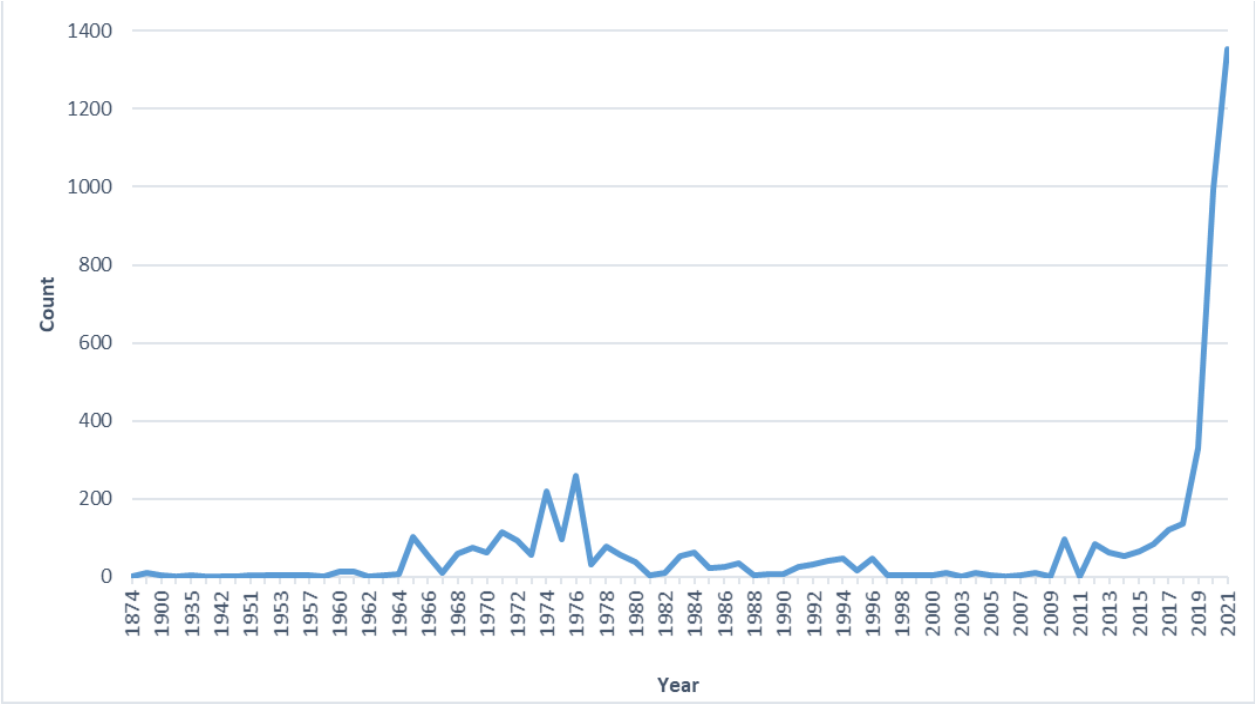
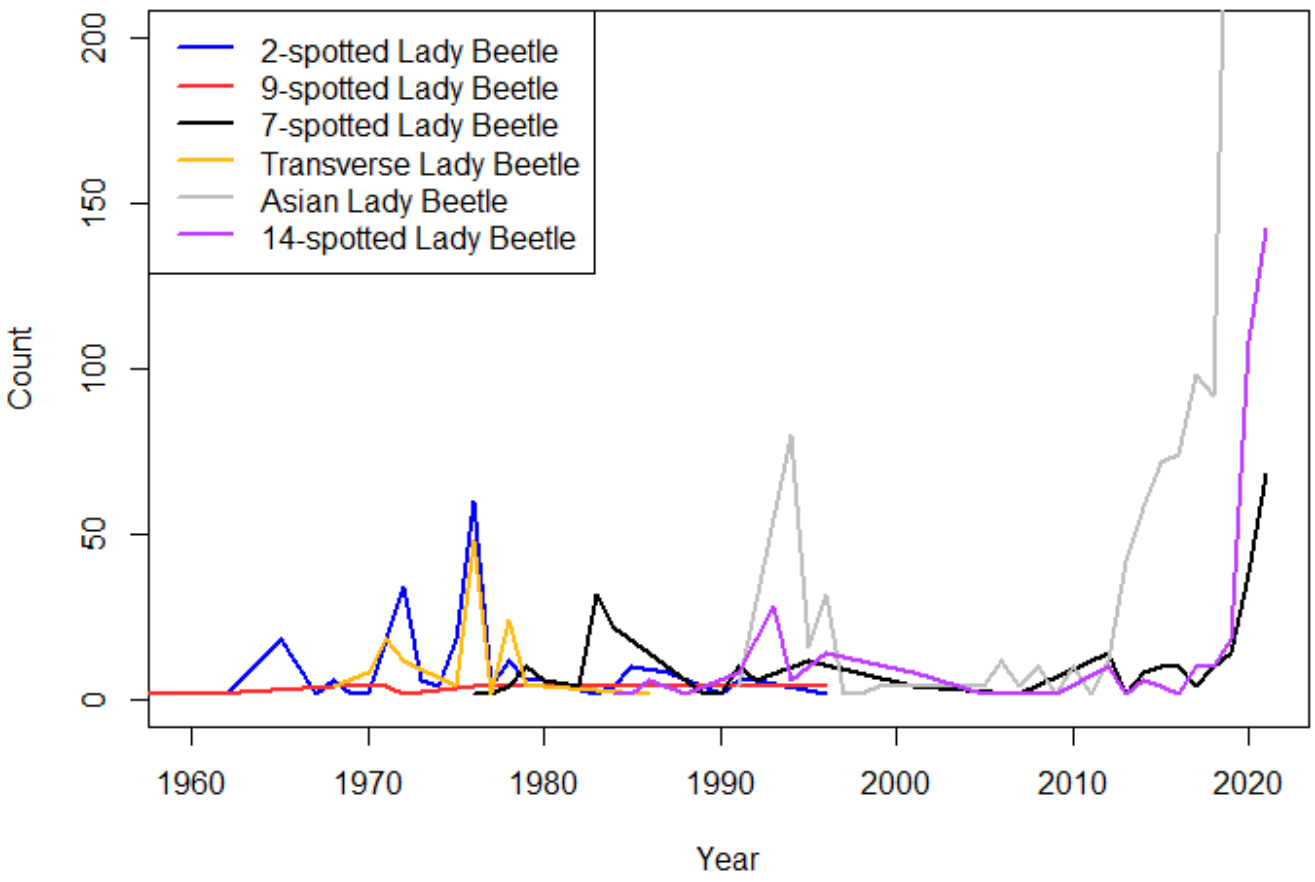


Figure 2. Annual records from 1960 to 2021 for three native species of conservation concern (Transverse Lady Beetle, Two-spotted Lady Beetle, and Nine-spotted Lady Beetle) and three introduced species (Seven-spotted Lady Beetle, Fourteen-spotted Lady Beetle, and Asian Lady Beetle). The native species have not been recorded in Vermont since 1986 for Transverse Lady Beetle and 1996 for both Two- and Nine-spotted Lady Beetles. The total count of Asian Lady Beetles is not included from 2019-2020 due to extreme high counts n=613 in 2020 and n=769 in 2021.



Acknowledgements

Thank you to the more than 700 volunteer naturalists that made this possible by contributing observations to this project. You can view the full list on our project at https://www.inaturalist.org/projects/vermont-lady-beetle-atlas?tab=observers. We'd also like to thank everyone that has helped us curate and determine crowd-sourced data - https://www.inaturalist.org/projects/vermont-lady-beetle-atlas?tab=identifiers. This project was made possible with financial support from the Binnacle Family Foundation, the Charles E. and Edna T. Brundage Charitable Science and Wildlife Conservation Foundation and private donations to the Vermont Center for Ecostudies.

LIterature Cited

- COSEWIC. 2012. COSEWIC Special Report on the Changes in the Status and Geographic ranges on the Canadian Lady Beetles Coleoptera: Coccinellidae: Coccinellinae and the selection of Candidate Species for Risk, in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. 60 pp
- Diepenbrock, L. M., Fothergill, K., Tindall, K. V., Losey, J. E., Smyth, R. R., & Finke, D. L. (2016). The influence of exotic lady beetle (Coleoptera: Coccinellidae) establishment on the species composition of the native lady beetle community in Missouri. *Environmental entomology*, *45*(4), 855-864.
- Ducatti, R. D. B., Ugine, T. A., & Losey, J. (2017). Interactions of the Asian lady beetle, Harmonia axyridis (Coleoptera: Coccinellidae), and the North American native lady beetle, Coccinella novemnotata (Coleoptera: Coccinellidae): prospects for recovery post-decline. *Environmental Entomology*, *46*(1), 21-29.
- Ellis, D. R., Prokrym, D. R., & Adams, R. G. (1999). Exotic lady beetle survey in northeastern United States: Hippodamia variegata and Propylea quatuordecimpunctata (Coleoptera: Coccinellidae). Entomological news (USA). 110 (2) 73-84.
- Harmon, J. P., Stephens, E., & Losey, J. (2006). The decline of native coccinellids (Coleoptera: Coccinellidae) in the United States and Canada. In *Beetle conservation* (pp. 85-94). Springer, Dordrecht.
- Hodek, I., Honek, A., & Van Emden, H. F. (Eds.). (2012). *Ecology and behaviour of the ladybird beetles (Coccinellidae)*. John Wiley & Sons.
- Jiang, J., Zhang, Z., Yu, X., Ma, D., Yu, C., Liu, F., & Mu, W. (2018). Influence of lethal and sublethal exposure to clothianidin on the seven-spotted lady beetle, Coccinella septempunctata L.(Coleoptera: Coccinellidae). *Ecotoxicology and environmental safety*, *161*, 208-213.
- Lamb, R. J., Bannerman, J. A., & Costamagna, A. C. (2019). Stability of native and exotic lady beetle populations in a diverse landscape. *Ecosphere*, *10*(3), e02630.
- Losey, J. E., Perlman, J. E., & Hoebeke, E. R. (2007). Citizen scientist rediscovers rare nine-spotted lady beetle, Coccinella novemnotata, in eastern North America. *Journal of Insect Conservation*, *11*(4), 415-417.
- Losey J. E., Allee L. L., Stephens E., Smyth R. R., Priolo P., Tyrrell L., Chaskey S., Stellwag L. (2014). Lady beetles in New York: insidious invasions, erstwhile extirpations, and recent rediscoveries. *Northeastern Naturalist*, *21*(2), 271-284.
- Marriott, M. (2012). *Assessing Geographic Distribution and Relative Abundance Patterns of Native and Non-native Lady Beetles (Coccinellinae) from Historic Occurrence Data* (Doctoral dissertation, University of Prince Edward Island).
- Parker, B. L., Nielsen, G. R., & Bell, R. T. (1976). *Lady beetles: A checklist of the Coccinellidae of Vermont (Insecta: Coleoptera)*. Agricultural Experiment Station, University of Vermont.