Research Reports

Abundance of Beneficial Arthropods on Woody Landscape Plants at Professionally-Managed Landscape Sites[1]

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Abstract

Eight 0.2–0.4 ha (0.5–1.0 A) sites managed by landscape professionals were monitored biweekly for beneficial arthropod activity. More than 30 generalist predator taxa were identified. Spiders and green lacewings were the most numerous taxa and both were found on all plant taxa sampled. Green lacewings, especially the egg stage, were the most numerous natural enemies detected on birch, crape myrtle, cherry, and oak trees accounting for 52.5, 49.9, 43.5, and 38.1%, respectively. Spiders accounted for 56.2% of the insectivorous arthropods observed on magnolia and were the most abundant predatory arthropod on azaleas comprising 46.5% of all arthropod predators/parasites across all properties. The most abundant predatory arthropods on junipers were spiders accounting for 75.5% of the beneficials encountered with ants (associated with an early season aphid outbreak), green lacewing larvae, lady beetles, harvestmen, and parasitic wasps comprising 15.8, 0.4, 4.3, 0.4, and 1.2%, respectively. Spiders were the most abundant predators on boxwood accounting for 70.6% of the natural enemies.

Index words: integrated pest management, beneficial arthropods, green lacewing, spiders, urban landscape, ants.

Significance to the Nursery Industry

Natural enemies in managed landscapes were identified and quantified. Identification of these taxa is the first step in determining their impact in urban landscape pest reduction and incorporating them into decision-making guidelines for landscape professionals. This information can be used to adjust management practices to enhance insectivorous arthropod activity and potentially reduce pesticide inputs. Furthermore, the identification of plant materials that support greater abundance of natural enemies will provide the nursery industry and landscape managers with additional information increasing the marketability of these plants. The study also provides baseline data for further research in landscape pest management.

Introduction

Beneficial arthropod abundance has been well documented in alfalfa, cotton, orchards, soybeans, turf, and other systems (3, 4, 5, 6, 21, 27). Few studies, however, describe the role of natural enemies in regulating landscape pest populations. Predators are a critical factor in regulating azalea lace bugs (*Stephanitis pyrioides* Scott) in both architecturally simple and complex landscapes (11). Natural enemy elimination in

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an adult mosquito control program was implicated in a pine needle scale (*Chionaspis pinifoliae* Fitch) outbreak on lodgepole and Jeffrey pine, *Pinus contorta* and *P. jeffreyi*, respectively (13). Scale populations declined after the program ceased and natural enemies recovered. Generalist predators such as the European earwig (*Forficularia auricularia* L.), harvestmen (*Phalangium* spp.), and snowy tree cricket (*Oecanthus fultoni* Walker) were 'singularly responsible' for excluding white peach scale (*Pseudaulacaspis pentagona* Targioni Tozzetti) from Maryland forests (7).

Economic thresholds and injury levels of key pests have been well-defined in field crops such as apple, corn, potatoes, soybeans, and other crops (14). In the urban landscape, economic and aesthetic thresholds are poorly defined and limit the adoption of integrated pest management (9, 20, 23). Landscape professionals now depend on personal experience instead of established guidelines to make pest management decisions (22). The objective of our study was to identify and quantify insectivorous arthropods on several plant species on properties managed by landscape professionals. This is an important step in establishing realistic landscape pest thresholds that incorporate the effects of insectivorous arthropods.

Materials and Methods

Eight 0.2–0.4 ha (0.5–1.0 A) properties managed by landscape professionals were monitored biweekly from April 8, 1998, to September 8, 1998, for beneficial arthropods as part of an integrated pest management (IPM) pilot program (31). Sites were located in Clayton, Coweta, Fayette, Henry, or Pike County, GA. All sites had a high degree of plant diversity and were established landscapes installed before 1996. Cooperating landscape professionals agreed to make spot pesticide applications only when recommended by the authors.

A scouting plan was developed in 1997 to accommodate the diverse plant material at the sites and refined in 1998. Sites were scouted for approximately one hour per visit between the hours of 9:00 AM and 4:00 PM. Scouting techniques varied according to plant material. Five 30.5 cm (1 ft) lower (< 180 cm, 6 ft high) branch terminals and the accompanying foliage of hemlock (*Tsuga canadensis*), birch (*Betula nigra* and *B. papyrifera*), and Burford holly (*Ilex cornuta* cv. canariensis) were examined per individual tree. Magnolias (*Magnolia* x *soulangiana* and *M. stellata*) were scouted by performing one 30-second foliar examination. All other trees were scouted by examining three 30.5 cm (1 ft) lower (< 180 cm, 6 ft high) branch terminals and the accompanying foliage. Large shrubs > 90 cm (3 ft) high and tree-form Burford hollies (*Ilex cornuta* cv. canariensis) at one commercial site (due to a dense canopy) were scouted by taking three beat samples over a 40 × 20 cm (15.7 × 7.9 in) white enamel pan. One beat sample was taken from small shrubs < 90 cm (3 ft) high. A hand magnifier was used as necessary. Arthropods were returned to the plant.

Within each of the three sampling methods, the number of beneficials per plant taxon was related to the number of plants of that taxon sampled to determine if a correlation existed. Natural enemy abundance data for each plant taxon were pooled across all properties and summarized as seasonal means per sampling unit. Due to low overall numbers and high variability, statistical analysis for a given taxon across sites was not possible.

Results and Discussion

Except for Site 2, a site with large populations of Japanese beetles (*Popillia japonica* Newman), few pesticide applications were required to meet the clients' aesthetic expectations (Table 1). Beneficial arthropod taxa were well represented in these managed landscapes (Table 2). Spiders and green lacewings (Chrysopidae) were detected on all plant material scouted. Lady beetles (Coccinellidae) were seen on all plants except hemlock, and harvestmen (Opiliones) were detected on all plants except crape myrtle, holly, and rose. Other predators such as berytids, and earwigs (Dermaptera) were rarely encountered. As expected, within a sampling type there was a strong correlation between the number of plants scouted within a given plant taxon and the number of beneficial arthropod taxa observed (Table 2). Correlation coefficients were 0.80, 0.85, and 0.25 (three data points) for beat samples, three branch/foliar examinations, and five branch/foliar examinations, respectively.

Table 1. Pesticides applied to plant material on eight landscape sites managed by landscape professionals in Georgia in 1998.

Site number and location		Date(s)	Pesticide	Plant
1	Newnan, GA	4/23, 7/1	Insecticidal soap	Azalea, boxwood
		5/19, 6/10	Sevin (carbaryl)	Azalea, crape myrtle, rose
2	Stockbridge, GA	5/1	Horticultural oil	Azalea, juniper, laurel
		5/1	Daconil 2787 (chlorothalonil)	Rose
		5/22	Battle (lambda cyhalothrin)	Hibiscus, hollyhock, viburnum
		5/22	Daconil 2787 (chlorothalonil)	Laurel, verbena, spirea
		6/11	Battle (lambda cyhalothrin), Sevin (carbaryl)	Cherry, crape myrtle, wax myrtle
		6/30	Battle (lambda cyhalothrin), Sevin (carbaryl)	Azalea, cherry, crape myrtle
		8/21	Horticultural oil	Juniper
		8/21	Orthene (acephate), Funginex (triforine)	Gardenia, Arizona cypress, magnolia
3	Jonesboro, GA	None	None	None
4	Peachtree City, GA	6/9	Battle (lambda cyhalothrin)	Birch, crape myrtle, juniper, holly
5	Zebulon, GA	7/8, 7/15, 7/24	Horticultural oil	Burford holly
		8/13	Horticultural oil	Crape myrtle
6	Peachtree City, GA	5/30, 6/27, 8/14	Dursban (chlorpyrifos)	Azalea
		6/27	Orthene (acephate)	Crape myrtle
7	Morrow, GA	4/2	Horticultural oil	Azalea, gardenia, maple
		5/11	Horticultural oil	Azalea, gardenia
8	Jonesboro, GA	7/1, 7/8, 8/1, 8/8	Horticultural oil	Yaupon holly, juniper

Table 2. Beneficial arthropod taxa detected by plant type.

Taxon	Azalea	Boxwood	Cotone-aster	Juniper	Birch	Hemlock	Holly	Cherry	Crape myrtle	Maple	Oak	Rose	Magnolia
Scouting method[z]	**Beat**	**Beat**	**Beat**	**Beat**	**5**	**5**	**5[y]**	**3**	**3**	**3**	**3**	**3**	**30 s. scan**
Araneae	X	X	X	X	X	X	X*	X	X	X	X	X	X
Asilidae													X
Berytidae	X												
Cantharidae									X				X
Carabidae	X	X											
Chrysopidae	X	X	X	X	X	X	X*	X	X	X	X	X	X
Coccinellidae	X	X	X	X	X		X*	X	X	X	X	X	X
Coniopterygidae	X	X					X			X	X		X
Dermaptera		X											
Formicidae	X	X	X	X	X		X	X	X	X	X	X	X
Geocoris spp.	X	X	X	X					X				
Hemerobiidae		X					X						
Ichneumonidae	X												
Lampyridae	X	X							X		X		X
Mantidae	X	X	X			X	X	X	X	X			
Meloidae	X	X	X					X					
Miridae	X	X											
Nabidae	X	X		X			X			X			
Odonata										X			X
Opiliones	X	X	X	X	X	X		X			X		X
Parasitic wasps	X	X	X	X			X	X	X	X	X		X
Reduviidae	X	X		X					X	X			X
Staphylinidae		X											
Syrphidae	X	X		X		X		X	X	X			X
Vespidae								X	X	X			X
Misc. wasps.	X	X											X
Total taxa	19	20	9	10	5	5	3	10	12	12	8	4	15
Plants scouted	57	34	5	17	4	3	3	26	36	25	12	5	32
Taxa/plant	0.33	0.59	1.8	0.59	1.25	1.67	1	0.38	0.33	0.48	0.7	0.8	0.49

[z]Sampling methods varied by plant type. See methods. '5' or '3' refers to 5 or 3 stems attached foliage/plant examined, respectively.

[y]Four plant units were beat sampled at a single site due a dense canopy. Nine beneficial arthropod taxa were detected on these plants.

Arthropod fauna observed in branch and foliar examinations. Green lacewings, especially the egg stage, comprised a large percentage of the potential natural enemies observed on tree foliage (Table 3). Seventy-six percent of the insectivorous arthropods observed on Burford holly were green lacewing eggs at a single site. When adult and larval green lacewings are included, green lacewings accounted for 88.0% of the beneficial arthropod taxa on Burford holly. Four of the eight sites had birch (*Betula nigra* and *B. papyrifera*) plantings. Green lacewings were the most abundant insectivorous arthropod on birch accounting for 52.5% of the natural enemies detected on them (Table 3). Ants, lady beetles,

Table 3. Seasonal means across all sites of beneficial arthropod taxa observed in stem and foliar examinations on plant material managed by landscape professionals in Georgia in 1998.

Plant[z]	Ant	Green lacewing (egg)[y]	Lady beetle	Opilione	Parasitic wasp	Spider
Birch	0.08 ± 0.06	**0.70 ± 0.30**[x]	0.18 ± 0.09	0.05 ± 0.04	0	0.33 ± 0.22
Burford holly	0	**0.33 ± 0.10**	0.03 ± 0.02	0	0	0.02 ± 0.02
Hemlock	0	0	0	**0.10 ± 0.10**	0	**0.10 ± 0.10**
Cherry	0.05 ± 0.01	**0.20 ± 0.11**	0.11 ± 0.04	0.001± 0.001	0.01 ± 0.01	0.05 ± 0.02
Crape myrtle	0.08 ± 0.02	**0.55 ± 0.07**	0.17 ± 0.02	0	0.02 ± 0.004	0.30 ± 0.04
Maple	**0.14 ± 0.02**	0.08 ± 0.02	0.09 ± 0.01	0	0.04 ± 0.01	0.05 ± 0.01
Oak	**0.22 ± 0.01**	0.21 ± 0.07	0.05 ± 0.02	0.01 ± 0.01	0.04 ± 0.00	0.05 ± 0.00
Rose	0.08 ± 0.04	0.09 ± 0.02	**0.32 ± 0.16**	0	0	0.07 ± 0.03
Magnolia	0.02 ± 0.01	0.15 ± 0.03	0.10 ± 0.02	0.06 ± 0.02	0.002± 0.001	**0.71 ± 0.17**

[z]Birch, Burford holly, and hemlock: means are per 5 stem examinations, magnolia: means are per 1 thirty second examination of entire tree, all others: means are per 3 stem examinations. See Table 1 for pesticides used.

[y]Other green lacewing stages detected: Burford holly, 0.03 ± 0.02 (adults), 0.02 ± 0.02 (larva); hemlock, 0.03 ± 0.03 (larva); crape myrtle, 0.004 ± 0.000 (larva), 0.001 ± 0.000 (pupa, adult); maple, 0.05 ± 0.01 (larvae, adults); oak, 0.02 ± 0.01 (larvae), 0.01 ± 0.01 (pupae, adults); rose, 0.01 ± 0.01 (larva); magnolia, 0.01 ± 0.002 (larvae), 0.004 ± 0.002 (pupae, adults).

[x]Most numerous natural enemy taxon on a given plant taxon on a particular site is shown in **bold face**.

Table 4. **Seasonal means across all sites of beneficial arthropod taxa observed in beat samples on plant material managed by landscape professionals in Georgia in 1998.**

Plant	Ant	Green lacewing (larvae)	Lady beetle	Opilione	Parasitic wasp	Spider
Azalea	0.50 ± 0.10	0.06 ± 0.01	0.08 ± 0.01	0.06 ± 0.01	0.16 ± 0.03	**0.86 ± 0.06**[z]
Boxwood	0.27 ± 0.13	0.10 ± 0.03	0.11 ± 0.03	0.06 ± 0.03	0.12 ± 0.04	**2.19 ± 0.42**
Burford holly	**9.02 ± 3.58**[y]	0.35 ± 0.14	0.52 ± 0.11	0	0.40 ± 0.11	1.63 ± 0.29
Cotoneaster	**0.27 ± 0.06**	0.02 ± 0.01	0.01 ± 0.01	0	0.02 ± 0.01	0.18 ± 0.04
Juniper	0.49 ± 0.20[x]	0.01 ± 0.01	0.13 ± 0.06	0.01 ± 0.01	0.04 ± 0.01	**2.30 ± 0.94**

[z]Most numerous natural enemy taxon on a given plant taxon on a particular site is shown in **bold face.** See Table 1 for pesticides used.

[y]Ants associated with cottony camellia scale (*Chloropulvinaria floccifera* Westwood).

[x]Ants associated with an early season aphid outbreak.

harvestmen (Opiliones), parasitic hymenopterans, and spiders accounted for 5.6, 13.1, 3.8, and 25.0% of the natural enemies, respectively. On hemlock (*Tsuga canadensis*) five of the 12 arthropod taxa observed were predators. Spiders, harvestmen (Opiliones), and green lacewing (eggs) were 33.3%, 33.3%, and 11.1% of the predators, respectively.

Oaks (*Quercus* spp.) were scouted on two sites. Green lacewings were the most numerous natural enemies detected on oak with eggs, larvae, pupae, and adults comprising 32.6, 2.3, 1.6, and 1.6%, respectively. Ants (associated with European fruit lecanium scale, *Parthenolecanium corni* Bouché), lady beetles, harvestmen (Opiliones), parasitic hymenopterans, and spiders accounted for 33.3, 7.8, 1.6. 6.2, and 7.0%, respectively (Table 3).

Similarly, green lacewing eggs were most the abundant potential natural enemy detected on cherry trees (*Prunus* spp.). They accounted for 43.5% of the natural enemies. No other green lacewing stages were observed on cherry. The other major arthropod taxa, ants, lady beetles, harvestmen, parasitic wasps, and spiders, were present in lesser amounts accounting for 10.4, 25.3, 0.3, 3.2, and 11.0%, respectively (Table 3).

All eight sites had crape myrtle (*Lagerstroemia indica*). Green lacewing eggs were most numerous across all properties accounting for nearly half (49.4%) of the beneficial arthropods. Green lacewing larvae, pupae, and adults comprised 0.3, 0.1, and 0.1% of the total natural enemies, respectively. Ants, lady beetles, parasitic wasps, and spiders were 7.4, 15.1, 1.5, and 23.8% of the total, respectively (Table 3).

No clear trends were observed on maples (*Acer* spp.) which were scouted at five of the eight sites. At each site a different natural enemy taxon predominated. Across all properties, ants, green lacewing eggs, lady beetles, parasitic wasps, and spiders comprised 27.4, 17.4, 19.1, 9.6, 21.7% of the insectivorous arthropods, respectively.

Five of the eight sites scouted contained magnolias. Spiders were the most common *arthropod* at three sites, and the most common beneficial at four properties. Across all sites spiders comprised more than half (56.2%) of the natural enemies detected (Table 3). Green lacewing eggs accounted for 12.0% of the potential natural enemies on magnolia while lacewing larvae, pupae, and adults, comprising 1.1, 0.3, and 0.3% of the total natural enemies, were less frequently observed. Ants, lady beetles, harvestmen, and parasitic hymenopterans comprised 1.6, 8.2, 5.1, and 0.2% of the insectivorous arthropods observed, respectively.

Arthropod fauna from beat sampling method. Seven of the eight sites contained azaleas. Spiders were the most abundant predatory arthropod on azaleas (Table 4) accounting for 46.5% of all arthropod predators/parasites on azaleas across all properties. Ants were also present in large numbers comprising 27.4% of the natural enemies.

Green lacewing larvae, lady beetles, harvestmen, and parasitic hymenopterans accounted for 3.3, 4.1, 3.5, and 8.5% of the insectivorous arthropods, respectively. Predator populations fluctuated throughout the growing season on untreated azaleas (Fig. 1). Except for dustywings (Coniopterygidae) which were more rare, the insectivorous arthropod taxa in Fig. 1 is representative of the other sites (31).

Similar results were seen on the four sites containing junipers. Spiders were the most abundant predatory arthropods accounting for 75.5% of the beneficials encountered with ants (associated with an early season aphid outbreak), green lacewing larvae, lady beetles, harvestmen, and parasitic wasps comprising 15.8, 0.4, 4.3, 0.4, and 1.2%, respectively (Table 4).

Four of the eight study sites contained boxwood. Spiders were the most common arthropods on boxwood on three of the four properties, and most abundant predators on all four accounting for 70.6% of all natural enemies detected across all properties (Table 4). Ants, green lacewing larvae, lady

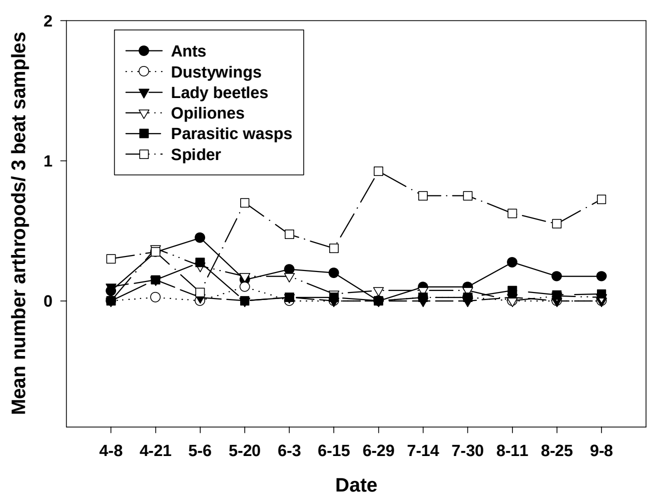

Fig. 1. Beneficial arthropod taxa by date on unsprayed azaleas at Site 4.

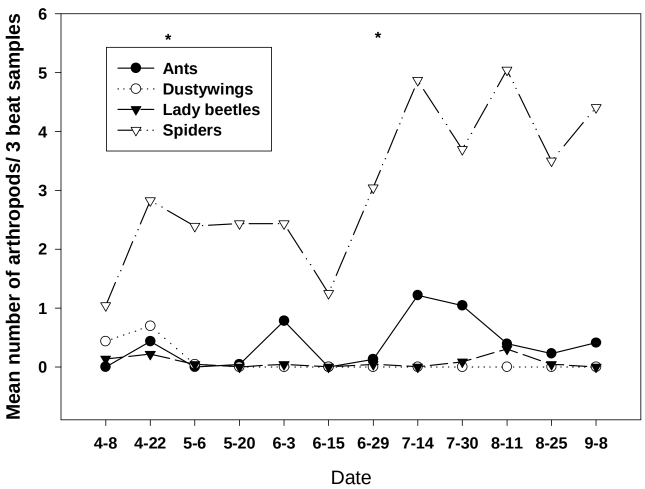

Fig. 2. Beneficial arthropod taxa on boxwood at Site 1. * Spot applications of insecticidal soap made 4-23-98, 7-1-98.

beetles, harvestmen, and parasitic wasps comprised 8.5, 3.0, 3.5, 1.9, and 3.9% of the beneficial arthropods on boxwood, respectively. Despite two spot applications of insecticidal soap for boxwood mite (*Eurytetranychus buxi* Garman) control, spider populations remained high at Site 1 (Fig. 2). The taxa shown were frequently encountered at the other sites. *Rhinocapsus vanduzeei* Uhler (a predatory mirid), adults and nymphs were detected in greater numbers on boxwood (0.17 ± 0.09) at Site 3 than on nearby azaleas (0.04 ± 0.02), with which they are normally associated (32).

At the one site containing cotoneaster, ants, green lacewing larvae, lady beetles, parasitic hymenopterans, and spiders accounted for 50.0, 3.7, 1.9, 3.7, and 33.0% of the predators, respectively. The presence of these and other predators were not sufficient to keep hawthorn lace bug (*Corythuca cydoniae* Fitch), a key pest, from reaching levels requiring chemical control.

The results indicate that a complex of generalist predators including spiders, green lacewings, lady beetles, dustywings, ants, and others were well represented in managed landscapes. Our data indicate that spiders are one of the most numerous insectivorous arthropod taxa on shrubs. Over 3,000 and 30,000 species of spiders have been described in North America and worldwide, respectively, and are often found in large numbers in terrestrial ecosystems (17, 35, 37). Spiders have been observed feeding on all insect stages, including eggs (15). In vegetable gardens, spiders accounted for 84% of the predators and were responsible for 98% percent of the observed predation events (25). In California rice fields, densities of the aster leafhopper (*Macrosteles fascifrons* Ståhl) were reduced 84–96% when compared to plots in which the spider *Pardosa ramulosa* McCook was excluded (18). Despite these and other observations on the impact of spiders in agriculture, spiders have been largely ignored in biological control programs which have primarily focused on monophagous insectivores rather than generalists (26).

Spider populations remained high after insecticidal soap (Fig. 2) or horticultural oil applications, but controlled studies need to be performed to determine the effect of these compounds and others on both spiders and green lacewings. While spiders were the most numerous taxon observed in beat samples of low shrubs, they generally accounted for a lower proportion of natural enemies on tree foliage. The relative dearth of spiders observed in the foliar examinations is puzzling, especially considering their numerical dominance at four of the five sites with magnolia. Hatching spider egg masses were also observed on tree foliage. In soybeans, the distribution of *Tetragnatha laboriosa* is size-dependent; as the spiders become larger they establish themselves higher on the plant (12). Vertical stratification of spider populations may occur in the landscape. The majority of spiders die before reaching maturity as a result of starvation, cannibalism, unsuccessful molts, or in 'ballooning mishaps' (35). Ballooning may be more common in the relatively more exposed leaf and branch surface habitat. Increased predation (especially from birds) may also be a factor. Green lacewing larvae have been observed feeding on immature lynx spiders (1). Due to the large number of green lacewing eggs present on the trees surveyed, intraguild predation may be another important source of mortality.

Green lacewing eggs were frequently observed in the foliar examinations. The larvae are voracious predators, feeding on a variety of soft-bodied arthropods (16). Despite the large number of eggs, few larvae were seen on the foliage. We suspect this is due to crypsis (many green lacewing larvae are nocturnal), starvation, dispersal, or intraguild predation. Nabids, assassin bugs, and other generalist predators have been shown to be a large source of green lacewing larval mortality (28). A parasitic wasp, observed stinging or ovipositing into a green lacewing egg, may be another source of mortality (Stewart, personal observation).

Lady beetles, frequently encountered in both the beat samples and the foliar examinations, are well recognized as predators of scales, aphids, and other pests (36). Dustywings (Coniopterygidae) feed on mites, scales, and small insects (2, 30). Evaluation of the effects of ants, another common generalist found in both beat samples and on foliage, are more problematic due to their association with aphids, scales, and whiteflies (24).

While the augmentative release of generalist predators, such as the use of green lacewing larvae (*Chrysoperla* spp.) to control the azalea lace bug (*Stephanitis pyrioides* Scott), may be a viable, short-term option to control certain pests, emphasis should be placed on installing structurally diverse, low input landscapes designed to conserve or augment the resident generalist predator complex (11, 29, 33). The landscape is a model system for the conservation of natural enemies. The diverse plant material provides a wide range of habitats and alternate food sources that favor generalist predators. Generalist predators were more numerous in azaleas in architecturally complex habitats (11). Increasing structural diversity resulted in significantly greater spider populations in big sage, *Artemisia tridentata* (8). Mulching, a common practice in the landscape, resulted in significantly greater spider numbers than in unmulched plots, and their systematic removal resulted in significantly greater vegetable damage compared to controls (25). Riechert and Lockley suggest that successful spider conservation is most realistic in perennial systems such as orchards (26). Tillage, frequently implicated in decreasing soil and litter-dwelling predators due to direct injury and habitat destruction, is an uncommon practice in established perennial landscapes (26, 34). Frequent insecticide applications suppressed beneficial arthropods in cotton (19). A low-input, IPM-based system with infrequent pesticide applications made when spiders were least active, helped preserve their numbers in the crop (10). The effect of both long-term and short-term pesticide use on spiders and the natural enemy complex as a whole needs to be evaluated in both high and low input landscapes.

While our study gives an indication of the predator and parasite taxa present in the managed landscape, more research needs to be directed at the family and species level to determine the contribution of each taxon, especially spiders and green lacewings, to pest management so that the arthropod complex may be evaluated as a whole. The impact of insectivorous arthropods on aesthetic injury in the landscape needs to be determined and incorporated into easy-to-use guidelines that will allow landscape professionals and homeowners to accurately and quickly assess the potential impact of a given pest population.

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