The effect of an invasive alien vine, *Vincetoxicum rossicum* (Asclepiadaceae), on arthropod populations in Ontario old fields

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Abstract

Vincetoxicum rossicum is an invasive alien vine introduced from Europe in the late 1800s that is now an emerging pest in upstate New York and eastern Ontario. The plant can form dense, monotypic stands in woodlots and old fields, and may be displacing native vegetation. As a consequence, *V. rossicum* may be displacing arthropod fauna associated with native vegetation. In June and August 2002, we sampled *V. rossicum* and three other old field plants (*Asclepias syriaca*, *Solidago altissima*, and mixed graminoids) for arthropods using pitfall traps and by sampling individual plants. A total of 7868 arthropods were counted on plants and 18,195 individuals were trapped; these were sorted by feeding guild. Overall, stands of *V. rossicum* supported the lowest abundance of both stem- and ground-dwelling individuals, as well as the lowest number of arthropods in most phytophagous guilds. Some feeding guilds are entirely absent: *V. rossicum* stands are completely devoid of gall-makers and miners, and support few pollinators. This study suggests that arthropod diversity will decline if *V. rossicum* displaces native old-field plants.

Introduction

Although invasive alien plants have been implicated in major ecological changes in a variety of environments (Mack 2000), their impact has proven difficult to define and measure (Parker et al. 1999). The visual impact of a monoculture of an alien plant can be striking, and it is often inferred that the plant is occupying space that would otherwise be covered by native vegetation. The effect of an alien plant monoculture on the native arthropod fauna is less obvious. Alien plants are unlikely to represent a palatable food source for most native herbivores, unless the alien is closely related to native plant species, or chemically similar to them. This, in turn, has implications for insectivores such as breeding birds and certain small mammals. Plants generally have fewer ene-mies in their introduced range than in their native range (Wolfe 2002; Mitchell and Power 2003). However, to assess the impact of an alien plant on the food resources of native insectivores, the relevant contrast is between the fauna associated with the alien plant and that associated with native plants that may have been displaced by the alien. To date, there are few studies comparing arthropods associated with native and alien plants (but notable exceptions include Toft et al. (2001), Agrawal and Kotanen (2003) and a few studies reviewed by Keane and Crawley (2002)).

Most studies on the impact of alien species usually consider the effect on a single population of a native species. Those that consider community-level impacts generally focus on species richness as the response variable, even though other community metrics might be more informative

(Parker et al. 1999). For example, summarizing community-level data by grouping the species into feeding guilds can yield insights into the mechanisms driving the effects and allow predictions about the consequences those effects may have on other components of the food web.

Pale swallow-wort, *Vincetoxicum rossicum* (Kleo.) Barb. (Asclepiadaceae; syn. *Cynanchum rossicum*) is a herbacious twining perennial vine that was introduced to North America from Ukraine and Russia in the late 1800s (Sheeley and Raynal 1996). It has recently become a persistent invader of old fields and woodlots in upstate New York (USA), as well as Toronto and Ottawa (Ontario, Canada). *Vincetoxicum rossicum* typically grows in very dense, montotypic stands that appear to displace native plants (Kirk 1985).

With the present study, we add to the rather short list of studies that assess the impact of an invasive plant on a terrestrial arthropod community. In particular, we examine how *Vincetoxicum rossicum* affects arthropods belonging to different feeding guilds. We predicted that stands of *V. rossicum* would support fewer arthropods than other old-field plants. In particular, we expected herbivore abundance to be lower on *Vincetoxicum* and we were interested in whether the effects of this alien plant extended to other trophic guilds, such as predators, parasitoids and detritivores. Using both stem sampling and pitfall trapping, we compared the assemblage of terrestrial arthropods associated with old-field stands of *V. rossicum* to that of other common old-field plants: tall goldenrod *Solidago altissima* L., common milkweed *Asclepias syriaca* L. and mixed graminoids.

Materials and methods

Although *V. rossicum* has been present in Ottawa since the 1930s (McNeill 1981), only recently has it become sufficiently abundant to attract the attention of land managers and its distribution is still patchy in the natural areas surrounding the city core. Our site selection was thus constrained by the limited availability of relatively large (25–100 m^2) monospecific patches of the weed in relatively undisturbed old fields. Six sites were chosen, with neighbouring sites spaced at least 0.5 km apart. The old-field communities at these sites were dominated by a mix of native and exotic grasses. Interspersed among the grasses were patches of common old-field forbs, including dense monocultures of the vegetatively spreading *Solidago altissima*, stands of sparsely dispersed *Asclepias syriaca*, smaller patches of other *Solidago* species and asters (*Aster novae-angliae* L.). Several other alien species were present as well at all sites, including Canada thistle (*Cirsium arvense* (L.) Scop.), garlic mustard (*Alliaria petiolata* (Bieb.) Cavara & Grande) at the field margins and purple loosestrife (*Lythrum salicaria* L.) in wetter areas.

Each site was visited during the middle 2 weeks of June and the last 2 weeks of August 2002. The timing of our surveys was based on host plant phenology: the first census coincided with the flowering of *Vincetoxicum* and the second with the flowering of *Asclepias* and *Solidago*.

Three to five unbaited pitfall traps were set in a staggered formation 10 paces apart in stands of *Vincetoxicum*, *Solidago* and mixed graminoids at each site, the number depending on the size of the stand. *Asclepias* was not sampled with pitfalls, because this plant did not grow in monospecific stands. Each trap was constructed using two 300 ml plastic drinking cups that were 10.5 cm deep and 7.5 cm in diameter. The cups were set one inside the other and were buried so that the top cup was flush with the ground. When the traps were emptied, only the top cup was removed, eliminating any digging-in effect (Majer 1978; Digweed et al. 1995). Approximately 2.5 cm of a 1 : 1 preservative solution of ethylene glycol (Prestone^{TM} antifreeze) and water was placed in each trap. During each of the two census periods, traps were left in the field for 7 days, after which all arthropod specimens were collected, cleaned with water, and stored in 80% ethyl alcohol for later sorting and counting.

To sample arthropods on individual plants, transects were walked in stands of *Solidago*, *Asclepias* and *Vincetoxicum*. Every third stride, a single plant was chosen haphazardly (by averting the eyes and pointing with a meter stick, and then selecting the stem closest to the end of the meter stick). Plants were measured and searched carefully for all arthropods, making sure to note any that flew or dropped off. Sixty plants of each

species were sampled at each site in both June and August. All arthropods found on the plant were counted, and, if possible, identified in the field. If identification was impossible or uncertain, representative specimens were returned to the lab and stored in 80% ethyl alcohol. All arthropod specimens were identified at least to the ordinal level (most to the familial level or below) using keys (e.g. Borror et al. 1989; Arnett 2000). These keys were also used to assign taxa to feeding guilds when the feeding ecology was not obvious from observations.

Fifty additional individuals of each host plant species were selected at random, cut at ground level, and returned to the lab. These were measured, then oven-dried at 60 °C for approximately 48 h until a constant drymass was reached. The regression of mass on height for each species was used to estimate the dry mass of each plant examined during the transect sampling.

Statistical analyses

The analyses were conducted using JMP version 3.2.5 (SAS Institute 1995). The pitfall trap data were standardized as the number of individuals per trap. For the stem sampling data we consider both the number of individuals per stem and the number per g plant drymass. Differences in the number of arthropods associated with the plants in June and August were analysed using repeated measures ANOVAs. The six study sites were used as replicates. When the ANOVA showed differences in the number of arthropods between plant species (significant at the 0.05 level), Tukey–Kramer HSD pairwise comparisons were performed.

Results

A total of 18,195 arthropods were collected by pitfall trapping (9036 in June; 9159 in August) and a total of 7868 arthropods were counted by stem sampling (2690 in June; 5278 in August). These represented seven orders of non-insect arthropods and 13 orders of insects (see Appendix 1 for a list of taxa). These taxa were assigned to nine feeding guilds. The mean number of arthropods collected directly from plants differed significantly among the three plant species (Tables 1 and 2). Measured

per stem and per g biomass, *Vincetoxicum* plants had fewer arthropods than both *Asclepias* and *Solidago*, although this difference was only significant for *Solidago*. The number of arthropods in the five guilds that feed directly on plant tissues were lower on *Vincetoxicum* than on *Solidago*, significantly so for all guilds measured per g drymass (Table 2), and for three guilds of the five measured per stem (Table 1). *Vincetoxicum* also supported fewer arthropods than *Asclepias* in all five phytophagous guilds, significantly so for stem borers per g drymass (Table 2) and for pollen/nectar feeders per stem (Table 1). Predacious arthropods were significantly lower on *Vincetoxicum* than either *Asclepias* or *Solidago* when measured per stem (Table 1), but were significantly higher than either plant when measured per g plant drymass (Table 2). The site of sampling explained none of the variance in the number of arthropods found in any feeding guild. The month of sampling was a significant predictor of abundance in detritivores, stem borers, stem gall-makers, leaf miners and leaf gall-makers, all of which were more abundant in the second sampling period. Significance levels notwithstanding, *V. rossicum* supported fewer individuals than *Solidago* or *Asclepias* in eight out of nine comparisons per stem and seven out of nine comparisons per g drymass. The probability of this occurring by chance alone is 0.0008 and 0.0069 respectively, based on a binomial test with P, the probability of one of the three plant species being lower than the other two, set at 0.333.

The type of plant stand – *Vincetoxicum*, *Solidago* or mixed graminoids – was not a significant predictor of the total of arthropods collected per pitfall trap (Table 3). Regardless of significance level, the per-trap abundance of leaf chewers, seed and sap feeders, pollen and nectar feeders, detritivores, omnivores and predators was lowest in traps set in *V. rossicum* stands (Table 3). The binomial probability of *Vincetoxicum* supporting the lowest abundance for six out of seven feeding guilds is 0.0061. The site at which pitfall traps were set explained some of the variance in the total number of arthropods collected; however, site was not a significant predictor of the abundance of any single feeding guild. The effect of month was significant only for predators, with higher numbers occurring in the earlier sample.

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Table 1. Results of repeated measures ANOVA (*F* and *P*) for each component of the model [species (SP), df = 2; site (SI), df = 1; month (MO), df = 1] and pooled mean number of arthropods counted per stem in each feeding guild ±SD.

Feeding guild	SP		SI (SP)		MO		Mean ± SD V. rossicum	Mean ± SD S. altissima	Mean ± SD A. syriaca
	F	P	F	P	F	P			
Total arthropods	26.6342	<0.0001	0.2458	0.9872	5.9051	0.0303	0.46 ± 0.18^{ac}	8.06 ± 6.95^{b}	3.34 ± 0.93^{c}
Phytophagous guilds									
Leaf chewers	9.3800	0.0042	0.4515	0.9027	0.6554	0.4328	0.46 ± 0.49^{a}	4.77 ± 3.82^{bc}	2.48 ± 2.37^{c}
Pollen/nectar feeders	22.2371	0.0001	0.1373	0.9989	2.0663	0.1742	0.00 ± 0.01^{a}	0.08 ± 0.12^{ab}	0.26 ± 0.29^{b}
Seed/sap feeders	1.9008	0.1954	0.8636	0.5913	4.4923	0.0539	0.01 ± 0.01	0.70 ± 1.39	0.29 ± 0.26
Stem borers/gallers	11.2191	0.0022	0.5371	0.8456	5.8384	0.0313	0.07 ± 0.10^{a}	0.89 ± 0.89^{b}	0.22 ± 0.11^{ac}
Leaf miners/gallers	11.3558	0.0021	0.3608	0.9506	8.7262	0.0112	0^{a}	2.31 ± 2.92^{b}	0.78 ± 0.58^{ab}
Predators	5.3523	0.0238	2.0540	0.1089	11.9173	0.0043	0.14 ± 0.16^{a}	0.49 ± 0.31^{b}	0.49 ± 0.23^{b}
Detritivores	3.6220	0.0619	0.7126	0.7097	39.8279	<0.0001	0.20 ± 0.25	0.14 ± 0.24	0.33 ± 0.37
Parasitoids	2.0175	0.1793	0.6845	0.7313	0.0221	0.8841	0.03 ± 0.04	0.04 ± 0.05	0.12 ± 0.18
Omnivores	2.4675	0.1302	0.7916	0.6469	0.3163	0.5834	0.00 ± 0.01	0.56 ± 0.87	0.34 ± 0.32

Italicized values indicate *P*-values significant at α = 0.05. Means with different superscript values indicate a significant difference between plant species, based on Tukey–Kramer honestly significant difference test of pairwise contrasts.

Table 2. Results of repeated measures ANOVAs (*F* and *P*) for each component of the model [species (SP), df = 2; site (SI), df = 1; month (MO), df = 1] and pooled mean number of arthropods counted per g of plant drymass in each feeding guild ±SD.

Feeding guild	SP		SI (SP)		MO		Mean ± SD V. rossicum	Mean ± SD S. altissima	Mean ± SD A. syriaca
	F	P	F	P	F	P			
Total arthropods	27.2214	<0.0001	0.4526	0.9021	2.8148	0.1173	12.05 ± 5.27^{a}	61.38 ± 36.36^{b}	15.21 ± 2.87^{ac}
Phytophagous guilds									
Leaf chewers	7.7460	0.0080	0.5377	0.8452	3.2537	0.6230	0.53 ± 0.70^{a}	19.73 ± 25.95^{b}	1.20 ± 0.55^{ac}
Pollen/nectar feeders	13.2959	0.0012	0.5184	0.8589	0.0353	0.8539	0.04 ± 0.12^{a}	0.83 ± 0.70^{b}	0.15 ± 0.18^{ac}
Seed/sap feeders	9.6923	0.0037	0.9354	0.5384	0.8377	0.3767	0.55 ± 0.61^{a}	12.72 ± 11.26^{b}	1.63 ± 0.86^{ac}
Stem borers/gallers	5.7197	0.0198	1.1447	0.4032	3.1159	0.1010	0^{a}	0.96 ± 0.98^{b}	1.00 ± 0.60^{b}
Leaf miners/gallers	6.7418	0.0123	1.1213	0.4168	6.9718	0.0204	0^{a}	17.54 ± 19.70^{b}	2.96 ± 2.61^{ac}
Predators	7.9600	0.0073	1.0100	0.4868	0.2535	0.6230	6.75 ± 3.19^{a}	3.23 ± 2.70^{b}	2.39 ± 0.65^{b}
Detritivores	1.6657	0.2334	0.9071	0.5589	6.6223	0.0231	0.42 ± 0.61	0.06 ± 0.14	0.20 ± 0.58
Parasitoids	33.7066	<0.0001	0.1884	0.9955	1.3550	0.2653	0.14 ± 0.20^{a}	0.27 ± 0.31^{ac}	1.09 ± 0.76^{b}
Omnivores	1.3540	0.2980	1.9464	0.1267	3.3127	0.0835	1.12 ± 1.61	4.80 ± 6.46	3.54 ± 2.23

Italicized values indicate *P*-values significant at α = 0.05. Means with different superscript values indicate a significant difference between plant species, based on Tukey–Kramer honestly significant difference test of pairwise contrasts.

Table 3. Results of repeated measures ANOVAs (*F* and *P*) for each component of the model [species (SP), df = 2; site (SI), df = 1; month (MO), df = 1] and pooled mean number of arthropods counted per pitfall trap in each feeding guild ± SD.

Feeding guild	SP		SI (SP)		MO		Mean ± SD V. rossicum	Mean ± SD S. altissima	Mean ± SD A. syriaca
	F-value	P-value	F-value	P-value	F-value	P-value			
Total arthropods	1.7511	0.2184	3.7345	*0.0116*	0.8768	0.3647	93.15 ± 75.13	128.00 ± 58.84	213.26 ± 174.78
Phytophagous guilds									
Leaf chewers	0.5901	0.5706	1.0815	0.4372	1.9409	0.1853	3.01 ± 3.70	9.04 ± 21.01	7.21 ± 8.77
Pollen/nectar feeders	1.9036	0.1941	0.8851	0.5739	2.9327	0.1089	0.60 ± 0.56	1.24 ± 1.21	1.40 ± 1.26
Seed/sap feeders	1.5278	0.2591	1.2356	0.3490	0.5618	0.4659	2.45 ± 3.29	3.58 ± 10.24	7.95 ± 5.51
Predators	3.7607	0.0565	1.4992	0.2349	30.1916	*<0.0001*	16.69 ± 12.42	26.04 ± 6.05	25.36 ± 11.10
Detritivores	0.5302	0.6025	0.8317	0.6151	0.0549	0.8181	43.70 ± 21.86	58.37 ± 57.33	53.84 ± 21.40
Parasitoids	1.2217	0.3309	0.7408	0.6876	0.1733	0.6835	1.33 ± 1.53	0.65 ± 0.40	0.81 ± 0.70
Omnivores	1.7068	0.2256	1.3384	0.2993	2.1034	0.1690	8.05 ± 13.75	14.42 ± 10.86	82.39 ± 159.55

Total pitfall traps: *V. rossicum* = 38; *S. altissima* = 39; graminoids = 42. Italicized values indicate *P*-values significant at $\alpha = 0.05$.

Discussion

Stands of the invasive alien vine *Vincetoxicum rossicum* that have established in old fields support lower numbers of individuals from several arthropod feeding guilds, compared to native old-field plants (*Asclepias syriaca*, *Solidago altissima*) and mixed graminoids (native and non-native), that dominate old-fields in eastern Ontario. This was true for arthropods dwelling directly on the host plants as well as the assemblages associated with the ground below the plant canopy, although the effects were more pronounced for plant-dwellers.

The lower abundance of herbivores on *V. rossicum* supports the hypothesis that alien plants have fewer herbivores in their introduced range than in their range of origin (Crawley 1986; Wolfe 2002). They also often have fewer enemies than the native species with which they co-occur (Keane and Crawley 2002), although in a phylogenetically controlled common garden experiment, Agrawal and Kotanen (2003) observed greater herbivore damage on aliens than on closely related natives. Interestingly, in their experiment, *Vincetoxicum rossicum* was one of only two alien species (out of 15) that suffered significantly less herbivory than its North American relative (Agrawal and Kotanen 2003).

Few herbivores were observed on *Vincetoxicum* and we saw almost no herbivore damage, indicating that it is highly unpalatable to native herbivores. *Vincetoxicum* is a member of the milkweed family, which is known for its potent antiherbivore defenses and highly specialized herbivores (Malcolm 1991). As one might have expected, herbivore levels on the common milkweed *Asclepias* syriaca were also relatively low, and significant contrasts in the stem samples were almost exclusively between *Vincetoxicum* and *Solidago*, a species with a large herbivore fauna that includes many generalists (Root and Cappuccino 1992). Interestingly, *Vincetoxicum* and *Asclepias* are not defended in the same way. *Asclepias* contains milky latex and cardiac glycosides (Malcolm 1991). Although the defensive chemistry of *Vincetoxicum rossicum* has not been studied, its congener *Vincetoxicum nigrum* contains phenanthroindolizidine alkaloids with strong antifungal activity (Capo and Saa 1989). The latex of

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Vincetoxicum is clear, rather than milky, and does not gush from wounds as if under pressure, the way *Asclepias* latex does. Despite these differences in chemical defenses, a few herbivores of *Asclepias* recognize the phylogenetic affinity of *Vincetoxicum*. Monarch butterflies (*Danaus plexippus* L.) occasionally oviposit on it, although the larvae do not survive (DiTommaso et al. in press). A single milkweed longhorn beetle (*Tetraopes tetraophthalmus* Forster) was seen nibbling on a *Vincetoxicum* plant (N. Cappuccino, pers. obs) and the beetles will feed on cut leaves in the lab (C.M. Ernst and N. Cappuccino, pers. obs.). The small milkweed bug (*Lygaeus kalmii* Stal) has also been observed feeding on *Vincetoxicum* seed pods (C.M. Ernst and N. Cappuccino, pers. obs.).

One of the difficulties in comparing the impact of an alien plant on the arthropod fauna lies in standardizing the alien and native vegetation to be compared. For this reason we were unable to conduct stem samples for mixed grasses that would have been comparable to the stem samples of the other three plant species. Furthermore, a small alien plant may support fewer arthropods on each stem than a robust native, simply by virtue of the fact that it is smaller. Our attempt at standardization was to divide the arthropod counts by stem biomass, as estimated by a regression of biomass on stem height. When the data were expressed per g dry biomass, *Asclepias*, a relatively stout plant, had the lowest values for predators, a lower value than *Solidago* for leaf chewers and a higher value than *Solidago* for seed and sap feeders. All other comparisons were qualitatively similar to the simple per-stem counts. Although, we recognize the value of standardizing the data on a per-biomass basis, it is nevertheless likely that for foraging, insects, the stem is the unit that is searched, regardless of its thickness or weight.

Although we expected fewer herbivores on *Vincetoxicum*, we had no *a priori* expectations regarding the relative abundance of pollinators visiting the three forb species. However, since *Vincetoxicum* has flat flowers with open access to nectar, characteristic of fly-pollinated plants (van der Pijl 1961) and since nectar is plainly visible in the flowers, we were surprised to observe almost no pollinators or floral visitors. Although flies have been reported visiting *Vincetoxicum nigrum* flowers in New York State (Lumer and Yost 1995), almost no arthropods were seen visiting *V. rossicum* flowers in a previous study (St Denis and Cappuccino 2004). Only a single vespid wasp was seen on *V. rossicum* in the present study. Lack of floral visitors is not expected to greatly hinder the spread of *V. rossicum*, which produces seed by *in situ* germination of selfed pollen (St Denis and Cappuccino 2004).

The ground-dwelling fauna was also lowest for most feeding guilds in *V. rossicum* stands. Other workers have also shown that the presence of an invading alien plant can reduce the diversity and distribution of epigaeic fauna (e.g. Samways et al. 1996).

The ability of *V. rossicum* to displace native old-field vegetation has yet to be quantified but is being investigated (N. Cappuccino, unpubl. data). However, its widespread presence and aggressive spread in a variety of habitats and localities appears to indicate that it is fully capable of such displacement. The impact of alien plant invasions and the subsequent displacement of native vegetation on resident fauna have important consequences for the conservation, management and restoration of invaded habitats. Our study suggests that if the spread of *V. rossicum* continues unchecked, arthropod populations in old-fields could significantly decline. This has immediate implications for the diversity of arthropods in this type of habitat and also for the success of other animals (e.g. birds and small mammals) that utilize arthropods as a source of food.

Appendix 1. List of all arthropod taxa collected during the duration of the study. Includes trapped and hand-sampled individuals, for both June and August 2002.

Class	Order	Suborder	Family	Subfamily	Species[a]
Arachnida	Araneae		Lycosidae		
			Thomisidae		
			Araneidae		
			Gnaphosidae		
	Opiliones	Cyphophthalmi			
		Palpatores			
	Acari	Ixodida			
	Pseudoscorpiones				
Diplopoda	Opisthospermophora				
	Polydesmida				
Chilopoda	Geophilomorpha				
Hexapoda (Pterygota)	Ephemeroptera		Baetidae		
			Ephemeridae		
	Orthoptera		Acrididae	Cyrtacanthacridinae	
				Acridinae	
			Gryllacrididae	Rhaphidophorinae	
			Gryllidae	Gryllinae	
	Dermaptera		Forficulidae		
	Hemiptera	Cimicomorpha	Tingidae		
			Miridae		
			Anthocoridae		*Orius insidiosus*
			Reduviidae		
		Pentatomorpha	Lygaeidae		*Lygaeus kalmii*
			Pentatomidae		
	Homoptera	Auchenorrhyncha	Membracidae		*Publilia concava*
			Cercopidae		*Philaenus spumarius*
			Cicadellidae	Cicadellinae	
				Idiocerinae	
		Fulgoroidea			
		Sternorrhyncha	Aleyrodidae		
			Aphididae		*Aphis nerii*
	Thysanoptera				
	Neuroptera	Planipennia	Chrysopidae		
	Coleoptera	Adephaga	Cicindelidae		
			Carabidae		
			Halipidae		
		Polyphaga	Ptiliidae		
			Silphidae		
			Staphylinidae	Aleocharinae	
				Oxytelinae	
				Xantholininae	
			Histeridae		
			Scarabaeidae	Melononthinae	
				Geotrupinae	
			Buprestidae		
			Elateridae		
			Lampyridae		
			Cantharidae		*Chauliognathus* sp.
			Cleridae		
			Nitidulidae		
			Erotylidae		
			Phalacridae		
			Corylophidae		
			Coccinellidae		
			Lathridiidae		

Appendix 1. Continued.

Class	Order	Suborder	Family	Subfamily	Species[a]
			Mordellidae		
			Anthicidae		
			Cerambycidae		*Tetraopes tetraophthalmus*
			Chrysomelidae		*Labidomera clivicolis*
					Chrysolina hyperici
					Exema canadensis
					Trirhabda virgata
			Curculionidae		*Rhyssomatus lineaticollis*
	Siphonaptera				
	Diptera	Nematocera	Tipulidae		
			Bibionidae		
			Mycetophilidae		
			Sciaridae		
			Culicidae		
		Brachycera	Chironomidae		
			Asilidae		
			Dolichopodidae		
			Phoridae		
			Syrphidae		
			Tephritidae		*Eurosta solidaginis*
			Argomyzidae		
			Sciomyzidae		
			Sphaeoceridae		
			Drosophilidae		
			Chloropidae		
			Scathophagidae		
			Muscidae		
			Calliphoridae		
			Sarcophagidae		
			Tachinidae		
	Trichoptera				
	Lepidoptera	Ditrysia	Psychidae		
			Gelechiidae		*Dichomeris* spp.
			Papilionidae		
			Pieridae		
			Danaidae		*Danaus plexippus*
			Geometridae		
			Lasiocampidae		
			Arctiidae		*Euchetes egle*
			Noctuidae		
	Hymenoptera	Apocrita	Ceraphronidae		
			Braconidae		
			Ichneumonidae		
			Chalicidae		
			Diapriidae		
			Sphecidae		
			Halictidae		
			Apidae		
			Vespidae		
			Formicidae	Myrmicinae	*Crematogaster* sp.
				Scelioninae	
				Formicinae	*Formica* sp.
					Lasius sp.
				Ponerinae	*Ponera* sp.

[a] This is not an exhaustive list; representative species are presented here as examples, but do not necessarily reflect all species collected.

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