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Cover Page Footnote

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Arthropod Fauna Associated with Wild and Cultivated Cranberries in Wisconsin

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Abstract

The cranberry (*Vaccinium macrocarpon* Aiton) is an evergreen, trailing shrub native to North American peatlands. It is cultivated commercially in the US and Canada, with major production centers in Wisconsin, Massachusetts, New Jersey, Washington, Québec, and British Columbia. Despite the agricultural importance of cranberry in Wisconsin, relatively little is known of its arthropod associates, particularly the arachnid fauna. Here we report preliminary data on the insect and spider communities associated with wild and cultivated cranberries in Wisconsin. We then compare the insect and spider communities of wild cranberry systems to those of cultivated cranberries, indexed by region. Approximately 7,400 arthropods were curated and identified, spanning more than 100 families, across 11 orders. The majority of specimens and diversity derived from wild ecosystems. In both the wild and cultivated systems, the greatest numbers of families were found among the Diptera (midges, flies) and Hymenoptera (bees, ants, wasps), but numerically, the Hymenoptera and Araneae (spiders) were dominant. Within the spider fauna, 18 new county records, as well as a new Wisconsin state record (Linyphiidae: *Ceratinopsis laticeps* Emerton), were documented. While more extensive sampling will be needed to better resolve arthropod biodiversity in North American cranberry systems, our findings represent baseline data on the breadth of arthropod diversity in the Upper Midwest, USA.

Key Words: Cranberry, insect biodiversity, peatland, spider, survey, *Vaccinium*

Cranberry, *Vaccinium macrocarpon* Aiton (Ericaceae), is an evergreen trailing shrub endemic to North American peatlands (Eck 1990). Peatlands are wetlands that accumulate poorly decomposed organic matter (peat) and range from alkaline and minerotrophic (rich fens) to highly acidic and ombrotrophic (bogs *sensu stricto*); they also range from treeless to forested (Rydin and Jeglum 2013). These plant communities vary but are usually floristically depauperate and dominated by *Sphagnum* and other mosses, sedges, and ericaceous shrubs (Marshall et al. 1999). Cranberries can be found growing in the wild in most Wisconsin counties, especially in the central and northern portions of the state (Johnson 2011, Chaddle 2013). While cranberry may dominate within relatively small areas, it is often tightly associated with *Sphagnum* moss.

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Cranberries have been grown commercially in Wisconsin for over 100 years (Eck 1990). Production is concentrated in the central portion of the state where growers produce approximately two-thirds of the nation's cranberries (USDA NASS 2014). In commercial cultivation, cranberries grow as dense monocultures, primarily in alternating layers of sand and detritus. Notably, cultivated cranberry marshes exclude *Sphagnum* moss from the ecosystem, which almost completely carpet the ground in wild peatlands (Rydin and Jeglum 2013). Fertilizers (N-P-K) and pesticides are added each year to maximize growth and berry production. Cranberry beds are flooded in the spring for frost protection/insect control, and again in the fall to facilitate harvest (Eck 1990). Thus, there are marked differences in soil type, soil structure, floristic diversity, and hydrology between wild and managed cranberry populations in Wisconsin. It stands to reason, then, that their respective fauna might also differ.

The objective of this study was to begin cataloging the arthropod diversity associat-

Table 1. Sampling sites across central Wisconsin peatlands.

Site #	County	Lat/Lon	Habitat
1	Wood	44.38502°N/90.01452°W	agricultural cranberry bed (cultivated)
2	Monroe	44.07005°N/90.40795°W	agricultural cranberry bed (cultivated)
3	Monroe	44.11126°N/90.34675°W	open to sparsely treed, poor fen (wild)
4	Jackson	44.31573°N/90.74091°W	sparsely treed, poor fen (wild)
5	Jackson	44.27450°N/90.73953°W	open, poor fen (wild)

ed with both wild and cultivated cranberry systems. In doing so, we provide baseline information on the fauna associated with this economically important native plant.

Materials and Methods

This study was conducted in Jackson, Monroe and Wood counties, of central Wisconsin (USA), the main production area of cranberry in the country. We sampled the arthropod communities at two commercial cranberry marshes and three naturally occurring peatlands (total five sites). The sites lie within a 60 km radius and all fall within the Glacial Lake Wisconsin Sand Plain ecoregion (Johnson 2011). Sampling at all sites was done midday, under mostly clear skies (no rain or high winds) in late July and early August of 2011. Each site was sampled once within a five-week period using multiple sampling techniques.

Cultivated Sampling Sites. Two commercial cranberry beds in central Wisconsin (Table 1) were selected based on growers' willingness to participate in the study. Both commercial marshes were managed conventionally, and planted with the cultivar, 'Stevens.' A single cultivar was used to control for insect and spider community differences attributable to variable plant traits. All samples were taken at least three meters from the edge of the bed.

Wild Sampling Sites. The three peatland sites (Table 1) were selected based on accessibility and the presence of large patches of cranberry (*V. macrocarpon*) while lacking small cranberry (*Vaccinium oxycoccos* L.). Once many patches of cranberries were located, a minimum patch-size of approximately 0.3 m^2 was sought. All three sites were predominately open oligotrophic peatlands (poor fen). The immediate sampling area consisted of a mostly level *Sphagnum angustifolium* (C.E.O. Jensen ex Russow) C.E.O. Jensen carpet dominated by sedges (esp. *Carex oligosperma* Michx.), grasses (mainly *Calamagrostis canadensis* (Michx.) P. Beauv.), and patches of cranberry. Other mosses, leatherleaf (*Chamaedaphne calyculata* (L.) Moench), dwarf raspberries (*Rubus pubescens* Raf.), steeplebush (*Spiraea tomentosa* L.), and black chokeberry (*Aronia melanocarpa* (Michx.) Elliot) were sparse. Sporadic to sparse stunted tamarack (*Larix laricina* (Du Roi) K. Koch) was present at all sites, and one site (#4, Table 1) also had sparse stunted white birch (*Betula papyrifera* Marshall) and white pine (*Pinus strobus* L.).

Specimen collection and curation. When an area harboring multiple visible patches of cranberry had been located, a single dense patch was randomly selected for the initial suction-sampling of the plant canopy. The suction-sample was taken using a "D-vac" unit (Rincon Vitova, Ventura, CA), which captures most above-ground arthropods within the 0.09 m^2 sampling area of the unit.

Following the suction-sample, the 0.09 m^2 area was excised to a depth of 0.3 m using a common garden spade, and the whole volume of plant, detritus, and soil was carefully removed from the ground. This mass of soil and plant material (referred to as a 'core') was placed within a plastic bag, then into a cooler for transport back to the laboratory. The core-sample provided access to below-ground arthropod diversity, and was supplemented with 80 further D-vac samples, taken randomly from the general area surrounding the core excavation (i.e., the available cranberry patches within 20 m of the core sample). The suction-samples provided an assessment of arthropods within the aerial portions of the plant canopy and supplemented the initial suction-sample at the site of the core-sample.

Once in the lab, the core sample was placed within an emergence cage (45 cm × 45 cm × 45 cm), within an incubator (22° C, 16:8 photoperiod). The emergence cage restricted almost all light sources except for a single circular portal that opened into a glass vial. Small emerging arthropods, such as parasitoids, ants, and midges, were collected in this manner for 10–14 days. Following this emergence period, the core was dissected and sorted under microscopes. All remaining arthropods were removed from the core, and curated in vials of 90% ethanol. Arthropods were separated to morphospecies, and identified to the lowest possible taxonomic level. Voucher specimens are housed at the University of Wisconsin-Madison, Depart-

Table 2. Insect specimens collected from wild and cultivated cranberry sites in Wisconsin.

Order	Family	Genus species	Wild	Cultivated
Odonata	Coenagrionidae	sp.	1	
Orthoptera	Gryllidae	*Allonemobius fasciatus* (DeGeer)	8	
		Nemobius sp.	2	
Hemiptera	Aphididae	sp.	6	1
	Cicadellidae	*Macrosteles fascifrons* (Stål)	4	
		sp.	288	17
	Membracidae	sp.	15	
	Cixiidae	sp.	166	
	Delphacidae	sp.	279	
	Mesoveliidae	*Mesovelia* sp.	2	
	Hebridae	*Hebrus* sp.	11	
		sp.	9	
	Veliidae	*Rhagovelia* sp.	1	
		sp.	3	
	Oxycarenidae	sp.	1	
	Miridae	*Coquillettia* sp.	3	
		sp.	7	
	Tingidae	sp.	1	
	Nabidae	*Nabis* sp.	11	
		sp.	1	2
	Anthocoridae	*Orius insidious* (Say)	2	
	Pentatomidae	sp.	2	1
	Lygaeidae	sp.	2	
	Geocoridae	sp.	3	
Thysanoptera	Phlaeothripidae	sp.	3	
Coleoptera	Carabidae	sp.	1	
	Staphylinidae	*Paederus* sp.	12	
		Stenus sp.	4	
		Subfamily: Scydmaeninae	2	
		Subfamily: Pselaphinae	37	1
		sp.	22	2
	Hydrophilidae	*Enochrus* sp.	4	
		sp.	3	
	Scirtidae	*Cyphon* sp.	3	
		sp.	3	
	Lycidae	sp.	1	
	Melyridae	sp.	1	
	Coccinellidae	sp.	1	
	Silvanidae	sp.	2	
	Latridiidae	sp.	11	1
	Anthicidae	sp.	1	
	Chrysomelidae	*Systena frontalis* (Fabricius)	3	
	Curculionidae	sp.	3	
		sp.*	1	
Neuroptera	Chrysopidae	sp.		2
Hymenoptera	Ichneumonidae	*Gelis* sp.	5	
		sp.	3	1
	Braconidae	sp.	33	1
	Diapriidae	sp.	16	
	Eucoilidae	sp.	1	
	Platygastridae	*Baeus* sp.	43	
		Macroteleia sp.	131	
		Opisthacantha sp.	254	
		Trimorus sp.	339	
		spp.	152	15
	Ceraphronidae	sp.	76	47
	Chalcididae	sp.	1	
	Pteromalidae	sp.	31	4
Hymenoptera	Perilampidae	sp.	1	
	Eupelmidae	*Eupelmis* sp.	1	
	Encyrtidae	sp.	212	1
	Aphelinidae	sp.	7	
	Eulophidae	*Cirrospilus* sp.	22	

(Continued on next page)

Table 2. Continued.

Order	Family	Genus species	Wild	Cultivated
Hymenoptera	Eulophidae	*Closterocerus* sp.	26	
		sp.		84
	Elasmidae	*Elasmus* sp.	2	
	Trichogrammatidae	*Trichogrammatoidea bactrae* Nagaraja	3	
		sp.	24	
	Mymaridae	sp.	48	
	Dryinidae	Subfamily: Gonatopodinae	2	
	Halictidae	sp.	2	
	Formicidae	*Tapinoma sessile* (Say)	374	
		Crematogaster sp.	1	
		Dolichoderus sp.	27	
		Myrmica sp.	1	
		Stenamma sp.	1	
		sp.	1884	1
Lepidoptera	Coleophoridae	*Coleophora* sp.	4	
	Gelechiidae	sp.	1	
	Tortricidae	*Sparganothis* sp.	1	
		sp.	4	
	Noctuidae	*Hypenodes* sp.	2	
		sp.	1	
Diptera	Tipulidae	sp.	4	
	Dixidae	sp.	23	
	Culicidae	sp.	8	1
	Chironomidae	*Chironomini* sp.	4	
		sp.	4	4
	Simuliidae	sp.	15	
	Mycetophilidae	sp.	8	1
	Sciaridae	sp.	3	28
	Cecidomyiidae	sp.	8	2
	Tabanidae	*Chrysops* sp.	1	
	Empididae	*Stilton* sp.	3	
		sp.	1	
	Dolichopodidae	sp.	1	
	Lonchopteridae	sp.		2
	Phoridae	*Megaselia* sp.	2	17
		sp.	27	7
	Syrphidae	sp.	1	
	Conopidae	*Conioscinella* sp.	2	
	Ulidiidae	sp.	4	
	Tephritidae	sp.	1	
	Dryomyzidae	sp.		2
Diptera	Sepsidae	*Sepsis* sp.	2	
		sp.	4	
	Sciomyzidae	sp.	3	
	Chamaemyiidae	sp.	4	
	Sphaeroceridae	*Leptocera* sp.	9	
		sp.	26	2
	Ephydridae	sp.	2	
	Drosophilidae	*Drosophila* sp.		1
		sp.	33	4
	Chloropidae	*Conioscinella* sp.	3	
		Elachiptera sp.	1	
		Epichlorops sp.	1	
		Lasion sp.	1	
		Lasiosina sp.	5	
		Oscinella sp.	37	
		sp.	40	1
	Aulacigastridae	sp.	1	
	Asteiidae	sp.		1
	Anthomyiidae	sp.	5	
	Scathophagidae	sp.	1	
	Calliphoridae	sp.	1	

*Unknown immature Coleoptera.

ment of Entomology (1630 Linden Drive, Department of Entomology, 545 Russell Laboratories).

Results

At the two cultivated cranberry sites, we collected a total of 384 specimens representing 5 orders and 39 families (Tables 2–4). Diptera (flies) and Hymenoptera (wasps, bees and ants) had the highest numbers of families represented (12 and 10, respectively) (Table 1), and Hymenoptera and Araneae (spiders) had the highest numbers of individual specimens (155 and 109, respectively). All insect and spider taxa were indexed by county (Table 5–7), providing greater resolution to the biogeography of Wisconsin's peatland arthropods.

At the three wild sites, we collected a total of 7,058 specimens, spanning 11 orders and 101 families (Tables 2–4). Again, Diptera and Hymenoptera had the highest numbers of families represented (26 and 19, respectively), and Hymenoptera and Araneae had the highest numbers of individual specimens (3,723 and 1,336, respectively). We were able to identify 625 specimens (9%) to species-level resolution. Most spiders, however, were not identified to species because they were immatures (Table 3). Immature spiders generally cannot be dependably identified to species because many of the characteristic traits are not developed until maturity (Ubick et al. 2005). Of the spiders identified to species, 18 were confirmed as new county records and one was a new state record (Table 6). Ten of the 18 county records were from the family Linyphiidae. The remaining new records were from the following families: Araneidae (2), Clubionidae (1), Hahniidae (2), Salticidae (1), Tetragnathidae (1) and Theridiidae (1).

The state record was for the species *Ceratinopsis laticeps* Emerton and was found at one of the wild sites in Monroe County. It is a relatively small spider in the family Linyphiidae, subfamily Erigoninae, which is the dominant spider group in temperate regions (Hormiga 2000). From the Great Lakes region, this species has already been found in Ohio, Michigan, and Illinois, with a predicted presence in Indiana (Sierwald et al. 2005). Therefore, it is not surprising to have found it in Wisconsin, and one would assume it is present elsewhere in the state. It does not appear to be a peatland specialist (Kaston 1948).

Discussion

Much research has been done on pests of economic importance (and their natural enemies) in cultivated cranberry (Eck 1990), but little is known of the background taxa that likely represent the majority of the arthropod community in managed systems. Moreover, relatively little is known of the arthropod complex in wild cranberry habitats (Marshall et al.1999, Spitzer and Danks 2006). Most peatland survey work has focused either on a specific taxon or a relatively specific geographic location (e.g. Rosenberg and Danks 1987, Blades and Marshall 1994). The survey work reported here was conducted to establish broad, baseline estimates of arthropod diversity among wild and cultivated *V. macrocarpon* stands in Wisconsin. The abundance and diversity of arthropods in this study are noteworthy considering the relatively small number of sample sites, total area surveyed, and narrow temporal coverage. Given the limited flora of Wisconsin peatlands (Chaddle 2013), the arthropod fauna in wild and cultivated cranberry sites appears to be relatively diverse.

The abundance of Hymenoptera was particularly noteworthy, comprising 40% of all specimens collected at cultivated sites (averaging 27 specimens per site) and 53% of all specimens at wild sites (averaging 478 per site). The hymenopterans found in the cultivated sites were almost exclusively parasitoid wasps (with the exception of one ant), suggesting the presence of an ample prey base for the parasitoid community. Wild sites also harbored many parasitoid wasps (numerically, 20 times that of the cultivated sites), but at these wild sites, only 38% of hymenopteran specimens were parasitoids, the remaining 62% being ants. The abundance and ecological importance of ants in peatland systems remains an interesting question for future work.

Most (44%) of the non-ant hymenopterans collected at the wild sites were exceedingly minute parasitoids in the family, Platygastridae (Table 2). Platygastrids are egg parasitoids of insects and spiders, and are generally solitary parasitoids (O'Connor and Notton 2013). The more abundant platygastrids found in this study were *Trimorus*, which are known to be parasitoids of beetle eggs (Coleoptera: Carabidae and Staphylinidae) (O'Connor and Notton 2013). The genus *Macroteleia* was also well-represented, and these platygastrids are egg parasitoids of tettigoniids (katydids) (Meusebeck 1977). Interestingly, many specimens of *Baeus* were found, and these tiny wasps are relatively uncommon parasitoids of spider egg masses (Margaría et al. 2006). Spiders were hyper-abundant in our study sites, suggesting there was a significant prey base for *Baeus* populations. Virtually no platygastrids were collected in the cultivated cranberry sites.

Table 3. Arachnid specimens collected from wild and cultivated cranberry sites in Wisconsin.

Order	Family	Genus species	Wild	Cultivated
Opiliones	Unknown	sp.	2	
Araneae	Araneidae	*Araniella* sp.	1	
		Argiope sp.	1	
		Cercidia prominens (Westring)	1	
		Gea sp.	9	
		Gea heptagon (Hentz)	1	
		Hypsosinga sp.	18	
		spp.	13	1
	Tetragnathidae	*Leucauge* sp.	1	
		Leucauge venusta (Walckenaer)	5	
		Pachygnatha sp.	1	
		Tetragnatha laboriosa Hentz	1	
		Tetragnatha sp.	4	
		sp.	1	
	Mysmenidae	*Microdipoena* sp.	62	
	Linyphiidae	*Agyneta fabra* (Keyserling)	4	2
		Agyneta spp.	3	
		Bathyphantes pallidus (Banks)	6	
		Bathyphantes sp.	7	
		Ceraticelus bulbosus (Emerton)	3	
		Ceraticelus fissiceps (O. Pickard-Cambridge)	23	
	Linyphiidae	*Ceraticelus laetus* (O. Pickard-Cambridge)	35	
		Ceraticelus sp.	14	1
		Ceratinops sp.	2	
		Ceratinopsis laticeps Emerton	1	
		Collinsia plumosa (Emerton)	3	
		Eridantes erigonoides (Emerton)	1	
		Erigone atra Blackwall	1	
		Erigone autumnalis Emerton	3	
		Erigoninae sp.	100	56
		Frontinella communis (Hentz)	16	
		Frontinella sp.	3	
		Grammonota gentilis Banks	2	
		Grammonota maculata Banks	7	
		Lepthyphantes sp.	1	
		Linyphiinae sp.		1
		Microlinyphia mandibulata (Emerton)	1	
		Neriene clathrata (Sundevall)	15	
		Oedothorax trilobatus (Banks)	14	
		Scylaceus sp.	1	
		Walckenaeria sp.	2	
		spp.		153 6
	Theridiidae	*Hentziectypus globosus* (Hentz)	1	
		Theonoe stridula Crosby	4	
		Dipoena sp.	1	
		spp.	8	
	Dictynidae	*Dictyna/Emblyna*	4	
	Anyphaenidae	*Anyphaena* sp.	1	
		Wulfila sp.	7	
	Clubionidae	*Clubiona abboti* L. Koch	1	
		Clubiona sp.	16	1
		spp.	13	
	Corinnidae	*Phrurotimpus* sp.	1	
		subfamily: Phrurolithinae	4	
		Scotinella divesta (Gertsch)	1	
	Philodromidae	*Ebo* sp.	9	

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Table 3. Continued.

Order	Family	Genus species	Wild	Cultivated
Araneae	Philodromidae	*Philodromus* sp.	4	
		Thanatus sp.	32	
		Tibellus sp.	84	
		spp.	20	
	Salticidae	*Sitticus striatus* Emerton	1	
		spp.	106	
	Thomisidae	*Coriarachne* sp.	4	
		Mecaphesa sp.	21	
Araneae	Thomisidae	*Misumena* sp.	1	
		Xysticus sp.	2	
		spp.		2
	Gnaphosidae	*Drassyllus* sp.	7	
		Gnaphosa sp.	3	
		spp.	5	
	Pisauridae	*Dolomedes* sp.	11	1
		sp.	1	
	Lycosidae	*Pardosa* sp.	10	1
		Pirata sp.	18	12
		spp.	418	2
	Hahniidae*	*Antistea brunnea* (Emerton)	2	
		Hahnia sp.		1
		Hahnia cinerea Emerton	3	
		Neoantistea sp.		3
		Neoantistea agilis (Keyserling)	2	
		spp.	8	

*The family Hahniidae has not been phylogenetically placed.

Table 4. Collembolan (springtail) specimens collected from wild and cultivated sites.

Order	Family	Genus species	Wild	Cultivated
Poduromorpha	Poduridae	*Podura aquatica* L.		3
Entomobryomorpha	Isotomidae		1	13
	Entomobryidae		605	
		Lepidocyrtus paradoxus Uzel	120	

Table 5. Insect specimens collected in Wisconsin cranberries, indexed by county.

			County		
Order	**Family**	**Genus species**	**Jackson**	**Monroe**	**Wood**
Odonata	Coenagrionidae		X		
Orthoptera	Gryllidae	*Allonemobius fasciatus* (DeGeer)	X		
		Nemobius sp.	X		
Hemiptera	Aphididae		X		
	Cicadellidae		X	X	X
		Macrosteles fascifrons (Stål)	X		
	Membracidae		X		
	Cixiidae		X	X	
	Delphacidae		X	X	
	Mesoveliidae	*Mesovelia* sp.	X		
	Hebridae	*Hebrus* sp.	X	X	
	Veliidae		X	X	
		Rhagovelia sp.	X		
	Oxycarenidae		X		
	Miridae		X	X	
		Coquillettia sp.	X		

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Table 5. Continued.

			County		
Order	**Family**	**Genus species**	**Jackson**	**Monroe**	**Wood**
Hemiptera	Tingidae		X		
	Nabidae		X	X	
		Nabis sp.	X	X	
	Anthocoridae	*Orius insidious* (Say)		X	
	Pentatomidae			X	X
	Lygaeidae		X	X	
	Geocoridae		X	X	
Thysanoptera	Phlaeothripidae		X	X	
Coleoptera	Carabidae			X	
	Staphylinidae	Subfamily: Scydmaeninae		X	
		Subfamily: Pselaphinae	X	X	
		Paederus sp.	X	X	
		Stenus sp.	X	X	
	Hydrophilidae	*Enochrus* sp.	X		
	Scirtidae		X		
		Cyphon sp.		X	
	Lycidae		X		
	Melyridae		X		
	Coccinellidae		X		
	Silvanidae			X	
	Latridiidae		X	X	
	Anthicidae			X	
	Chrysomelidae	*Systena frontalis* (Fabricius)		X	
	Curculionidae			X	
Neuroptera	Chrysopidae		X	X	
Hymenoptera	Ichneumonidae		X	X	X
		Gelis sp.	X	X	
	Braconidae		X	X	X
	Diapriidae		X	X	
	Eucoilidae				X
	Platygastridae		X	X	X
		Baeus sp.	X	X	
		Macroteleia sp.	X	X	
		Opisthacantha sp.	X	X	
		Trimorus sp.	X	X	
	Ceraphronidae		X	X	X
	Chalcididae			X	
	Pteromalidae		X	X	X
	Eupelmidae	*Eupelmis* sp.	X		
	Encyrtidae		X	X	X
	Aphelinidae			X	
	Eulophidae			X	X
		Cirrospilus sp.	X		
		Closterocerus sp.	X		
	Elasmidae	*Elasmus* sp.	X	X	
	Trichogrammatidae	*Trichogrammatoidea bactrae* Nagaraja		X	
	Mymaridae		X	X	
	Dryinidae	Subfamily: Gonatopodinae		X	
	Halictidae		X		
	Formicidae	*Crematogaster* sp.	X		
		Dolichoderus sp.	X	X	
		Myrmica sp.	X	X	
		Stenamma sp.		X	
		Tapinoma sessile (Say)	X	X	

(Continued on next page)

Table 5. Continued.

Order	Family	Genus species	County		
			Jackson	Monroe	Wood
Lepidoptera	Coleophoridae	*Coleophora* sp.	X	X	
	Gelechiidae		X		
	Tortricidae		X	X	
		Sparganothis sp.		X	
	Noctuidae	*Hypenodes* sp.		X	
Diptera	Tipulidae		X		
	Dixidae		X	X	
	Culicidae		X	X	
	Chironomidae			X	
		Chironomini sp.	X		
	Simuliidae		X		
	Mycetophilidae		X	X	
	Sciaridae			X	
	Cecidomyiidae		X	X	X
	Tabanidae	*Chrysops* sp.	X		
	Empididae			X	
		Stilton sp.	X		
	Dolichopodidae		X		
	Lonchopteridae			X	
	Phoridae	*Megaselia* sp.	X	X	X
	Syrphidae		X		
	Conopidae	*Conioscinella* sp.		X	
	Ulidiidae		X		
	Tephritidae			X	
	Dryomyzidae				
	Sepsidae		X	X	
				X	X
		Sepsis sp.		X	
	Sciomyzidae			X	
	Chamaemyiidae		X		
	Sphaeroceridae	*Leptocera* sp.	X	X	
	Ephydridae			X	
	Drosophilidae		X	X	X
		Drosophila sp.		X	
	Chloropidae		X	X	X
		Conioscinella sp.	X	X	
		Elachiptera sp.	X		
		Lasion sp.	X		
		Lasiosina sp.		X	
		Oscinella sp.	X	X	
	Aulacigastridae		X		
	Asteiidae			X	
	Anthomyiidae		X	X	
	Scathophagidae			X	
	Calliphoridae		X		

Table 6. Arachnid specimens collected in Wisconsin cranberries, indexed by county († new county record; ‡ new state record).

			County		
Order	**Family**	**Genus species**	**Jackson**	**Monroe**	**Wood**
Opiliones				X	
Araneae	Araneidae		X	X	X
		Araniella sp.	X		
		Argiope sp.	X		
		Cercidia prominens (Westring)		X†	
		Gea heptagon (Hentz)	X†		
		Hypsosinga sp.	X	X	
	Tetragnathidae	*Leucauge venusta* (Walckenaer)	X		X
		Pachygnatha sp.		X	
		Tetragnatha sp.	X		
		Tetragnatha laboriosa Hentz		X†	
	Mysmenidae	*Microdipoena* sp.		X	
	Linyphiidae	*Agyneta fabra* (Keyserling)	X†	X†	
		Bathyphantes pallidus (Banks)		X†	
		Ceraticelus bulbosus (Emerton)	X†		
		Ceraticelus fissiceps (O. Pickard-Cambridge)	X†	X†	
		Ceraticelus laetus (O. Pickard-Cambridge)	X†	X†	
		Ceratinopsis laticeps Emerton		X‡	
		Collinsia plumosa (Emerton)		X	
		Eridantes erigonoides (Emerton)	X†		
	Linyphiidae	*Erigoninae* sp.	X	X	X
		Erigone atra Blackwall		X	
		Erigone autumnalis Emerton	X†	X†	
		Frontinella communis (Hentz)	X	X	
		Ceraticelus laetus (O. Pickard-Cambridge)	X		
		Grammonota gentilis Banks		X†	
		Grammonota maculata Banks		X	
		Lepthyphantes	X	X	
		Linyphiinae sp.		X	
		Microlinyphia mandibulata (Emerton)	X†		
		Neriene sp.	X	X	
		Oedothorax trilobatus (Banks)		X†	
		Scylaceus sp.	X		
		Walckenaeria sp.		X	
	Theridiidae	*Dipoena* sp.	X		
		Hentziectypus globosus (Hentz)	X		
		Theonoe stridula Crosby		X†	
	Anyphaenidae	*Anyphaena* sp.	X		
		Wulfila sp.	X		
	Clubionidae	*Clubiona* sp.	X	X	
		Clubiona abboti L. Koch		X†	
	Corinnidae	*Phrurotimpus* sp.		X	
		Scotinella sp.		X	
	Philodromidae	*Ebo* sp.	X		
		Philodromus sp.		X	
		Thanatus sp.	X		
		Tibellus sp.	X	X	
	Salticidae		X	X	
		Sitticus striatus Emerton		X†	
	Thomisidae	*Coriarachne* sp.	X	X	
		Misumena sp.	X		
		Misumenops sp.	X		

(Continued on next page)

Table 6. Continued.

Order	Family	Genus species	County Jackson	County Monroe	County Wood
Araneae	Thomisidae	*Xysticus* sp.		X	
	Gnaphosidae	*Drassyllus* sp.	X		
		Gnaphosa sp.	X		
	Pisauridae	*Dolomedes* sp.	X	X	X
	Lycosidae	*Pardosa* sp.		X	
		Pirata sp.	X	X	
	Hahniidae*	*Antistea brunnea* (Emerton)	X	X	
		Hahnia cinerea Emerton	X†		
		Hahnia sp.	X	X	
		Neoantistea sp.	X		
		Neoantistea agilis (Keyserling)		X†	

*The family Hahniidae has not been phylogenetically placed.

Table 7. Collembola (springtails) found in Wisconsin cranberries, indexed by county.

Order	Family	Genus species	County Jackson	County Monroe	County Wood
Poduromorpha	Poduridae	*Podura aquatica* L.			X
Entomobryomorpha	Isotomidae		X	X	X
	Entomobryidae	*Lepidocyrtus paradoxus* Uzel	X	X	

Of the hymenopteran specimens found in the cultivated sites, 21% were eulophid parasitoids, and 12% were ceraphronids, compared with less than 1% from the wild sites for each of these families. The Eulophidae are a taxonomically and ecologically diverse family, often of significant economic importance, with many species targeting an array of dipterous hosts, as well as various agricultural pests (Goulet and Huber 1993).

Araneae comprised 28% of the collected specimens at the cultivated sites. Of these, 79% were linyphiids (sheet-web spiders), and within this single family, 65% were from its largest subfamily, Erigoninae (dwarf spiders). This subfamily is common and pervasive in northern peatlands (Ubick et al. 2005), thus it is not surprising to find such abundance in Wisconsin cranberry systems. From the wild sites, Araneae comprised 19% of the collected specimens, 30% of which were linyphiids, and 26% of those were from the subfamily Erigoninae. Erigonines are very small spiders that tend to live in leaf litter and readily balloon to disperse (Emerton 1902). They often have a significant presence in agricultural fields when other spider families are absent, and are particularly common in perennial systems (Schmidt and Tscharntke 2005). Aside from linyphiids, the Lycosidae (wolf spiders) were well represented. At the wild sites, 33% of the spiders were lycosids, while only 14% of the spiders at the cultivated sites were lycosids.

Collembola (springtails) comprised 10% of the individuals collected from the wild sites and 4% from the cultivated sites (Table 4). *Podura aquatica* L. (Collembola: Poduromorpha), the only species of the family Poduridae, was collected only from the cultivated sites. This may be due to the flooding events on cultivated beds, which involve the filling of cranberry beds with large volumes of water from local reservoirs, rivers, or lakes. The springtail species, *P. aquatica*, has been shown to be highly abundant during and immediately after ecological flooding events, and then absent a short time after such events (Lessel et al. 2011). Many aquatic or semi-aquatic organisms, therefore, may be imported into cranberry beds from such water bodies, and these taxa may persist for periods of time thereafter.

Other well-represented taxa from the cultivated sites were the dipteran families Phoridae (6%) and Sciaridae (7%). Conversely, in the wild sites, Phoridae represented less than 1% of the total number of specimens, and there were only three sciarid individuals collected among the three wild sites. Both fly families are widely distributed, living in damp habitats and feeding largely on detritus (McAlpine et al. 1981).

Lepidoptera were poorly represented, with only 13 individuals representing at least six taxa (0.18% of the individuals at wild sites; none were found in cultivated sites). This is likely an artifact of the sampling techniques used, which are not ideal for trapping adult Lepidoptera. Extensive sampling in peatland habitats across Wisconsin, Michigan, and Minnesota have revealed the presence of over 1,000 lepidopteran species (M.S. thesis, KEJ). Even though these efforts were focused on Canadian life zone peatlands, there is currently no reason to believe that Glacial Lake Wisconsin Sand Plain peatlands do not support a diverse fauna (although the number of boreal peatland specialists should be less given the warmer climate and lower diversity of peatland habitats). One species, *Lycaena epixanthe* (Boisduval and Le Conte) was documented at Site 4 (Table 1) and other similar, poor fen sites outside of this study; this species is a well-known cranberry specialist and field work in the Great Lakes region shows it uses both *V. macrocarpon* and *V. oxycoccos* (KEJ, pers. obs.).

It is often found that agroecosystems contain substantially lower biodiversity than unmanaged, natural ecosystems (Andow 1991, Pimentel et al. 1992, Chen and Bernal 2011, Chen et al. 2013). From our preliminary investigation, this does appear to be the case for cultivated and wild cranberry ecosystems, but further survey work will be required to better characterize the arthropod communities in these ecosystems. A better understanding of the community composition and trophic function of cranberry arthropods will inform cranberry production practices and provide a baseline to gauge future changes to the cranberry arthropod community.

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