

Spiders (Araneae) of the Glen Helen Nature Preserve, Greene County, OH

RICHARD A. BRADLEY¹ and WILLIAM L. HICKMAN, EEO Biology Department, Marion Campus, The Ohio State University, Marion, OH

ABSTRACT. The purpose of the current project was to assess the species diversity of spiders (Araneae) at Glen Helen Nature Preserve and compare it to the diversity of spiders at other forest sites in the region. Glen Helen Nature Preserve is located near the village of Yellow Springs, Greene County, OH. The reserve area is 404.6 hectares. The primary habitat is mixed mesophytic hardwood forest. In addition to forested areas, spider sampling was conducted in old field and restored tallgrass prairie habitats. Samples were collected between 4 November 1993 and 1 September 2008 with the preponderance of sampling occurring during summer. Sampling techniques included pitfall traps, litter extraction, visual searches at ground level and in the understory, and sweep/beat samples. A total of 108 collections from 33 sites in the preserve produced 3,766 identified specimens. The spider fauna of Glen Helen is relatively diverse including representatives of 23 families and 170 species. Three species represent first records for Ohio. There is little clear evidence that this site has a depauperate spider fauna, despite its relatively isolated position in a fragmented landscape. Of the specimens collected within forest sites at Glen Helen, 93 species were found which is similar to the mean value of 94 spider species recorded for 5 other forested sites within the North Central Till Plains ecoregion that have been sampled during the Ohio Spider Survey. Open habitats yielded relatively more species per unit sampling effort than forested sites. Rarefaction analysis estimates predict a complete spider diversity of between 190-227 species.

OHIO J SCI 109 (2): 3-14, 2009

INTRODUCTION

Glen Helen Nature Preserve is located in rural Southwestern Ohio near the village of Yellow Springs in Greene County. It is one of the oldest nature preserves in the region, having been protected continuously since 1929. The reserve area is 404.6 hectares. The eastern edge of the reserve abuts John Bryan State Park and Clifton Gorge Nature Preserve comprising an additional 304 ha. To the west is the village of Yellow Springs and elsewhere it is surrounded primarily by row crop agricultural fields. The primary habitat in Glen Helen is mixed mesophytic hardwood forest. The reserve is drained in the northern portions by Birch and Yellow Springs Creeks, and in the southern portions by the Little Miami River. While most of the reserve is forested, there are some open areas associated with educational facilities as well as a few old fields, spring-fed wetlands, and a small restored tallgrass prairie.

The central portion of the reserve is characterized by a series of rocky outcrops and cliffs enclosing the floodplain adjacent to the Little Miami River and its local tributaries. The geological setting and vegetation were described in detail by Anliot (1973). Glen Helen lies just north of the southernmost extent of the most recent Pleistocene glacial advance (Wisconsinan) in an area with deep deposits of glacial till. To the southeast about 75 km away are the extensive areas of hilly unglaciated topography and more heavily forested landscapes of the Ohio River valley.

The purpose of the current project was to assess the species diversity of spiders (Araneae) in the reserve and compare it to the diversity in similar reserves as well as the more continuously forested regions farther to the southeast. The reserve and adjacent parks represent islands of relatively undeveloped habitat in a matrix of small town, rural and agricultural development. This study addressed two questions. 1) Is the species diversity of spiders relatively depauperate because of the fragmented nature of the landscape and its distance from more contiguous forest habitat? 2) How much do the spider assemblages differ among the major habitat types within the reserve itself?

METHODS

Spiders were sampled from 33 sites within the Glen Helen Nature Preserve, Greene County, OH (Fig. 1). The choice of sites was coordinated with the administration at the reserve so as to include all major habitat types but avoid conflict with ongoing programs. The approximate center of the reserve is located at 39° 48'N 83° 53'W. These sites included areas representing seven vegetation types. Some additional specimens were collected around buildings. Eight sites were in floodplain forest, nine were in upland forest, two were a mature planted pine forest with some oaks, one was a small spring-fed marsh, one was a 1.8 ha reconstructed tallgrass prairie, three sites were along exposed limestone cliffs and ravines, four sites were in old fields, and five sites were around human-built structures. Samples were obtained between 4 November 1993 and 1 September 2008. Most (89 percent) sampling occurred during June, July and August and no sampling occurred between December and May.

The vegetation of the Glen Helen Nature Preserve was documented extensively by Anliot (1973). The floodplain forest sites are dominated by willow (*Salix* sp.) cottonwood (*Populus deltoides*) and American sycamore (*Platanus occidentalis*) with an understory of box elder (*Acer negundo*), spicebush (*Lindera benzoin*), prickly-ash (*Zanthoxylum americanum*), bladdernut (*Staphylea trifolia*), and hop-tree (*Ptelea trifoliata*). Upland forests include chinquapin oak (*Quercus muehlenbergii*), white oak (*Quercus alba*), red oak (*Quercus rubra*), shagbark hickory (*Carya ovata*) with an open understory of sapling sugar maples (*Acer saccharum*) and spicebush. Unfortunately there is an increasing dominance by invasive bush honeysuckles (*Lonicera* spp.) and multiflora rose (*Rosa multiflora*). In some areas, there is a dense diverse understory of native herbaceous plants. The introduced garlic mustard (*Alliaria petiolata*) has replaced much of this herbaceous vegetation at ground level in other areas. The pine forest is an abandoned plantation with a mixed stand of *Pinus strobus*, *P. resinosa* and *P. sylvestris*. The small reconstructed prairie is dominated by big bluestem (*Andropogon gerardii*), Indian grass (*Sorghastrum nutans*), and little bluestem (*Schizachyrium scoparium*) with a variety of perennial forbs including Canada goldenrod (*Solidago canadensis*) and smooth aster (*Aster laevis*).

¹Corresponding author: Richard A. Bradley, EEO Biology Department, Marion Campus, The Ohio State University, 1465 Mt. Vernon Ave., Marion, OH 43302. Email: bradley.10@osu.edu

The old-fields were dominated by perennial forbs including Canada goldenrod and New England aster (*Aster novae-angliae*).

Sampling was somewhat uneven, with greater sampling effort focused on open habitats, particularly the tallgrass prairie. The prairie sampling effort was part of an ongoing study at other sites in Ohio, thus the increased sampling at Glen Helen's prairie was the result of this co-occurring project. One sample consists of one of the following methods conducted by one observer on one date. Spiders were collected by the following methods; timed diurnal searches within 50 cm of the ground (ground search 1,158 min); timed diurnal searches between 50 cm and 2 m of the ground (aerial search 2,886 min); timed nocturnal searches within 2 m of the ground (nocturnal 1,678 min); sweeping and beating vegetation (sweeps 1,582 min); 1 m² litter samples extracted with a Berlese funnel apparatus (litter 13 samples), casual hand collections (casual 13 samples), and; pitfall traps (pitfall 14 samples). The pitfall traps were constructed following the design of Alan Cady (1994) and included a 10 cm diameter opening with a smooth plastic funnel secured within the top of the pit to minimize escape, a wooden lid

secured 2 cm above the trap, and filled with a 50 percent mixture of water and either ethylene or propylene glycol. Each trap assembly was covered with 3 cm hex netting and a second 1m² layer of heavy wire mesh (~ 6x4 cm) staked firmly into the ground to prevent damage from mammals. Pitfall traps were installed at various times throughout the year and checked at weekly intervals, for a total of 960 trap days.

Specimens collected during this study have been deposited in the collections of the Department of Entomology Acarology range, The Ohio State University (OSAL) and are housed at the Museum of Biodiversity on the Ohio State University Columbus campus.

Descriptive statistical analyses were conducted with MINITAB® release 8. Species diversity estimation and community similarity analyses were conducted using the EstimateS statistical package version 8.0 (Colwell 2005).

Spiders were identified by microscopic examination of the genitalia. Whenever Table 1 includes reference to species unidentified (sp?), that indicates an immature individual(s). Most immature were not included in this analysis unless they represented

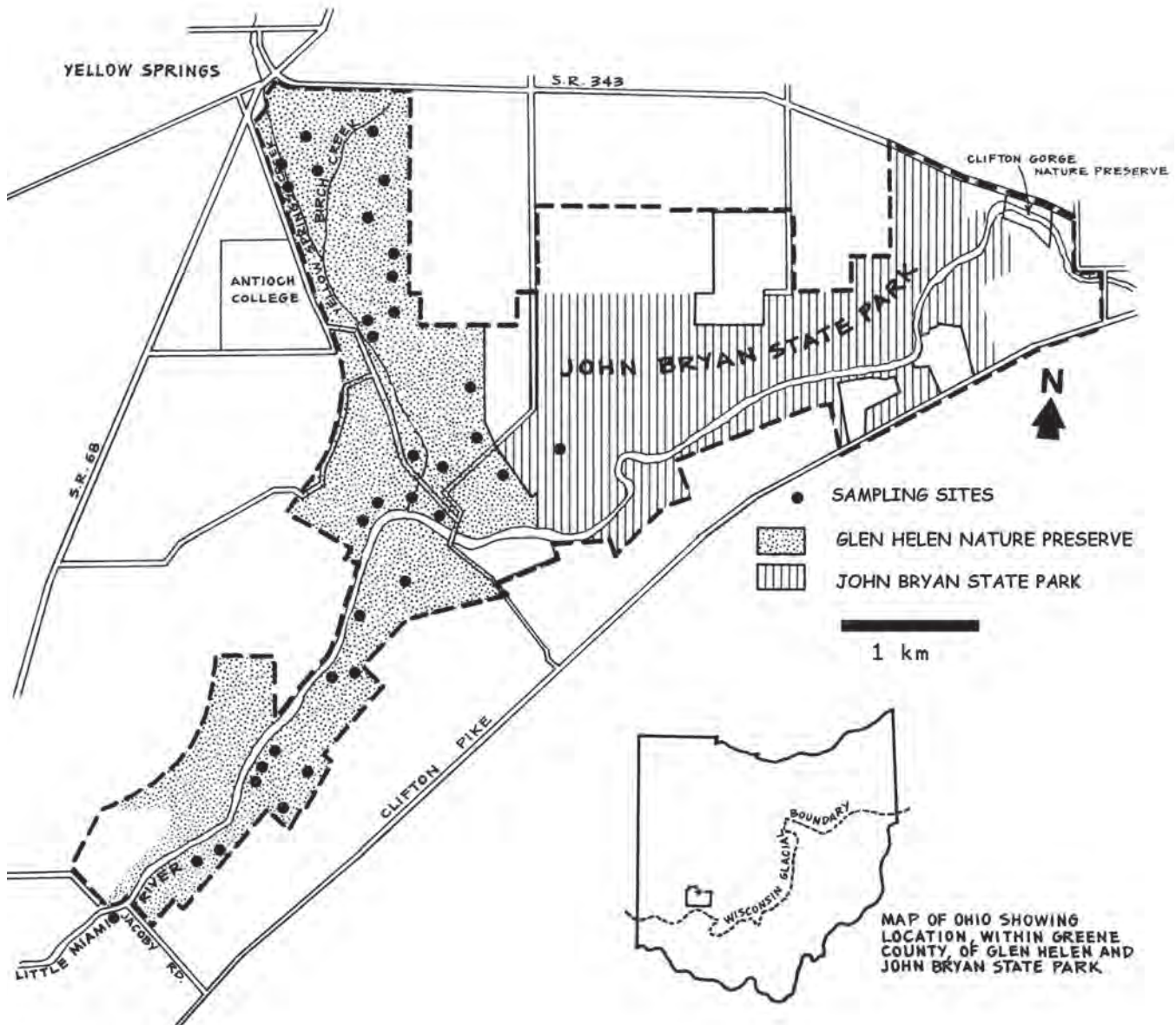


FIGURE 1. Map of the Glen Helen area, including Glen Helen Nature Preserve (stippled area), John Bryan State Park (vertical hashed). Spider sampling sites are indicated by black dots. The heavy dashed line indicates the extent of the most comprehensive vegetation survey of this area (Anliot, 1973).

a genus with few adult specimens. Spider nomenclature follows Platnick (2009); plant nomenclature follows Cooperrider, Cusick and Kartesz (2001).

RESULTS

A total of 3,766 spider specimens were collected and identified including 170 species representing 23 families (Table 1). Sweep and beating samples were the most productive, yielding 41 percent of the specimens (86 specimens/sample), pitfall samples were the next most productive (26 percent; 70 specimens/sample) followed by ground timed searches (11 percent; 19 specimens/sample), aerial timed searches (10 percent; 17 specimens/sample), nocturnal searches (six percent; 37 specimens/sample), casual hand collections (four percent; 11 specimens/sample), and litter samples (two percent; five specimens/sample). To some extent, this reflects a combination of sampling intensity and efficiency by each of these methods.

We employed rarefaction analysis (Colwell 2005) to estimate actual spider species diversity at Glen Helen. Using the entire sample, typically the most conservative bootstrap analysis provides an estimate of 190 species. Thus predicting a total 24 species higher than the current list. The Jackknife procedure yielded an estimate of 219 (95 percent conf. interval = 201-238) species. The Chao1 estimator, a more sophisticated approach that incorporates relative abundance information (rather than only presence/absence), yielded an estimate of 227 (95 percent conf. interval = 195-296) species. Each method generates higher estimates of diversity for open sites (combined prairie, old fields, and wetland; 146-188 species) than forest sites (109-129 species). It seems clear that the current list of species is incomplete and that further sampling will reveal additional spider species in the Glen.

We compared the species overlap among habitats using the Jaccard Index of Similarity. The overall average similarity between all seven vegetation habitat combinations (21 comparisons) is 0.19. For comparisons among the three forest types (upland, floodplain, pine) the average similarity was 0.42. Relatively few species found in the forests were unique to a specific forest type (upland 19 percent, floodplain seven percent, pine 12 percent; Table 1). Comparing the three open habitats (prairie, old fields, wetland) yielded a similarity value of only 0.22, not very different from the overall between-habitat similarity value. This is hardly surprising considering that the prairie and wetland samples had the highest proportions of species that were found exclusively in that habitat (see "uniques" Table 1), 42 percent and 27 percent, respectively.

Upland forest collections yielded 705 spiders of 77 species, 15 of these species were found only in this habitat. The upland forests were characterized by few of the larger (total body length (tbl) > 10mm) species of orb weavers (family Araneidae; genera *Araneus*, *Argiope*, *Larinioides*, *Neoscona*). From this group, only six *Araneus marmoreus* were found. The most common medium-sized orb weavers were *Micrathena gracilis* and *Verrucosa arenata*. In contrast to the paucity of larger orb weavers, there were many of the smaller species (tbl 4-7mm) of this family. The most numerous of the small sized species included *Cyclosa conica*, *Eustala anastera*, *Mangora maculata*, *Mangora placida*, and *Micrathena mitrata*. The family Tetragnathidae (longjawed orb weavers) were represented by the extremely common orchard spider, *Leucauge venusta*. The triangle spider, *Hyptiotes cavatus* (family Uloboridae) was found exclusively in this upland forest habitat. Its presence seems related to the abundance of dead branches in the understory where it prefers to build its unique triangle-shaped web. Among sheetweb weavers

(family Linyphiidae) in the understory herbaceous vegetation, the bowl and doily spider, *Frontinella communis*, was common. Two other members of this family, *Neriene clathrata* and *Neriene variabilis* were found as well. Their relative, the filmy-dome spider *Neriene radiata* was surprisingly uncommon. The most abundant sheetweb weaver in this habitat was the hammock spider, *Pityohyphantes costatus*. Among the cobweb weavers (family Theridiidae), *Theridion frondeum* and *Yunohamella lyrica* were the most abundant. The most numerous wolf spiders (family Lycosidae) were the smaller species *Pirata alachuus*, and *Pirata piraticus*. Medium-sized wolf spiders (body length 10-15 mm) are usually common in Ohio (pers. obs.). For example, only one of the typically abundant *Schizocosa ocreata* was captured in the upland forest sites. It is interesting to note that this wolf spider was captured in large numbers in the tallgrass prairie site. There were only 11 ground spiders (family Gnaphosidae) of two species captured in the upland forest pitfall traps, but the same sort of trap captured dozens, representing six species in the tallgrass prairie site. Some ground-living spiders that are typical of forest habitats throughout Ohio (pers. obs.) were rarely captured in those habitats at Glen Helen. In particular, only one individual (an immature) member of the family Hahniidae was captured. The Hahniidae are small spiders that build their miniature sheet webs in the layers of decomposing leaf litter in forests throughout Ohio. Leaf litter samples did yield representatives of seven species of tiny erigonine linyphiids, or dwarf spiders (family Linyphiidae; subfamily Erigoninae). One linyphiid spider, *Diplostyla concolor*, that is abundant in this region was absent from our samples, likely because we did not sample during the winter and early spring when this species is most often detected. The upland forest samples had representatives of three of the most common Ohio crab spiders (family Thomisidae; *Misumenoides formosipes*, *Misumenops asperatus*, *Xysticus ferox*). Very few jumping spiders (family Salticidae) were found in this habitat.

Floodplain forest collections yielded 300 individuals representing 55 species; four of which were unique to this habitat type. The floodplain forest spider fauna was similar to that found in the upland forest sites. There were even fewer large orb weavers than were found in upland forest. Similar to upland forest, most of the orb-weaving species which were found in the floodplain forest have relatively small body sizes. *Mangora maculata*, *Mangora placida* and the orb-weaving tetragnathid *Leucauge venusta* were the most common species. The most common medium-sized (tbl 5.5mm) spider was the introduced cosmopolitan cobweb weaver, *Parasteatoda tepidariorum*. Sheet-web weavers were less common than in the upland forest samples; only *Neriene clathrata* and the tiny *Ceraticelus fissiceps* were frequently encountered. Wolf spiders were sparse in the floodplain forest samples, most (80 percent) being one small species, *Pirata alachuus*. Most of the hackled mesh weaving *Callobius bennetti* (family Amaurobiidae) individuals captured at Glen Helen were found in floodplain forest. Ground spiders were entirely absent from the floodplain forest samples. The only crab spiders collected in the floodplain forest were individuals of *Xysticus ferox*. In fact, this species was detected in each of the habitat types except the wetland and buildings. As with the upland forests, very few jumping spiders were found.

Pine forest collections yielded 232 specimens of 51 species, six being unique. The numbers and proportions of orb weavers found in the pine forests were quite similar to those found in the upland forest habitat. The orchard spider, *Leucauge venusta* was relatively common here. Among the sheet-web weavers, the most common species were *Neriene clathrata* and *Pityohyphantes costatus*.

Table 1
Spiders collected at the Glen Helen Nature Preserve

Family	Genus	Species	Author	All	Up-land Forest	Flood-plain Forest	Pine Forest	Old Fields	Prairie	Out-crops	Wet-land	Buildings
Agelenidae	<i>Agelenopsis</i>	<i>emertoni</i>	Chamberlin & Ivie, 1935	2	1						1	
	<i>Agelenopsis</i>	<i>naevia</i>	(Walckenaer, 1805)	4					4			
	<i>Agelenopsis</i>	<i>pennsylvanica</i>	(C.L. Koch, 1843)	4	4							
	<i>Agelenopsis</i>	<i>sp?</i>		28	2	13	11	1				1
Amaurobiidae	<i>Callobius</i>	<i>bennetti</i>	(Blackwall, 1848)	9		6	1				2	
	<i>Coras</i>	<i>medicinalis</i>	(Hentz, 1821)	1							1	
	<i>Coras</i>	<i>montanus</i>	(Emerton, 1889)	1								1
	<i>Coras</i>	<i>sp?</i>		33	7	3	1		2	19		1
	<i>Wadotes</i>	<i>calcaratus</i>	(Keyserling, 1887)	5	2	2					1	
Anyphaenidae	<i>Anyphaena</i>	<i>pectorosa</i>	L. Koch, 1866	6	2	1	1		1			1
	<i>Hibana</i>	<i>gracilis</i>	(Hentz, 1847)	1	1							
	<i>Wulfilia</i>	<i>saltabundus</i>	(Hentz, 1847)	21				9	12			
	unidentified			25	15	1	1		8			
Araneidae	<i>Acanthepeira</i>	<i>stellata</i>	(Walckenaer, 1805)	4					4			
	<i>Araneus</i>	<i>marmoreus</i>	Clerck, 1757	12	6		4	2				
	<i>Araneus</i>	<i>pratensis</i>	(Emerton, 1884)	46				15	31			
	<i>Araneus</i>	<i>sp?</i>		16	3	1	6	1	2		3	
	<i>Araniella</i>	<i>displicata</i>	(Hentz, 1847)	3				2	1			
	<i>Argiope</i>	<i>aurantia</i>	Lucas, 1833	14	1	1		2	10			
	<i>Argiope</i>	<i>trifasciata</i>	(Forsk. 1775)	25				7	18			
	<i>Cyclosa</i>	<i>conica</i>	(Pallas, 1772)	16	14		2					
	<i>Cyclosa</i>	<i>turbinata</i>	(Walckenaer, 1841)	3	2				1			
	<i>Cyclosa</i>	<i>sp?</i>		21	10		11					
	<i>Eustala</i>	<i>anastera</i>	(Walckenaer, 1841)	20	7		9	1	3			
	<i>Hypsosinga</i>	<i>pygmaea</i>	(Sundevall, 1832)	1	1							
	<i>Larinia</i>	<i>borealis</i>	Banks, 1894	1					1			
	<i>Larinia</i>	<i>directa</i>	(Hentz, 1847)	5					5			
	<i>Larinia</i>	<i>sp?</i>		5				3	2			
	<i>Larinioides</i>	<i>cornutus</i>	(Clerck, 1757)	1		1						
	<i>Larinioides</i>	<i>patagiatus</i>	(Clerck, 1757)	1				1				
	<i>Mangora</i>	<i>gibberosa</i>	(Hentz, 1847)	19				14	4			1
	<i>Mangora</i>	<i>maculata</i>	(Keyserling, 1865)	25	13	7	4		1			

Table 1 (cont.)
Spiders collected at the Glen Helen Nature Preserve

Family	Genus	Species	Author	All	Up-land Forest	Flood-plain Forest	Pine Forest	Old Fields	Prairie	Out-crops	Wet-land	Buildings
	<i>Dictyna/Emblyna</i>	<i>sp?</i>		1	1							
Gnaphosidae	<i>Drassyllus</i>	<i>creolus</i>	Chamberlin & Gertsch, 1940	2					2			
	<i>Drassyllus</i>	<i>depressus</i>	(Emerton, 1890)	29					29			
	<i>Drassyllus</i>	<i>novus</i>	(Banks, 1895)	1					1			
	<i>Drassyllus</i>	<i>sp?</i>		6					6			
	<i>Haplodrassus</i>	<i>signifer</i>	(C.L. Koch, 1839)	1	1							
	<i>Micaria</i>	<i>sp?</i>		10	10							
	<i>Sosticus</i>	<i>insularis</i>	(Banks, 1895)	2					2			
	<i>Zelotes</i>	<i>exiguoides</i>	Platnick & Shadab, 1983	5					5			
	<i>Zelotes</i>	<i>laccus</i>	(Barrows, 1919)	1					1			
	<i>Zelotes</i>	<i>sp?</i>		8					8			
	<i>unidentified</i>			24					24			
Hahniidae	<i>Neoantistea</i>	<i>sp?</i>		1	1							
Linyphiidae	<i>Bathypantes</i>	<i>alboventris</i>	(Banks, 1892)	9	3	1	4		1			
	<i>Bathypantes</i>	<i>pallidus</i>	(Banks, 1892)	49	4	2	1		42			
	<i>Ceraticelus</i>	<i>bulbosus</i>	(Emerton, 1882)	2	1		1					
	<i>Ceraticelus</i>	<i>fissiceps</i>	(O.P.Cambridge, 1874)	17	1	15	1					
	<i>Mermessus</i>	<i>maculatus</i>	(Banks, 1892)	1								1
	<i>Erigone</i>	<i>autumnalis</i>	Emerton, 1882	1					1			
	<i>Frontinella</i>	<i>communis</i>	(Walckenaer, 1841)	15	6		3	1	5			
	<i>Grammonota</i>	<i>ornata</i>	(O.P.Cambridge, 1875)	1							1	
	<i>Helophora</i>	<i>insignis</i>	(Blackwall, 1841)	8	1	3	4					
	<i>Lepthyphantes</i>	<i>leprosus</i>	(Ohlert, 1865)	1		1						
	<i>Lepthyphantes</i>	<i>turbatrix</i>	(O.P.-Cambridge, 1877)	2	1		1					
	<i>Meioneta</i>	<i>unimaculata</i>	(Banks, 1892)	4		1			3			
	<i>Neriene</i>	<i>clathrata</i>	(Sundevall, 1830)	38	11	8	19					
	<i>Neriene</i>	<i>radiata</i>	(Walckenaer, 1841)	4	3		1					
	<i>Neriene</i>	<i>variabilis</i>	(Banks, 1892)	17	12	1	4					
	<i>Pityohyphantes</i>	<i>costatus</i>	(Hentz, 1850)	38	26	3	7		2			
	<i>Styloctetor</i>	<i>purpurescens</i>	(Keyserling, 1886)	5	3	1						1
	<i>Tenuiphantes</i>	<i>sabulosus</i>	(Keyserling, 1886)	1	1							
	<i>Tenuiphantes</i>	<i>zebra</i>	(Emerton, 1882)	3	3							

Table 1 (cont.)
Spiders collected at the Glen Helen Nature Preserve

Family	Genus	Species	Author	All	Up-land Forest	Flood-plain Forest	Pine Forest	Old Fields	Prairie	Out-crops	Wet-land	Buildings
	<i>Tibellus</i>	<i>duttoni</i>	(Hentz, 1847)	3					3			
	<i>Tibellus</i>	<i>oblongus</i>	(Walckenaer, 1802)	6				2	4			
Pholcidae	<i>Pholcus</i>	<i>phalangioides</i>	(Fuesslin, 1775)	4			4					
Pisauridae	<i>Dolomedes</i>	<i>tenebrosus</i>	Hentz, 1843	54	16	10	6	6	14	2		
	<i>Pisaurina</i>	<i>mira</i>	(Walckenaer, 1837)	107	15	3	7	26	30			26
Salticidae	<i>Eris</i>	<i>militaris</i>	(Hentz, 1845)	5		3	1					1
	<i>Euophrys</i>	<i>monadnock</i>	Emerton, 1891	1					1			
	<i>Evarcha</i>	<i>hoyi</i>	Roewer, 1954	1					1			
	<i>Hentzia</i>	<i>palmarum</i>	(Hentz, 1832)	1	1							
	<i>Maevia</i>	<i>inclemens</i>	(Walckenaer, 1837)	14				6	5			3
	<i>Marpissa</i>	<i>lineata</i>	(C.L.Koch, 1846)	3					3			
	<i>Metacyrba</i>	<i>undata</i>	(DeGeer, 1778)	1			1					
	<i>Neon</i>	<i>nellii</i>	Peckham & Peckham, 1888	1					1			
	<i>Paraphidippus</i>	<i>aurantius</i>	(Lucas, 1833)	38				3	32			3
	<i>Pelegrina</i>	<i>galathea</i>	(Walckenaer, 1837)	58				13	45			
	<i>Pelegrina</i>	<i>proterva</i>	(Walckenaer, 1837)	29	2	1	1	1	21			3
	<i>Pelegrina</i>	<i>sp?</i>		36	1		2		32	1		
	<i>Phidippus</i>	<i>audax</i>	(Hentz, 1845)	3	1		1		1			
	<i>Phidippus</i>	<i>clarus</i>	Keyserling, 1885	23				18	2			3
	<i>Phidippus</i>	<i>sp?</i>		13	2				11			
	<i>Sassacus</i>	<i>papenboei</i>	(Peckham & Peckham, 1895)	1								1
	<i>Synemosyna</i>	<i>formica</i>	Hentz, 1846	1								1
	<i>Thiodina</i>	<i>puerpera</i>	(Hentz, 1846)	23					22			1
	<i>Thiodina</i>	<i>sylvana</i>	(Hentz, 1846)	2					1			1
	<i>Thiodina</i>	<i>sp?</i>		5			1	2	1			1
	<i>Tutelina</i>	<i>elegans</i>	(Hentz, 1846)	6				4	2			
	<i>Zygoballus</i>	<i>nervosus</i>	(Peckham & Peckham, 1885)	7			1					6
	<i>Zygoballus</i>	<i>rufipes</i>	(Peckham & Peckham, 1885)	16	2	3			11			
	<i>Zygoballus</i>	<i>sp?</i>		1				1				
	<i>unidentified</i>			209				158	51			
Tetragnathidae	<i>Leucauge</i>	<i>venusta</i>	(Walckenaer, 1841)	83	51	13	9	2	4		4	
	<i>Tetragnatha</i>	<i>elongata</i>	Walckenaer, 1805	3	2			1				

Table 1 (cont.)
Spiders collected at the Glen Helen Nature Preserve

Family	Genus	Species	Author	All	Up-land Forest	Flood-plain Forest	Pine Forest	Old Fields	Prairie	Out-crops	Wet-land	Buildings
	<i>Synema</i>	<i>parvulum</i>	(Hentz, 1847)	2					2			
	<i>Tmarus</i>	<i>angulatus</i>	(Walckenaer, 1837)	5			4				1	
	<i>Xysticus</i>	<i>elegans</i>	Keyserling, 1880	3			2		1			
	<i>Xysticus</i>	<i>ferox</i>	(Hentz, 1847)	23	5	5	1	3	8	1		
	<i>Xysticus</i>	<i>fraternus</i>	Banks, 1895	4	1					1	1	1
		<i>unidentified</i>		169	35	1		101	32			
Uloboridae	<i>Hypitiotes</i>	<i>cavatus</i>	(Hentz, 1847)	6	6							
	<i>Uloborus</i>	<i>glomosus</i>	(Walckenaer, 1841)	11	3	7	1					
all species		habitat total (no. uniques)			15	4	6	1	40	4	9	3
all species		habitat totals (no. species)		170	77	55	51	41	95	19	33	15
all species		habitat totals (no. individuals)		3766	705	300	232	572	1558	97	276	26

The wolf spiders were relatively uncommon in the pine forests; of these, most were members of the genus *Pirata*. The stick-mimic crab spider, *Tmarus angulatus* was found in the pine forest sites. This is not surprising because of the relatively large number of thin dead branches, where this species typically resides, that are found in the deeply-shaded understory of the pine forest.

In comparison to the forested sites at Glen Helen, the small reconstructed tallgrass prairie was home to a relatively diverse and abundant spider fauna. Collections there were the most productive of any at Glen Helen; 1,558 individuals representing 95 species were found. Of these 95 species, 40 were unique to this habitat. This represents the highest proportion of unique species (42 percent) found in a single habitat type during this study. Old field sampling yielded 572 individuals of 41 species (only one unique) but this difference with respect to the similar prairie habitat may be the result of greater sampling effort on the prairie. Four individuals of the star-bellied orb weaver, *Acanthepeira stellata*, a tallgrass prairie indicator species, were captured. The most conspicuous spiders in the prairie and old field areas are representatives of the two large *Argiope* species; *A. aurantia* and *A. trifasciata*. The numerically most abundant orb weaver is the small (body length ~ 4-6 mm) *Araneus pratensis*. The orb weaver *Neoscona arabesca*, often described as an "habitat edge" species was common. A large number of long-jawed orb weavers were found on the prairie and old fields, including representatives of five of the six species collected at Glen Helen. Among the sheet-web weavers, the small *Bathyphantes pallidus* was most abundant. One of only two common members of the meshweb weavers (family Dictynidae) found at Glen Helen was *Dictyna foliacea* and 29 of the 30 specimens came from the prairie. There were a great number and diversity of ground-living spiders captured in the tallgrass prairie. These included five corinnid species (family Corinnidae) in the genus *Castianeira*, known to prefer open sunny habitats. A very large number (133) of small ground-living corinnids were also found in the prairie. Most of

these were either *Phrurotimpus borealis*, *Scotinella fratrella*, or *Scotinella pugnata*. Among the nocturnal ground spiders in the family Gnaphosidae, the prairie sampling was extremely productive. A total of 54 individuals representing seven species were captured; an additional 24 immatures could not be identified. The common ground spider *Drassyllus depressus* was the most abundant with 29 individuals in the sample. Among the wolf spiders there were 18 species collected. The most numerous were *Pirata alachuus*, *Rabidosa* spp., and *Schizocosa ocreata*. The lynx spiders (family Oxyopidae) *Oxyopes salticus* and *Oxyopes scalaris* were very common on the prairie and each of the old fields. These are among the most conspicuous species found in sweep samples during summer in these open habitats. In addition, the two nurseryweb spiders (family Pisauridae), *Dolomedes tenebrosus* and *Pisaurina mira* are common in sweep samples from both prairie and old fields. Another spider found commonly in sweep samples is the very pale ghost spider (family Anyphaenidae), *Wulfila saltabundus*. A great many of the diurnal and conspicuous jumping spiders were found in the open habitats; tallgrass prairie and old-fields. A total of 449 individuals were captured, including 200 immatures. Among the identifiable adults, 15 species were tallied. The most abundant species were the beautiful iridescent green *Paraphidippus aurantius*, and the peppered jumpers *Pelegrina galathea* and *Pelegrina proterva*.

Sampling at the small spring-fed wetland along Yellow Springs Creek near its confluence with the Little Miami River yielded 276 individuals of 33 species, nine of which were unique to this site. The most common orb weavers found at the wetland site were the distinctive arrowhead-shaped *Micrathena sagittata* as well as immatures of the genus *Neoscona*. It seems likely that these immatures were representatives of *Neoscona arabesca*, common in open habitats. *Micrathena sagittata* is known to prefer moist, humid habitats as is demonstrated by its presence here (19 individuals) in comparison to its rarity in other Glen Helen samples (two individuals in the floodplain forest, none elsewhere). The semi-aquatic wolf spider,

Pirata sedentarius was commonly collected at this site. Eight individuals of the meshweb weaver *Emblyna sublata* were captured, but none were found on the prairie where this common species might have been expected. Somewhat surprisingly the grass inhabiting *Philodromus marxi* were collected at this wetland but not in the prairie or old fields. *Tetragnatha versicolor* was captured only here. This species has previously been found in marshy habitats by Kaston (1981). The tiny (<3 mm), but attractive, red and yellow *Theridula emertoni* was captured only at this site, like *E. sublata* it is surprising that it was not captured on the prairie particularly considering that sampling effort was much higher there.

Rocky limestone outcrops are one of the scenic hallmarks of the Glen Helen Nature Preserve. Limestone cliff and ravine samples included 97 spiders of 19 species, four of which were found nowhere else. Each of these four species was represented by a single specimen. Two of these four species, *Coras medicinalis* and *Achaearenea globosa*, typically retreat into crevices and other very sheltered sites. *Coras medicinalis* is probably common in this habitat as indicated by 19 additional immature specimens of this genus, possibly of this species, also captured in the rocky areas. The fact that only one identifiable adult was captured may thus be the result of insufficient sampling during the late fall and early spring when adults are most easily captured. These spiders often hide in rock fissures, and are very difficult to extract. The crab spider *Ozyptila curvata* was found in this habitat. This species may represent a boreal relict species, its typical habitats being bogs and northern coniferous forests. In contrast, we cannot suggest a reason why *Castianeira cingulata*, a relatively common species elsewhere in Ohio, is represented by only one individual at a rock outcrop which is perhaps another indication of under sampling bias. The most common spider found on rocky outcrops was the introduced cobweb weaver, *Parasteatoda tepidariorum*.

Relatively few spiders were collected on structures, but a surprising number of dewdrop spiders, *Neospintharus trigonum* were collected. Perhaps these small spiders were more conspicuous against the relatively simple background of human construction than in the complex vegetation of the woods. For whatever reason, seven of the 12 collected at Glen Helen were found on human made structures.

For the two largest habitat categories (forests combined, open habitats combined) there is sufficient data to compare the relative species diversity, corrected for sampling intensity. By using the rarefaction curves generated with EstimateS, a random sample of 40 collections in forest yielded 74 species (95 percent confidence limits 65-83). A similar random sample of 40 collections from open habitats yields 123 species (95 percent confidence limits 111-134). Thus there is evidence that the species diversity in the open habitats (prairie, old field, wetland) is significantly higher than present in forests (pine, floodplain, upland) when corrected for sampling intensity.

Considering the entire Glen Helen sample, the most widely distributed species were the orb weavers; *Mangora maculata* and *Mangora placida*, the wolf spiders; *Pirata alachuus* and *Schizocosa ocreata*, the nurseryweb spiders; *Dolomedes tenebrosus* and *Pisaurina mira*, the orchard spider; *Leucauge venusta*, the cobweb weaver; *Theridion frondeum*, and the crab spider; *Xysticus ferox*. The species most frequently encountered by human visitors was probably the spined micrathena, *Micrathena gracilis*. This common spider often builds its web across trails at head-height in the woods. This habit is likely the result of a particular gap-size preference for web-site

selection. Whatever the cause, during our work in the Glen we witnessed numerous unsuspecting hikers dismayed at encountering this harmless species face-to-face.

Three species represent the first records for Ohio. Five individuals of *Zelotes exiguoides* Platnick and Shadab were captured in pitfall traps at the tallgrass prairie between 19 June and 11 September 2001. The nearest published records are from southwestern Pennsylvania. Two individuals of *Achaearenea conjuncta* (Gertsch and Mulaik) were captured on 23 August 1997. One was captured in a sweep sample in an old field and one from a sweep sample at the tallgrass prairie. Previous records of this species have been from the southeastern United States, the nearest record being from North Carolina. One individual of *Ozyptila curvata* Dondale and Redner was captured on a rocky cliff on 25 June 1996. Subsequently this species has been recorded at Conkle's Hollow, Hocking County, OH. These Ohio records fall within the previously published range from "Manitoba, Massachusetts, southward to Virginia." (Dondale and Redner, 1978).

DISCUSSION

The diversity of spider species represented at Glen Helen seems typical for mixed mesophytic forests in Ohio. If we consider only the spiders collected within forested sites at Glen Helen (1,201 specimens) a total of 93 species were recorded from Glen Helen. Previous studies as well as unpublished data from the Ohio Spider Survey yield spider diversity estimates for eight other forest sites in the region. The Ohio Spider Survey is an ongoing public/private cooperative effort to document spider diversity in Ohio since 1994 (<http://www.marion.ohio-state.edu/SpiderWeb/mainpage.htm>). Of the five sites that are most similar to Glen Helen, because they are each isolated in a landscape of rural or agricultural development within the glaciated North Central Tillplain ecoregion, the mean diversity was 94 species. The other three sites are surrounded primarily by forest and are located in the unglaciated Western Allegheny Plateau ecoregion, and had a mean spider diversity of 120 species. It is difficult to know if these three sites possess higher diversity because they support different habitats, they are imbedded within contiguous forest, they are at a lower latitude, or perhaps because of the negative influence of a history of glaciation at the tillplain sites. Each of these appears to be a reasonable hypothesis.

Perhaps the most surprising result from this study is the remarkable abundance and diversity of spiders captured in the two most restricted habitats, the prairie and spring-fed wetland. A total of 1,558 specimens representing 95 species were collected at the 1.8 ha reconstructed tallgrass prairie. Many (40) of these species were not found at any other site in the Glen. By comparison, the old field sites at the Glen, comprising approximately 12.2 ha, yielded only 572 specimens of 41 species. The 0.4 ha spring-fed wetland was sampled only eight times but yielded 276 specimens of 33 species, nine of which were unique to this habitat.

Using the program EstimateS (Colwell 2005) to generate a random resampling of our data to compute species diversity yield from 40 random sample collections for both forests (combined) and open habitats (combined) data, 74 species would be found in the forest and 123 in the open habitat sites. Thus controlling for sampling intensity, diversity still appears to be greater on the open habitat sites.

The high yield of spiders captured in the sweep/beat samples may reflect the higher relative sampling intensity using that method. Some methods were probably underutilized. For example, only 13

litter samples were collected. No litter samples were collected in the late autumn, winter, or early spring, periods when a number of litter-inhabiting and speciose linyphiid spiders would typically be most abundant. Some species are most often found in the vicinity of human-built structures. One of those, *Pholcus phalangioides*, was captured only in the pine forest, an anomalous event. Very little time was spent examining the buildings, it is very likely that this species is also present there. Relatively few unusual species were captured during this study. There are no comparative data available for Greene County OH, but three species (*Zelotes exiguoides*, *Achaearanea conjuncta*, and *Ozyptila curvata*) were new for the state.

The spider fauna at Glen Helen is diverse, but there is reason to be concerned about this area because of the potential changes resulting from the increasing prevalence of introduced exotic plants in the understory at Glen Helen such as bush honeysuckles (*Lonicera* spp.), multiflora rose (*Rosa multiflora*) and garlic mustard (*Alliaria petiolata*) in the upland forest areas. Garlic mustard in particular has been implicated in significant changes in ground plant communities (Stinson et al. 2007). In contrast to Stinson's study, a study of carabid beetle predators failed to detect any influence of invasive garlic mustard on the beetles or their prey in a central New York forest (Davalos & Blossey, 2004). While the data are too sparse for statistical analysis, it appears that more recent sampling in upland forest sites, which have experienced a large increase in garlic mustard coverage, yielded fewer species of spiders in the later years of this study.

ACKNOWLEDGEMENTS. We thank the following individuals for assistance with sampling; Todd Blackledge, Audra Gibson, Clay Harris, Bonnie MacNett, Foster Purrington, and Dan Regelski. Clay Harris and Victoria Emans Ciola assisted with sorting and identification of specimens. We thank Bruce Cutler, Charles Dondale and Michael Draney for assistance with determinations of some specimens. In particular, we are indebted to Amy Tovar for many hours of assistance in the field, including sampling and logistical support, for reading an earlier draft of this manuscript, and providing helpful suggestions. Bob Klips read an earlier draft of the manuscript and helped to clarify the paper. We thank four anonymous reviewers for constructive criticism and many helpful suggestions that improved this paper.

We thank the staff at Glen Helen Nature Preserve and the Glen Helen Ecology Institute for permission to conduct this research on lands under their care. Specific thanks to Barbara Case who spent many hours showing us some of the special places in the Glen and her expertise with the flora of the sites, and Rick Flood who gave us initial approval to conduct this study. We thank the Ohio Biological Survey for permission to reprint a modified version of the map from Ohio Biological Survey Biological Notes No. 5 as Figure 1. Financial support for this project was provided by the Ohio Department of Natural Resources, Division of Wildlife, Wildlife Diversity Grants WANR06, NGSCW-94-06, NGSCW-95-03, NGSCW-96-06, NGSCW-00-08, NGSCW-02-19, NGSCW-03-04, NGSCW-04-24, NGSCW-05-24, NGSCW-06-24, NGSCW-07-24. Additional financial support was provided by small research grants from The Ohio State University at Marion.

LITERATURE CITED

- Anliot, S.F. 1973. The Vascular Flora of Glen Helen, Clifton Gorge, and John Bryan State Park. *Biological Notes No. 5* Ohio Biological Survey, Columbus, OH.
- Cady, A. 1994. A pitfall trap design for repeated use which repels rain and animal intrusion. *American Arachnology*, No. 50; p 3.
- Colwell, R.K. 2005. EstimateS: Statistical estimation of species richness and shared species from samples. Version 8.0. User's Guide and application published at: <http://purl.oclc.org/estimates>.
- Cooperrider, T.S., A.W. Cusick and J.T. Kartesz. Editors. 2001. *Seventh Catalog of the Vascular Plants of Ohio*. The Ohio State University Press, Columbus, OH. 195 p.
- Davalos, A. and B. Blossey. 2004. Influence of the invasive herb garlic mustard (*Alliaria petiolata*) on ground beetle (Coleoptera: Carabidae) assemblages. *Environmental Entomology* 33: 564-576.
- Dondale, C.D. and J.H. Redner. 1978. The crab spiders of Canada and Alaska (Araneae: Philodromidae and Thomisidae). The insects and arachnids of Canada. Part 5. Agriculture Canada, Ottawa. Publication 1663. 255 pp.
- Kaston, B.J. 1981. Spiders of Connecticut. *State Geological and Natural History Survey of Connecticut. Bulletin* 70. 1020 pp.
- Levi, H.W. 1955. The Spider Genera *Coessa* and *Achaearanea* in America North of Mexico (Araneae, Theridiidae). *American Museum Novitates* No. 1718. 33pp.
- Levi, H.W. 1963. American Spiders of the Genus *Achaearanea* and the new Genus *Echinotheridion* (Araneae, Theridiidae). *Bulletin of the Museum of Comparative Zoology*, 129: 189-240.
- Platnick, N. I. 2009. *The world spider catalog*, version 10.0. American Museum of Natural History, online at <http://research.amnh.org/entomology/spiders/catalog/index.html>
- Stinson, K., S. Kaufman, L. Durbin, and F. Lowenstein. 2007. Impacts of garlic mustard invasion on a forest understory community. *Northeastern Naturalist* 14: 73-88.