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A SURVEY OF SPIDER DIVERSITY IN MORGAN-MONROE/ YELLOWWOOD STATE FOREST

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ABSTRACT. As both predators and prey, spiders are important components of forest ecosystems, yet there is a paucity of information about spider species assemblages in Indiana forests. Between 2014 and 2017, the Indiana Forest Alliance sponsored an extensive taxonomic survey, called an ecoblitz, in Morgan-Monroe/ Yellowwood State Forests in Indiana. During this ecoblitz, 128 spider species were collected. Of these species, 31 were new distribution records for Indiana. Of the total number of species collected, 62% were collected in the bottomland habitat, 60% on slopes, and 19% on ridges. Only 10% of the total species were found in all three habitats. In pair-wise comparisons of habitats, species composition differed between habitats even when species richness was similar. Likewise, collection of spider species during the day differed in composition from those collected at night with only 26% collected during both periods. These data emphasize the benefits of multi-year surveys, such as the ecoblitz, and the importance of sampling in multiple habitats as well as during the day and the night. The high number of new distribution records in our sample reinforces the premise that spiders as a group are underrepresented in scientific studies of forests in Indiana.

Keywords: Araneae, species richness, Indiana state forests, ecoblitz, spiders

INTRODUCTION

As conservation practitioners become increasingly aware of the importance of baseline taxonomic surveys, the "bioblitz" has become a popular means of rapid field assessment (Parker et al. 2018) as well as a means to engage and educate the public as "citizen scientists" (Lundmark 2003). In most cases, a bioblitz engages volunteers to document as many species as possible of a specific taxon within a narrow time window and location. Since the first bioblitz in 1996 organized by the U.S National Park Service, these surveys have collected baseline inventories for numerous natural history museums, parks, nature preserves, and land trusts. The collected information contributes to knowledge and decision-making for conservation managers (Ballard et al. 2017). The value of baseline information to conserving the biodiversity of our natural areas is becoming increasingly critical as we face increased loss of habitats and the inevitable environmental shifts through climate change (Bellard et al. 2012).

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While bioblitzes have been essential in documenting species inventories, they have been limited in that they are typically restricted to one or two days. The Indiana Forest Alliance (IFA) organized the first extensive and intensive taxonomic survey in an Indiana State Forest. This expanded version of a bioblitz – labeled the "ecoblitz" – was conducted in the Back Country Area (BCA) of Morgan-Monroe/Yellowwood State Forests in south-central Indiana. The survey covered 12 taxonomic groups and was led by experts with teams including 41 scientists, 45 students, and numerous volunteers over a four-year period. The ecoblitz also covered seasons from spring through fall and included natural history observations. As part of this ecoblitz effort, we surveyed the diversity of spiders from 2014–2017.

Spiders are important components in forest ecosystems as both predators and prey. As first-level consumers in the forest food web, spiders eat an array of insect species due to their varying lifestyles (Wise 1993). For example, some species are ambush or hunting spiders, while other species build webs varying from platforms to orbs (Cardoso et al. 2011). As generalist predators, individual spiders are constrained by the size and abundance of available insect prey rather than by availability of specific insect species. Spiders vary in body size from minute cryptic species found in the leaf litter to large, active hunters found on tree bark, and they regulate insect populations from all forest microhabitats, e.g., leaf litter (Uetz 1979; Wise 2006).

Conversely, spiders are important prey items for numerous forest animals. Small mammals such as shrews eat ground spiders found in woody debris (Whitaker & Mumford 1972). Numerous insectivorous bird species snatch spiders from their webs, or glean spiders crawling on leaves in the canopy, and can have a significant effect on spider assemblages in forests (Gunnarsson 2007). Salamanders, toads, frogs, and insectivorous snakes and lizards also eat spiders. In fact, spiders are a component of the diet of all insect-eating animals, including predaceous insects and other spiders (Wise 2006).

In many biodiversity studies, spiders are considered robust indicators of arthropod diversity due to their spatial and temporal ranges, small size, and high relative abundance (New 1999). Because the distribution of spider species reflects characteristics of habitat structure (Uetz 1991), different forest successional stages contain characteristic species assemblages. Recent studies have suggested that spiders are good indicators of the effects of forest management, which typically alters habitat structure (Willett 2001; Pearce & Venier 2006).

Although there is much information in the literature about mammals and birds in Indiana forests, there is little knowledge about spider species despite their important ecological role. In fact, there is a paucity of information about spiders in Indiana for all habitats (Milne et al. 2016) and baseline data are sorely needed in a world where global biodiversity is rapidly diminishing.

METHODS

The ecoblitz area included the 900-acre (364 ha) Back Country Area of Morgan-Monroe/Yellowwood State Forests (Fig. 1) located along the border of Monroe County and Brown County in south-central Indiana. The two state forests represent a mature eastern deciduous forest within the maple-beech to oak-hickory transition zone. This area has ridge-ravine topography with a predominately closed canopy. Because of the deep ravines that dissect the forest, there is a wide range of microhabitats. Also, due to the maturity of the forest, there are numerous snags and a large amount of coarse woody debris, thick leaf litter on the forest floor, and sunny openings from tree fall. The bottomlands include intermittent creeks.

Spiders were collected as part of the ecoblitz in the Back Country Area for four years (2014–2017). During 2014–16, spiders were sampled both early in the season (June) and late (September) to obtain a representation of spiders with varying life histories. Both day and night sampling were done to include spiders with different activity periods. In 2017, samples were collected in only one survey period, which was at night in July. Each survey period included three habitats: dry ridge, mesic slope, and bottomland with a creek bed.

Our sampling methods included: 1) aerial search of leaves, branches, tree trunks, and the empty spaces between vegetation within arm's reach; 2) sweep netting to capture spiders in shrubby or herbaceous vegetation; 3) ground search on low vegetation, fallen logs, rocks, or steep banks; 4) beat-sheet method in which a square sheet was stretched under the edge of a tree branch or bush and, upon shaking the plant, spiders that fell onto the sheet were captured; and 5) litter sort method where handfuls of leaf litter was collected and dumped into a litter sorter. Material fell onto a white sheet and the small spiders living in this microhabitat were then captured.

Spiders were identified in the field when possible. Unknowns were collected in 70% ethanol for later identification under the microscope. Abundance data was not collected, so results reflect presence-absence only. Adult spiders were identified to species using *The Spiders of North America* by Ubick et al. (2005) and other taxonomic keys from the primary literature. The analysis and species list reflect data pooled from the four years of sampling.

The ecoblitz survey was authorized by permits from the Indiana Department of Natural Resources. Voucher specimens are located at the Indiana State University collection.

RESULTS

Species richness.—A total of 128 species from 28 families were identified (Table 1). Each year new species were added to the cumulative list (2014: 73 species; 2015: 100 total species; 2016: 122 total species; 2017: 128 total species), as well as representatives from new families.

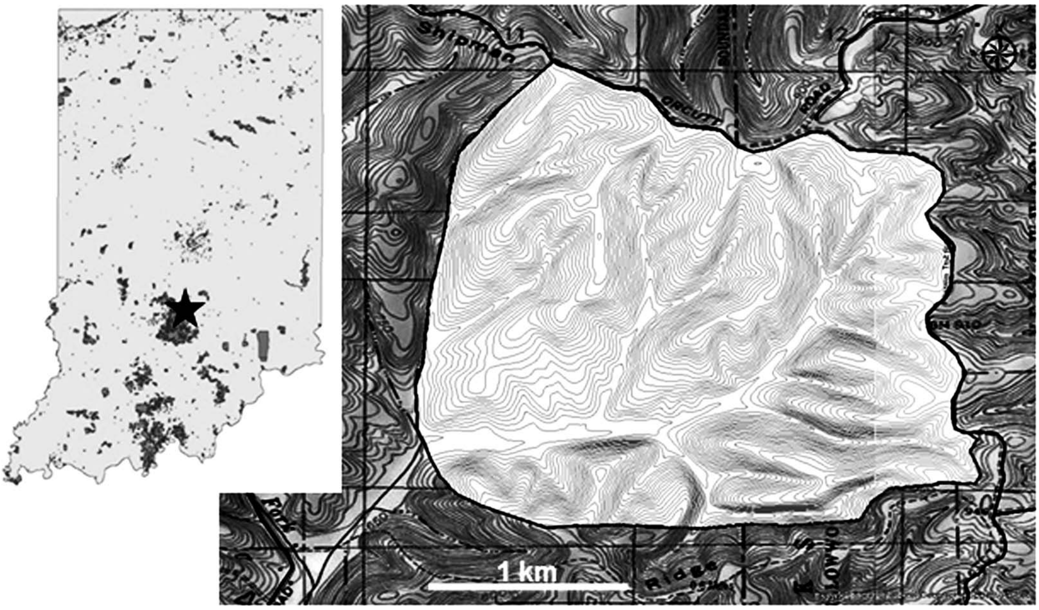

Figure 1.—Map illustrating the location of Morgan-Monroe/Yellowwood State Forest within Indiana (left; marked by star) and location of the 900-acre Ecoblitz area (right; light gray) within the Morgan Monroe/ Yellowwood State Forest Back Country Area. Black lines depict roads. (*Map prepared by Rae Schnapp*)

For example, in 2016 our first representative species in the families Liocranidae, Mysmenidae, Titanoecidae, and Halonoproctidae were found. Our forest sample represents about 28% of the total spider species (454) documented for Indiana (Milne et al. 2016).

New distribution records.—In the four years of sampling, 31 species were collected that are new records for Indiana (Table 1, marked with *). All but six of these species are included in a recent report on Indiana spider distributions (Milne et al. 2016). The latest additions include: *Drapetisca alteranda*, a tree-trunk specialist sheet-web weaver in the family Linyphiidae; *Ocrepeira ectypa*, an orb weaver in family Araneidae; *Emblyna zaba*, a mesh-web builder in family Dictynidae; *Agyneta semipallida*, a small sheet-web builder in family Linyphiidae; *Maymena ambita,* a horiziontal web builder in the family Mysmenidae; and *Chinattus parvulus*, a jumping spider in the family Salticidae.

Habitat comparisons.—Of the 128 species collected, 62% were collected in the bottomland habitat, 60% on slopes, and 19% on ridges (Fig. 2). Only 10% of total species were found in all three habitats (13 species out of a total of 128). Even though the bottomland and slope habitats were similar in the number of species, their actual species composition was moderately dissimilar (Sørensen Coefficient = 0.44 comparing pooled habitat assemblages, Table 2). Species compositions in the bottomland and slope habitats were moderately dissimilar from the species composition on ridges (Sørensen Coefficient values < 0.40, Table 2).

Comparison of day versus night collections.—The data revealed that different assemblages of spider species were active during the day versus the night (Sørensen Coefficient = 0.40 comparing pooled data). Of the 128 species documented, 41% were found only during the day and 33% were found only during the night; 26% of the total species were present in both the day and night samples (Fig. 3).

DISCUSSION

The results illustrate several points about the value of an inventory that samples spiders over multiple years and seasons, in both daytime and nighttime, and across multiple habitats. First, the multi-year and multi-season ecoblitz allowed us to find a greater number and variety of species than the typical one-shot bioblitz. The typical bioblitz, or rapid assessment survey, takes place during a single designated time irrespective of weather

Table 1.—Spider species list by family from Morgan Monroe/Yellowwood State Forests Ecoblitz 2014–2017. Species marked with an "*" represent new distribution records (31) for Indiana. Spiders unable to be identified past the genus level but distinct species (in some cases due to immaturity) are indicated by "sp." Habitat: B = bottomland; R = dry ridge; S = mesic slope. Time of Collection: D = daytime only; N = nighttime only; B = both daytime and nighttime. (See Milne et al. (2016) to find more information on the biology and distributions of some of the species listed.)

Family and species	Habitat	Time of collection
Agelenidae		
Agelenopsis emertoni	B	D
Agelenopsis pennsylvanica	S	B
Agelenopsis potteri	S	N
Agelenopsis utahana	B	D
Coras juvenilis	B,S	B
Wadotes calcaratus	B,S	B
Wadotes hybridus	B,S,R	N
Anyphaenidae		
Anyphaena pectorosa	B,R	D
Wulfila saltabundus	B,S,R	B
Araneidae		
Acanthepeira stellata	S	D
Araneus bicentenarius	B	N
Araneus marmoreus	B,S	N
Cyclosa conica	B,S,R	D
Eustala anastera	B	B
Mangora maculata	B,S,R	B
Mangora placida	S	N
Metepeira labyrinthea	S	N
Micrathena gracilis	S	B
Micrathena mitrata	B,S	B
Micrathena sagittata	B	D
Neoscona arabesca	B,S	B
Neoscona crucifera	B	N
Ocrepeira ectypa	B	N
Verrucosa arenata	B	N
Cheiracanthiidae		
Cheiracanthium inclusum	B	D
Clubionidae		
Clubiona sp.	B,S	N
Elaver excepta	S	N
Corinnidae		
Castianeira cingulata	B,S,R	B
Ctenidae		
Anahita punctulata	B,S,R	B
Cybaeidae		
Cybaeus sp.	S	N
Dictynidae		
Emblyna zaba	B	N
Lathys immaculata	S,R	B

Table 1.—Continued.

Family and species	Habitat	Time of collection
Gnaphosidae		
Drassodes neglectus	B	D
Drassyllus fallens	B	D
Gnaphosa fontinalis	B	D
Herpyllus ecclesiasticus	S	N
Micaria longipes	S	N
Hahniidae		
Cicurina arcuata	R	N
Hahnia flaviceps	S	D
Neoantistea agilis	B	N
Neoantistea magna	S	D
Halonoproctidae		
Ummidia tuobita	S	N
Linyphiidae		
Agyneta barrowsi	S	D
Agyneta semipallida	B	D
Bathyphantes alboventris	B,S	D
Bathyphantes pallidus	S	N
Centromerus latidens	S	N
Ceraticelus fissiceps	B,S	N
Ceraticelus sp.	S	B
Drapetisca alteranda	S	N
Frontinella pyramitela	S	D
Islandiana longisetosa	B	D
Lepthyphantes turbatrix	S	D
Mermessus maculatus	B,S	B
Pityohyphantes costatus	B	D
Styloctetor purpurescens	B,S	D
Liocranidae		
Agroeca sp.	R	D
Lycosidae		
Allocosa funerea	S	D
Gladicosa gulosa	B	N
Gladicosa pulchra	B	N
Pardosa lapidicina	B,S	D
Pardosa milvina	B,S	B
Pirata alachuus	B	B
Pirata sedentaris	B	N
Piratula insularis	B,S	B
Piratula minuta	B	B
Schizocosa crassipes	B,S,R	B
Schizocosa ocreata	B,S,R	B
Schizocosa saltatrix	S,R	N
Tigrosa aspersa	S	N
Mysmenidae		
Maymena ambita	R	D
Oxyopidae		
Oxyopes salticus	B	D
Philodromidae		
Philodromus imbecillus	B	D
Philodromus rufus vibrans	S	D
Tibellus sp.	B,S	D

Table 1.—Continued.

Family and species	Habitat	Time of collection
Phrurolithidae		
Phrurotimpus alarius	B,S,R	B
Phrurotimpus borealis	B,R	B
**Scotinella redempta*	B,S,R	B
Pisauridae		
**Dolomedes albineus*	B,S	N
Dolomedes tenebrosus	B,S	B
Dolomedes triton	B	N
Dolomedes vittatus	B,S,R	N
Pisaurina brevipes	B	D
Pisaurina mira	B,S	B
Salticidae		
**Chinattus parvulus*	S	D
**Colonus puerperus*	R	D
Colonus sylvanus	B	D
Eris militaris	B	D
Hentzia sp.	B	D
Maevia inclemens	B,S	D
Pelegrina galathea	R	D
Pelegrina proterva	S	D
Phidippus audax	S	D
Sassacus sp.	S	D
Zygoballus rufipes	B,S	D
Segestriidae		
Ariadna bicolor	S	N
Tetragnathidae		
Leucauge venusta	B,S,R	B
Tetragnatha elongata	S	N
Tetragnatha versicolor	B	D
Theridiidae		
Argyrodes sp.	S	B
Crustulina altera	S	D
Cryptachaea porteri	B	N
**Dipoena nigra*	S	N
**Enoplognatha caricis*	B	N
Faiditus globosus	B	D
Latrodectus variolus	S	N
Neospintharus trigonum	B	N
**Parasteatoda tabulata*	B	N
Pholcomma hirsutum	S	D
**Phylloneta pictipes*	S	D
**Robertus frontatus*	S	B
Steatoda triangulosa	B	N
Theridion albidum	B,S	D
**Theridion cheimatos*	B,S	D
Theridion fronduem	B,S	B
Theridion murarium	S	D
Theridula opulenta	B	N
**Thymoites marxi*	B	N
Thymoites unimaculata	B	N
Yunohamella lyrica	B,R	D
Theridiosomatidae		
Theridiosoma gemmosum	B,S	B

Table 1.—Continued.

Family and species	Habitat	Time of collection
Thomisidae		
Misumena vatia	B	N
Tmarus angulatus	S	D
Xysticus ferox	B,S,R	B
Xysticus fraternus	R	B
Titanoecidae		
Titanoeca brunnea	S,R	D
Uloboridae		
Hyptiotes sp.	S	D
Uloborus sp.	B	D

conditions. Spider activity, however, varies widely with weather conditions (Radai et al. 2017). For example, during a single bioblitz sample along waterways of Indianapolis, Milne found only 37 species of spiders (Holland et al. 2017) due to rain on the sampling day. For perspective, 78 species of spiders were collected during the one day bioblitz at Goose Pond in June 2016 (unpublished data). On the other hand, 128 species of spiders were found in the multi-year and multi-season ecoblitz. The ecoblitz made it possible for us to choose tentative sampling dates and, if the weather on a scheduled date was adverse to spider activity, to reschedule to take advantage of the best conditions for spider activity. Each subsequent year in the multi-year inventory yielded unique species (in 2014, 73 species collected; in 2015, an additional 27 species collected; in 2016, an additional 22 species collected, and in 2017, an additional 6 species collected). Furthermore, seasonality is important to the spider inventory (Toti et al. 2000). Since we are limited to species identification for adult spiders only (due to the role of genitalia in identification), it is imperative to sample spiders when adults are present. Some species overwinter

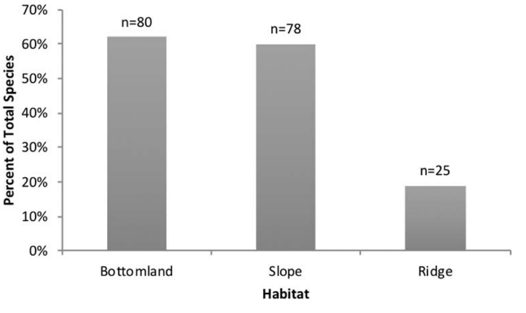

Figure 2.—Percent of total species found in each habitat: bottomland, slope, and ridge.

Table 2.—Sørensen Coefficients comparing the similarity in species composition between 1) habitats: bottomland (n = 80), slope (n = 78), and ridge (n = 25), and 2) time of sample: day (n = 84) vs. night (n = 78) using pooled presence-absence data (where 0.00 = no similarity, 1.00 = maximum similarity).

Bottomland vs slope	Bottomland vs ridge	Slope vs ridge	Day vs night
0.44	0.33	0.32	0.40

as adults, and others do not reach maturity until fall (Wise 1993).

Second, the multi-habitat inventory allowed us to sample from a wide variety of spider species with different habitat requirements. The overlap of species assemblages between the moist bottomlands and slopes and the dry ridges was relatively low. This result was expected. Numerous studies demonstrate the effect of plant community physiognomy and the resulting microhabitats on the composition of the spider community (reviewed in Turnbull 1973; Uetz 1991; Halaj et al. 2000). Different spider species vary in their microhabitat requirements, and species composition will vary among herbaceous vegetation, shrubs, tree bark, rotting logs, stream banks, and creek beds (Uetz 1991). Many of the spiders collected were from the litter. The dominant tree species varied among habitats (e.g., black oak (*Quercus velutina* Lam.) on ridges, tulip poplar (*Liriodendron tulipifera* L.) on slopes, and American beech (*Fagus grandifolia* Ehrh.) in the bottomlands), and thus the type of litter varied as well. Leaf litter structure (Bultman & Uetz 1982), as well as litter depth (Wagner et al. 2003), can have significant effects on spider species composition.

Third, as found in several other studies (Coddington et al. 1996; Green 1999; Costello & Daane 2005), our results emphasize the importance of sampling spiders during both day and night. Many spiders such as orb weavers hide in retreats during their non-active period (Foelix 2011) and would be more difficult to find, whereas they would be visible during their active period (e.g., *Araneus bicentarius*). Many nocturnal hunting spiders withdraw under bark or other reclusive places during the day (e.g., *Dolomedes albineus*) (Cloudsley-Thompson 1987). Other spiders, such as the nursery spider (*Pisurina mira)* are present both day and night. In the absence of our night sample, 33% of the total species would have been

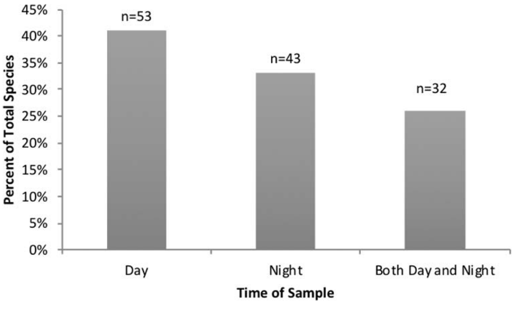

Figure 3.—Percent of total species found only during the day, only during the night, or found in both day and night.

missed (Fig. 3). In fact, the large fishing spider, *Dolomedes albineus* (Fig. 4) – one of the new distribution records for Indiana – would have been missed entirely if we had not sampled at night.

Even though the design of our ecoblitz allowed us to sample a large number and variety of spider species, the design has an important limitation. Because our survey was limited to spiders within our physical reach, our result on species richness likely under-estimates the total spider species of Morgan-Monroe/Yellowwood State Forests. Forest spiders occur on tree trunks and in the tree canopy beyond the reach of our sample (Szinetár & Horváth 2005). Several studies have shown that the forest canopy is a significant reservoir of spider diversity with distinct species assemblages associated with different forest horizontal layers as well as with the canopy of different tree species (Larrivée & Buddle 2009; Hsieh & Linsenmair 2011).

In conclusion, the 31 new distribution records for Indiana produced by the ecoblitz indicate that typical biodiversity surveys underestimate the diversity of spiders in Indiana forests. This underestimate is further highlighted by the fact that even the ecoblitz missed the spider species richness that occurs in forest canopies which is logistically difficult. Thus, all estimates of Indiana spider species to date are likely severe underestimates (Milne et al. 2016).

The ecoblitz design can be improved to capture a greater proportion of the spider species diversity that exists in the forests. For example, the addition of a third sampling period may yield additional species. Coddington et al. (1996) suggested May, July, and September as prime sampling periods for spiders. We also could have more systematically sampled the large woody

Figure 4.—A large female fishing spider, *Dolomedes albineus*, in the family Pisauridae, guarding an eggcase. An example of a new distribution record in Indiana found in the ecoblitz site of Morgan-Monroe/Yellowwood State Forest. (*Photo by Brian Foster*)

debris and standing dead trees or snags that provide habitat for additional assemblages of spiders. Buddle (2001) found spider diversity higher on woody debris than on the forest floor litter. Castro & Wise (2010) reported that distance from woody debris can affect the leaf-litter spider assemblage.

Yet, despite these limitations, sampling efforts like the ecoblitz – which rely heavily on volunteers – have encouraged surveys of under-represented groups, such as spiders and lichens (Lendemer 2017), and provide baseline data on species present in a relatively undisturbed mature forest such as the Morgan-Monroe/Yellowwood State Forest. Since state forests are managed for multiple uses, including timber harvest, baseline data in unlogged areas can serve as a reference for assessing the consequences of such practices on species diversity and the effectiveness of these management practices (Frelich et al. 2005). The current knowledge of spiders and other invertebrates, which are integral to forest ecosystem functioning, is minimal. Organized surveys such as ecoblitzes are invaluable strategies to improve basic understanding of species diversity.

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