

EPIGEIC SPIDER (ARANEAE) DIVERSITY AND HABITAT DISTRIBUTIONS IN
KINGS MOUNTAIN NATIONAL MILITARY PARK, SOUTH CAROLINA

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ABSTRACT

This study examined the epigeic spider fauna in Kings Mountain National Military Park. The aim of this study is to make this information available to park management for use in the preservation of natural resources. Pitfall trapping was conducted monthly for one year in three distinct habitats: riparian, forest, and ridge-top. The study was conducted from August 2009 to July 2010. One hundred twenty samples were collected in each site. Overall, 289 adult spiders comprising 66 species were collected in the riparian habitat, 345 adult comprising 57 species were found in the forest habitat, and 240 adults comprising 47 species were found in the ridge-top habitat. Eight species richness estimators were used to analyze the data: ACE, ICE, Chao 1, Chao 2, first-order jackknife, second-order jackknife, bootstrap, and Michaelis-Menton means. Based on the 8 species richness estimators, the riparian habitat is predicted to have between 76 and 98 total species, the forest 67 to 96 total species, and the ridge-top has 55 to 72 total species. Species accumulation curves based on the 8 species richness estimators and sampling completeness indices suggest that the realized species richness of the riparian and ridge-top habitats are closer to the actual species richness than is the forest habitat. The Shannon diversity index suggests the spider community in the riparian habitat is more diverse and had more similar numbers of individuals in all species than either the forest or ridge-top habitats. The complementarity values and similarity indices suggest that the forest and ridge-top habitats have the most similar community structure. Comparisons of trap cover color show no differences in the numbers of spiders captured in traps with red versus blue covers.

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Introduction

The purposes of this study are to gain baseline data of the epigeic (ground and litter-dwelling) spider (Araneae) species composition and assess their habitat distributions in Kings Mountain National Military Park (KMNMP) in upstate South Carolina. In addition, I examined whether the color of pitfall trap covers impacts the number of individual spiders trapped. These types of data are important because they provide researchers and park officials with information necessary to maintaining the health of the managed environment, are relevant for conservation, and add knowledge of field protocols to the pool of existing data.

As humans influence environments, it is becoming evident that many habitats are in need of conservation efforts. Environments in their natural state are a cache for biodiversity, and maintaining the quality of these areas plays a crucial role in our future. While humans have undoubtedly altered these environments, data collected under current conditions will allow future studies to determine how environmental changes impact species present. Untapped biological resources may hold the keys for future medicines, environmentally friendly and sustainable materials, and a plethora of other assets. If these habitats are altered or destroyed, information useful to the betterment of life may be lost with them. Changes in populations of biological indicator taxa, such as spiders, can be used as a gauge of changes of environmental quality. Without baseline data from relatively undisturbed habitats, little can be done to maintain habitats or restore them if they are disturbed in the future.

Three habitat types (riparian, forest, and ridge top) in KMNMP were monitored using pitfall-trapping techniques to assess the habitat distributions of epigeic spiders. The pitfall traps used had either blue or red cover plates and numbers of spiders captured were examined to determine if the cover color results in significant differences in captures.

Questions:

1. How does spider species richness compare across habitats?
2. How does the similarity of the spider communities compare across habitats?

Hypotheses:

H₁: The three habitat types will have different assemblages of epigeic spiders.

H_a: The three habitat types will have the same assemblages of epigeic spiders.

H₂: Pitfall trap cover color will affect the number of spiders trapped.

H_a: Pitfall trap cover color will not affect the number of spiders trapped.

Literature Review

Spider Ecology

Spiders as Ecological Indicators

Spiders are a highly diverse group of organisms and are well represented in nearly all environments. In addition, they are sensitive to environmental changes, especially changes in vegetation composition, making them good biological indicators (Petillon et al. 2006). In addition to representing the current state of an environment, biological indicators also reveal whether an environment has returned to a previous state following disruption, and can indicate whether there are lingering effects following a disturbance (Mgobozi et al. 2008). Allred (1975) conducted an experiment within the southern portions of Utah, Nevada, and Idaho, USA, investigating the significance of arachnids (spiders, scorpions, solpugids, phalangids) as ecological indicators. Three geographically and ecologically distinct habitats, one in each state, having similar vegetation structures were examined using pitfall-trapping methods during various years between 1957 and 1973. The study revealed that each area had its own assemblage of arachnid fauna despite the habitat similarities. Of the 179 species captured, only 4 were found in all 3 areas and 3 of these species were spiders, *Calilena restricta* Chamberlin & Ivie (Araneae: Agelenidae), *Euryopsis scriptipes* Banks (Araneae: Theridiidae), and *Haplodrassus eunis* Chamberlin (Araneae: Gnaphosidae) (Allred 1975). Allred (1975) also noted that ballooning behaviors easily disperse spiders, suggesting the differences in environmental factors in each of these areas must be significant enough to influence species composition.

A study investigating the invasive plant *Elymus athericus* Link (Poales: Poaceae) in salt-marsh microhabitats of Mont-Saint-Michel Bay, France, found that numbers of the two dominant halophilic spider species *Pardosa purbeckensis* F.O.P-Cambridge (Araneae: Lycosidae) and *Arctosa fulvolineata* Lucas (Araneae: Lycosidae) changed drastically following *E. athericus* invasion of these areas during 2002-2003 with *P. purbeckensis* numbers declining, while *A. fulvolineata* numbers increased (Petillon et al. 2006). The authors suggest using these spiders as indicators for determining impacts of future marsh management techniques. Willett (2001), in a study exploring old growth versus logged redwood (*Sequoia sempervirens* (D. Don)) stands found consistent declines in spider species abundance following logging. It was noted that even in tree farms, where trees are selectively harvested, spiders and other arthropods showed a decline in diversity. Since litter fauna play an important role in forest stability, it is important to maintain litter faunal community structures, as they may ultimately determine the quality of useable resources in these areas (Willett 2001).

Spiders and Cascade Effects

Cascade effects, the secondary influence on organisms following an initial interference of a key species, have been well documented (Dayton et al. 1998, Estes et al. 1989). Carter and Rypstra (1995) showed the effects of artificially increasing or decreasing the number of spiders in a soybean agroecosystem. Their data showed that there was less plant damage from herbivores where spider numbers were increased, and more plant damage from herbivores where spider numbers were reduced, demonstrating the cascade from predator to producer (Carter and Rypstra 1995). In an effort to

understand the influences of habitat complexity on intraguild (organisms with similar life history habits) predation, an experiment in Atlantic coastal salt marsh habitats showed a reduction in intraguild predation with increased habitat complexity. This cascade resulted in a rise in plant productivity through the increase of herbivore captures when spiders were able to avoid each other and focus on other prey. In less complex habitats where intraguild predation breaks down the cascade, spiders may feed more often on each other instead of other arthropods which can reduce primary producer biomass due to herbivory. The cascade influence of predators on herbivores and primary producers demonstrates the importance of preserving ecologically diverse habitats for a healthier environment (Finke and Denno 2006). In western Oregon, Halaj et al. (1998) investigated the relationship between spiders and habitat complexity in the forest canopy. They found that spider communities were significantly influenced by both habitat structure and prey availability. They reported that increased foliage complexity accounted for a large percentage of species abundance and diversity. Prey availability based on foliage structure also accounted for these factors, though on a lesser scale (Halaj et al. 1998). In a study investigating intraguild predation, Lang (2003) examined the relationship between generalist predator assemblages of predacious beetles and spiders in winter wheat fields. The results revealed interference between these two groups of arthropods, as artificially increasing or decreasing either group caused different reactions in the numbers of focus prey (aphids, thrips, delphacids, cicadellids). Fields having normal populations of both spiders and beetles seemed to have lower numbers of herbivorous species demonstrating the associated cascade roles of these groups (Lang 2003). These studies support the

importance of spiders in cascades, their direct and indirect influence on the surrounding flora and fauna, and the necessity of obtaining baseline data for future scientific assessments. The results of these studies are also useful because they suggest that different habitats will contain different spider species assemblages.

Riparian Zones

Riparian zones, areas adjacent to streams, generally have distinctive vegetation, and often are host to unique communities. Uetz (1976) conducted research investigating spider distributions over riparian flood gradients using pitfall trapping in a midwestern river bottomland forest. His objective was to examine the influence of harsh, alternating environments on community structures. He found that different sections of the riparian zone adjacent to the stream bank had unique spider species compositions. Only one species, *Schizocosa ocreata* Hentz (Araneae: Lycosidae), was found in all sections (Uetz 1976). Loeser et al. (2006) examined the microhabitat structure created by flooding along an Arizonan creek. Litter hovels, as described by the authors, are “flood-deposited clumps of intertwined plant material and inorganic debris attached to trees and elevated above ground by past high water events.” Their study revealed that spiders occupied over 90% of litter hovels examined. It was also found that both spider species abundance and diversity were not random within the habitats examined (vegetated floodplain, creek edges, islands) (Loeser et al. 2006). These studies suggest that riparian habitats in KMNMP could have unique spider species assemblages.

Forest

Forest habitats play an important role in web-building spider species compositions due to their complex vegetation patterns, but cursorial ground dwelling spiders do not have a dependence on vegetation for web building needs (Uetz 1979). However, the types of litter created by various plant communities whose leaves and other parts accumulate on the forest floor do have an impact on ground dwelling spider species composition (Stevenson and Dindal 1982, Uetz 1974). Stevenson and Dindal (1982) examined *Enoplognatha ovata* Clerck (Araneae: Theridiidae) and species richness in litter with different characteristics and found that leaf shape (curled vs. flat) influences *E. ovata* microhabitat choices and overall richness. These studies were conducted in a mixed hardwood-pine stand composed of red oak and sugar maple. Both spider species richness and numbers of *E. ovata* increased with the increasing proportion of curled leaves. Litter having different leaf shapes also supported different spider guild compositions (Stevenson and Dindal 1982). Wagner et al. (2003) reported that litter depth is also important. Their study was conducted in a deciduous forest in Kentucky, USA, and found that smaller web-building spiders were more abundant in the lower layers of litter, whereas larger cursorial spiders were captured in higher numbers in the upper layers (Wagner et al. 2003). These studies suggest that vegetation has an effect on both the spider species assemblages and spider abundance.

Ridge-top

Although there is not enough elevation difference to allow comparison of spider communities at various altitude gradients in KMNMP, ridge-tops represent unique

habitats with the potential of having distinct species assemblages. The literature on this habitat type is lacking, and this study will provide data to help fill this gap.

Pitfall Trapping

Advantages and Deficiencies

Pitfall trapping is an inexpensive and effective method of capturing litter dwelling arthropods (Uetz and Unzicker 1975, Brennan et al. 1999, Work et al. 2002). Pitfall trapping can be used to trap either continuously or repeatedly in the same area and provides reproducible data. However differences in the density, gender, or activity of the target species can cause bias in the results (Greenslade 1964, Muma 1973). Since male spiders tend to wander in search of mates, they have a higher probability of being captured than females (Muma 1973).

Pitfall trapping can be used to qualitatively compare species richness among habitats (Blumberg and Crossley 1983). However, without using mark and recapture techniques, or direct counting within specific boundaries, pitfall trapping will not provide absolute population numbers (Morris 1960).

Trap Size, Fencing, and Color

Some methods of pitfall trapping use different size traps or employ fences, structures arranged horizontally along the ground to direct specimens toward the trap. Since there is no standardized pitfall trap size or structure, research has been conducted to determine whether capture efficiency is related to either trap size or use of directional fencing. Brennan et al. (1999) reported that in general, larger traps captured more arthropod specimens, but Thompson and Thompson (2008) noted that larger traps may

result in capturing larger or unwanted organisms, such as small vertebrates. Brennan et al. (2005) showed that longer fences usually resulted in higher captures of both individuals and species, and yielded higher spider family richness.

Very little data has been reported regarding the effect of trap cover color on pitfall capture efficiency. Haskins et al. (1982) examined the influence of trap cover transparency on cursorial spiders and found that traps with white covers caught significantly more adult spiders than did those with transparent covers.

Trapping/Preserving Medium

Pitfall traps left out for several days must have a liquid trapping medium to prevent specimen desiccation. Since media like EtOH or soapy water evaporate quickly or will not preserve specimens for more than a day, respectively, one of the more traditional materials used in pitfall traps to both kill organisms and act as a short-term preservative (generally ≤ 2 weeks) for arthropods is ethylene glycol. Ethylene glycol is both attractive to and potentially fatal to vertebrates, and can lead to small vertebrate by-catch in pitfall traps (Thomas 2008). Weeks and McIntyre (1997) demonstrated that there were no differences in capture efficiency between ethylene and propylene glycol compounds used as trapping/preservation media in pitfall traps. Schmidt et al. (2006) showed that due to the low surface tension, glycol based products resulted in higher capture efficiency in pitfall traps than other materials tested. Jud and Schmidt-Entling (2008) reported glycol based trapping media to be the best specimen preservatives in pitfall traps when compared to glycol-free mediums. Thomas (2008) compared the preservative qualities of ethylene glycol and the more environmentally safe propylene

glycol and found no significant difference between them for short-term preservation of specimens.

Materials and Methods

Study Site

Kings Mountain National Military Park (KMNMP) (Fig. 1) is the site of the Battle of Kings Mountain, an important Revolutionary War event fought on October 7, 1780. It is located in what is now York and Cherokee Counties, South Carolina, and is approximately 64 kilometers southwest of Charlotte, North Carolina. The park both preserves the historical area as an archeological site and provides educational and recreational opportunities for visitors. The park encompasses 15.96 km², and contains a variety of habitats that provide a protected area for wildlife. While the park is relatively small, it abuts Kings Mountain State Park (SC) and Crowders Mountain State Park (NC) (not shown) and together they provide a protected area surrounded by developed land (Fig. 1).

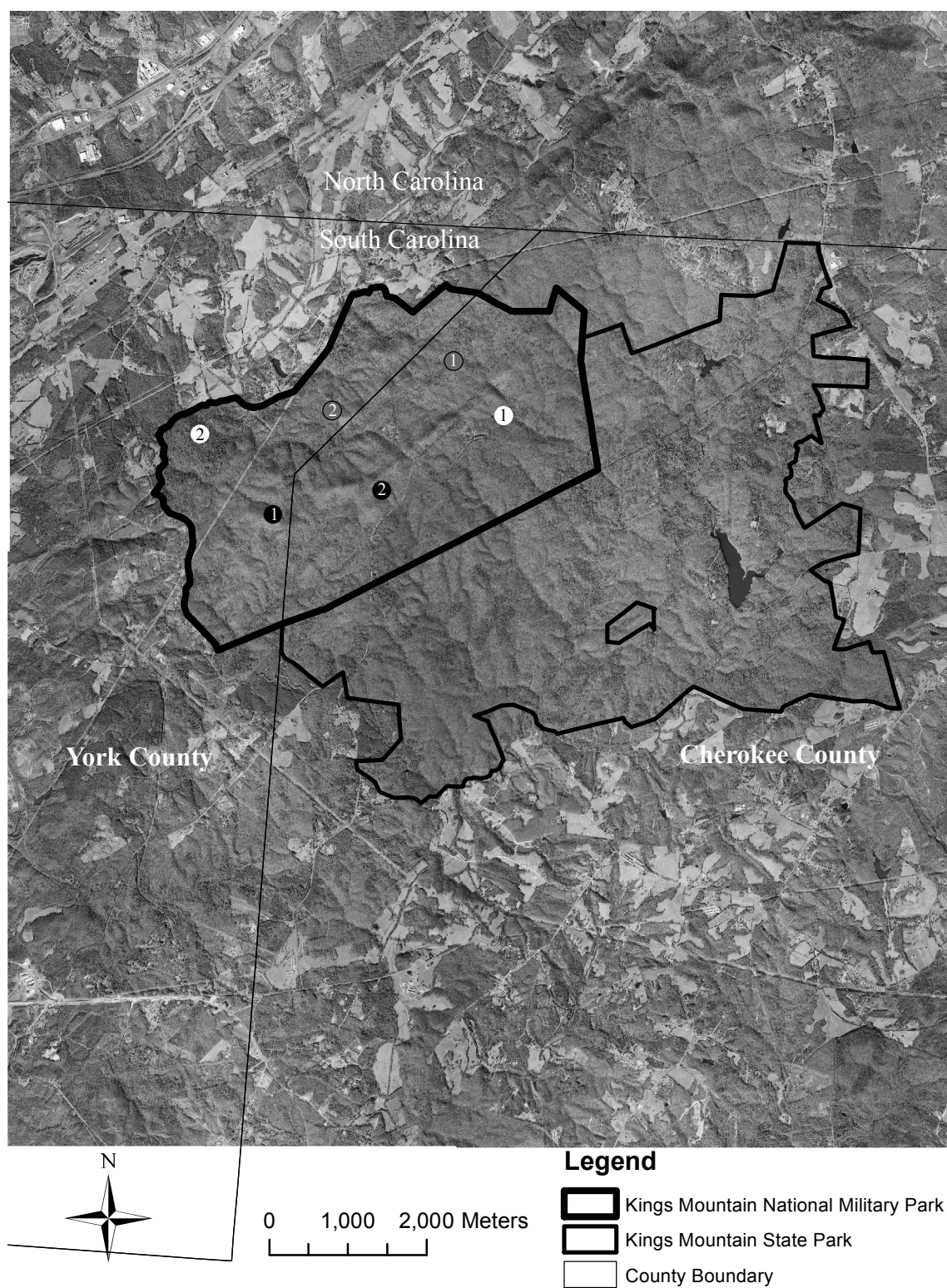


Figure 1. Orthophotograph of Kings Mountain National Military Park and the surrounding area, and sampling locations. White=riparian, gray=forest, black=ridge-top.

Spiders were examined in the following habitat types (Fig. 1):

1. *Riparian*: These sites are adjacent to Long Branch (N 35°08.589' W 081°22.212') (riparian site #1) and Stone House (N 35°08.572' W 081°24.783') (riparian site #2) Creeks. These creeks flow year round and are similar in depth and width where sampling sites are located. The canopy and understory are dense and consist of various hardwood species at both sites, creating a thick layer of leaf litter.
2. *Forest*: These sites are located off the fire roads Yorkville-Shelbyville Road (N 35°09.084' W 081°22.774) (forest site #1) and a branch of Rock House Road (N 35°08.700' W 081°23.820') (forest site #2). These sites are in areas of moderately dense canopies created by mixed hardwood and evergreen species, and have little understory vegetation and a thin layer of leaf litter. They are located away from creeks and are at a lower elevation than the ridge-top sites. The Rock House Road site was burned as part of park management practices in March, 2010.
3. *Ridge-top*: These sites are located on the summits of Browns Mountain (N 35°07.888' W 081°24.310') (ridge-top site #1) and Brushy Ridge (N 35°07.971' W 081°23.422') (ridge-top site #2). They are characterized by low density of oaks (*Quercus* spp.) and other hardwoods, with little to no understory. The soil is sandy and rocky, and during the summer months these areas are dry and hot with considerable sun exposure. The leaf litter layer is patchy at both sites.

Traps

Trap Construction

Each trap was constructed by burying a 473 ml (16 oz) plastic drink cup (Walmart Stores Inc., Bentonville, AR; 9 cm diam. top, 5.5 cm diam. bottom, and 12.3 cm deep) with the top rim flush with the ground surface (Fig. 2). These remained in place for the duration of the study. Four 45 cm long, 12 cm high pieces of plastic garden edging were placed at 90-degree intervals around the edge of each cup and buried approximately 6 cm deep into the soil to direct specimens toward the trap. Plastic plates (27 cm diam., United Plastics[®], Goodlettsville, TN) were used to cover the traps to prevent rain and debris from entering the traps (Fig. 2). Two holes were cut on opposite sides of each plate near the edge and two large binder clips threaded into each hole. The clips attached the plate to the garden edging and could be easily unfastened to access the cups.

Activating Traps

When traps were active, another 473 ml cup, with the top rim removed was placed inside each of the permanent cups installed in the ground at each trapping site. Propylene glycol antifreeze (Arctic Ban[™], Camco Mfg., Greensboro, NC) was used as the trapping/preserving medium in the removable inner cup. At the beginning of each trapping session, approximately 100 ml of propylene glycol was placed in each trap.

When samples were collected, the inner cup was easily removed to obtain the specimens without disturbing the fixed components of the trap. When traps were inactive, the removable inner cup was inverted in the permanent cup to prevent debris and

organisms from falling into and clogging the traps, keeping them clean for the next trapping session.

Sampling Method

Sampling was conducted monthly for 1 year starting in August 2009. Within each of the 3 habitats examined (riparian, forest, and ridge-top), 2 sample sites were selected for a total of 6 sites. The 6 sample sites were chosen to ensure representation across the park. Five traps were placed within each site, separated by at least 3 m and by no more than 15 m. This provided a total of 30 traps. Trapping sessions lasted for 96 hours.

After each trapping session, the inner cups containing the samples were emptied into small containers and returned to Clemson University for processing and spider identification. For processing, the narrow end of a funnel (1 cm diam.) was placed against the mesh of a sieve (5 μ m mesh), and a single sample was poured into the funnel and rinsed with water. Samples were then rinsed using 95% EtOH and placed in vials filled with fresh 95% EtOH. Prior to identification, spiders were removed, placed individually into vials, and later identified to the lowest possible taxonomic level. Adults or easily recognizable penultimate juveniles were identified to species using published keys (Ubick et al. 2005, and references therein). Voucher specimens from this study and unsorted arthropod by-catch were deposited in the Clemson University Arthropod Collection (CUAC).

While most immature spiders cannot be identified to genus or even family, several penultimate individuals were easily recognizable to species level and were therefore included in the data analyses. Two families and genera, each represented by a single

immature specimen (Araneidae, *Mangora* sp., and Pisauridae, *Dolomedes* sp.), were left out of the analyses and count totals. Due to the unresolved taxonomy of female Linyphiidae, all female linyphiid specimens were left out of the analyses. While these specimens may have been able to be matched and sorted into unidentified groups, the inability to associate them with their male counterparts could potentially create faulty species richness estimates. In contrast, not counting them could lead to lower species richness since species identified using only males may not represent the unidentified females collected. I am choosing to use the males to represent linyphiid diversity since males wander in search of mates and are therefore more likely to be captured by pitfall traps than the generally sedentary females.

Statistical Analyses

Species Accumulation and Estimation

To test the thoroughness of my survey and accurately illustrate the true epigeic spider community composition, I used EstimateS Version 8.2.0 (Colwell 2009) to calculate the Mao Tau observed species (S) accumulation curves. EstimateS also estimates species accumulation curves using 8 methods: ACE (abundance-based coverage estimator), ICE (incidence-based coverage estimator), Chao 1, Chao 2, first-order jackknife, second-order jackknife, bootstrap, and Michaelis-Menton means. The Mao Tau accumulated S observed curve allows for statistical comparisons with the number of species actually observed. Species accumulation curves illustrate the rate at



Figure 2. A. Pitfall trap with cover in place. B. Pitfall trap with cover removed showing trap design.

which new species are found, and estimators of these curves extrapolate the actual number of species in a particular area (Magurran 2004). These estimators measure only the number of species, which may allow inference of how many species each habitat can support. However these estimators do not take into account shared species, and similarity of values does not imply similarity of community structures. Species estimators may accurately predict species richness if estimated richness curves become asymptotic before the observed species accumulation curve (Coddington et al. 1996). Observed and estimated species accumulation curves were randomized 100 times. Rarity curves show the accumulation of singletons (species represented by a single specimen), doubletons (species represented by two specimens), uniques (species found in only one sample), and duplicates (species found in only two samples). As species accumulate during a sampling program, it's expected that these curves will increase, level off, and then decrease as more specimens of each species are collected in more samples.

Shannon Index and Rank Abundance

The Shannon index is used to measure biodiversity by taking into account both the number of species present and the evenness with which the total number of individuals are distributed among the species present. This index ranges from 0 to 4.6, where 0 represents low species evenness and diversity and 4.6 represents high species evenness and diversity as long as there is a large sample size and more than 5 species are captured. Like the species richness estimators, the Shannon index does not imply similar community structure. Rank abundance curves show the number of individuals per species in descending order. A typical temperate rank abundance distribution for epigeic spiders

is skewed with many individuals representing a few species and many species represented by only a few specimens (Toti et al. 2000).

Completeness Indices

The term completeness has been used to describe different ways of computing how thoroughly a sampling project accounts for all species. In this study, inventory completeness refers to the percentage of species that are not singletons (Coddington et al. 1996), and estimated completeness is the percentage range of species estimated to exist in the habitats that are observed using the highest estimator and the lowest estimator. The adjusted estimate range is another indicator of inventory completeness and is the range of the richness estimate values divided by the observed species (Toti et. al. 2000). The asymptotic behavior of the species estimator accumulation curves can also be used to determine how complete a survey is, and care must be taken not to confuse completeness indices with other methods of determining whether a species inventory is complete. The results of these indices are described together under the Completeness Indices heading. All other methods of describing whether the inventory is complete are discussed elsewhere.

Community Structure

EstimateS was also used to compute shared species richness estimates, Classic Jaccard and Sørensen indices, Chao-Jaccard and Chao-Sørensen indices, Bray-Curtis, and Morisita-Horn indices. Compositional similarity of species assemblages is comprised of two features, relative abundance and incidence, and all similarity indices are measured from 0-1, where 0 represents two communities with no similarity in species assemblages

and 1 represents two samples with the same species assemblages (Chao et al. 2005). However, the classic Jaccard and Sørensen indices are based on incidence alone (whether a species is present or not) and fail to recognize species abundance as part of their estimates (Chao et al. 2005). Chao et al. (2005) suggest several new probability-based versions of these classic similarity estimators, which include measures of relative abundance, and reduce undersampling bias. In this study I include both the Chao et al. (2005) adjusted Chao-Jaccard and Chao-Sørensen indices, which include abundance measures and are corrected for uncollected species, along with their classic counterparts. All formulae and descriptions of these estimators and indices can be found on the EstimateS User's Guide website (Colwell 2009).

Complementarity is the proportion of all species in two habitats that occurs in only one or the other (Colwell and Coddington 1994). This percentage is a measure of how distinct the communities in the two habitats are from each other.

Results

Observed Species Totals

In total, 875 adult spiders representing 22 families and 96 species were captured in the three habitats (Table 1). These totals do not include 29 unidentifiable female Linyphiidae (see above), which are not included in analyses. The riparian habitat had the highest number of species (66), an intermediate number of individuals (289), and the highest number endemic species (found only in this habitat) (19) (Table 1). The forest habitat had an intermediate number of species (57), the highest number of individuals (345), and an intermediate number of endemic species (12) (Table 1). The ridge-top habitat had the lowest number of species (47), the lowest number of individuals (240), and the lowest number of endemic species (7) (Table 1).

Richness Estimates

Eight species estimates and the S observed randomized accumulated Mao Tau estimate were calculated for the total number of species in the 3 habitats separately (Table 2). The Mao Tau S suggests that the forest and ridge-top habitats do not have a significantly different number of species, while the riparian habitat has a significantly greater number of species than either of the other two habitats. The ACE, ICE, and bootstrap estimators each predict that all three habitats support significantly different numbers of species, and suggest the riparian habitat has the highest number of species, followed by the forest then ridge-top habitats, respectively. Chao 1 and Chao 2 estimators suggest all of the habitats contain similar total numbers of species. The jackknife 1 and jackknife 2 estimators and the average of the 8 estimators all suggest the riparian and

forest habitats have similar numbers of species, and the ridge-top has significantly less than the other two habitats.

The mean, randomized, and observed species accumulation curves for the three habitats suggest that although species richness has not reached an asymptote for any of the habitats, they appear to be approaching an asymptote in the riparian and ridge-top habitats. The singleton and unique curves of the riparian zone have begun to decline, and the doubleton and duplicates curves have leveled off. The ridge-top habitat species total appears to be nearing completion, as 5 of the estimators are clustered and appear to be leveling off asymptotically. However, the doubletons and duplicates rarity curves have not leveled off in this habitat. The forest habitat estimated species accumulation curves are more spread out and appear to be steeper and trending less toward asymptotes compared with the other habitats, and the singleton and unique rarity curves have neither leveled off nor started decreasing as they have in the other habitats (Fig. 8).

The second-order jackknife yielded the highest estimates of species richness for all habitats, and the bootstrap estimator the lowest. Both observed species richness and the richness generated by the estimators indicate that the riparian habitat contains the highest number of epigeic spider species, while the forest has an intermediate number and the ridge-top the lowest (Table 2). The riparian habitat has the lowest adjusted estimate range and is similar to the ridge-top habitat while the forest had a much higher range than the other habitats.

Table 1. List of Spider species collected by pitfall traps in each habitat once monthly for 96 hours from August 2009 - July 2010.

Family	Species	Riparian	Forest	Ridge-top
Agelenidae				
	<i>Agelenopsis emertoni</i> Chamberlin & Ivie			1
	<i>Agelenopsis kastoni</i> Chamberlin & Ivie		1	
Agelenidae				
	<i>Tegenaria domestica</i> (Clerck)			2
Amaurobiidae				
	<i>Wadotes bimucronatus</i> (Simon)	5		1
	<i>Wadotes dixiensis</i> Chamberlin	2	2	
	<i>Wadotes mumai</i> Bennett	1		
Antrodiaetidae				
	<i>Antrodiaetus unicolor</i> (Hentz)	2		1
Anyphaenidae				
	<i>Anyphaena celer</i> (Hentz)	7		
Atypidae				
	<i>Atypus snetsingeri</i> Sarno	9		
	<i>Sphodros</i> sp.	2		
Corinnidae				
	<i>Castianeira alata</i> Muma	6	1	
	<i>Castianeira amoena</i> (C. L. Koch)	2	4	8
	<i>Castianeira cingulata</i> (C. L. Koch)		1	
	<i>Castianeira crocata</i> Hentz	3	1	7
	<i>Castianeira descripta</i> (Hentz)	1	3	3
	<i>Castianeira floridana</i> (Banks)		1	1
	<i>Castianeira longipalpa</i> (Hentz)	7	3	12
	<i>Castianeira variata</i> Gertsch	3		
	<i>Phrurolithus emertoni</i> Gertsch	6	2	1
	<i>Phrurotimpus alarius</i> (Hentz)	9	18	28
	<i>Phrurotimpus borealis</i> (Emerton)	5	4	
	<i>Scotinella redempta</i> (Gertsch)	4	1	
	<i>Scotinella</i> sp. A Banks	1		
	<i>Scotinella</i> sp. B Banks		1	
Ctenidae				
	<i>Anahita punctulata</i> (Hentz)	3	1	
Cybaeidae				
	<i>Cybaeus signifer</i> (Simon)	1		
Cyrtachenidiidae				

	<i>Myrmekiaphila torreyi</i> Gertsch & Wallace	2	2	1
Dictynidae	<i>Cicurina arcuata</i> Keyserling	29	11	11
	<i>Cicurina brevis</i> (Emerton)	1		
	<i>Cicurina minima</i> Chamberlin & Ivie		1	
	<i>Lathys maculina</i> Gertsch	5	31	16
Gnaphosidae	<i>Callilepsis pluto</i> Banks		1	2
	<i>Cesonia bilineata</i> (Hentz)		1	2
	<i>Drassyllus aprilinus</i> (Banks)	5	21	4
	<i>Drassyllus covensis</i> Exline	8	11	2
	<i>Drassyllus dixinus</i> Chamberlin	2	1	3
	<i>Drassyllus dromeus</i> Chamberlin	1		6
	<i>Drassyllus eremitus</i> Chamberlin			7
	<i>Drassyllus novus</i> (Banks)	1	1	
	<i>Gnaphosa fontinalis</i> Keyserling	12	18	1
	<i>Litopyllus temporarius</i> Chamberlin		2	1
	<i>Soticus insularis</i> Banks	1		
	<i>Zelotes duplex</i> Chamberlin	10	12	15
	<i>Zelotes hentzi</i> Barrows	7	10	7
	<i>Zelotes lymnophilus</i> Chamberlin			24
Hahniidae	<i>Neoantistea agilis</i> (Keyserling)	12	3	
Leptonetidae	<i>Appaleptoneta silvicultrix</i> (Crosby & Bishop)		2	2
Linyphiidae	<i>Agyneta angulata</i> (Emerton)	10	2	
	<i>Agyneta barrowsi</i> Chamberlin & Ivie	1	1	
	<i>Agyneta micaria</i> (Emerton)	1	2	2
	<i>Agyneta unimaculata</i> (Banks)	3	2	
	<i>Bathyphantes pallidus</i> (Banks)	2		
	<i>Centromerus denticulatus</i> (Emerton)	2	4	
	<i>Centromerus latidens</i> (Emerton)	3		1
	<i>Epiceraticelus fluvialis</i> Crosby and Bishop	3	31	3
	<i>Erigone autumnalis</i> Emerton		1	
	<i>Lepthyphantes sabulosa</i> (Keyserling)	3		
	<i>Organates rostratus</i> (Emerton)	8	6	2
	<i>Souessoula parva</i> (Banks)	1		
	<i>Wubana drassoides</i> (Emerton)		1	2
	Linyphiidae Sp. A	1		

	Linyphiidae Sp. B	2		5
	Linyphiidae Sp. C	2	3	
	Linyphiidae Sp. D			1
Lycosidae				
	<i>Allocosa funerea</i> Hentz	2		
	<i>Allocosa furtiva</i> Gertsch	2		
	<i>Allocosa mulaiki</i> Gertsch	4		
	<i>Allocosa noctuabunda</i> Montgomery	1		
	<i>Gladicosa gulosa</i> Walckenaer	13	10	1
	<i>Gladicosa pulchra</i> Keyserling		1	
	<i>Hogna carolinensis</i> Walckenaer	1		2
	<i>Pardosa</i> Sp. A			1
	<i>Rabidosa punctulata</i> Hentz	1		
	<i>Schizocosa crassipes</i> Walckenaer		1	
	<i>Schizocosa ocreata</i> Hentz	19	21	9
	<i>Schizocosa saltatrix</i> Chamberlin	1	63	22
	<i>Varacosa avara</i> (Keyserling)		4	6
	Lycosidae Sp. A	4		
Miturgidae				
	<i>Strotarchus piscatorius</i> Hentz	1		
Pholcidae				1
	<i>Psilochorus pullulus</i> Hentz			
Salticidae				
	<i>Anasaitis canosa</i> Walckenaer	4	1	4
	<i>Habronattus</i> sp.			1
	<i>Maevia inclemens</i> Walckenaer		1	
	<i>Naphrys pulex</i> Hentz		6	4
	Salticidae Sp. A		1	
	Salticidae Sp. B		2	1
	<i>Sitticus sylvestris</i> (Emerton)	1		
	<i>Phidippus cardinalis</i> Hentz	3		
	<i>Thiodina sylvana</i> Hentz		1	
Segestriidae				
	<i>Ariadna bicolor</i> Hentz		1	2
Theridiosomatidae				
	<i>Theridiosoma savannum</i> Chamberlin & Ivie		4	
Thomisidae				
	<i>Ozyptila monroensis</i> Keyserling	7		
	<i>Xysticus elegans</i> Keyserling		1	

	<i>Xysticus ferox</i> Hentz	4	
	<i>Xysticus fraternus</i> Banks	2	2
Titanoecidae			
	<i>Titanoeca nigrella</i> Chamberlin	2	1

Table 2. Observed species richness, 8 species richness estimates, the average of the 8 estimates, the Shannon diversity index, and Inventory and Estimated completeness indices for the three habitat types. Each richness estimate represents the mean for 100 randomizations of sample order. The adjusted estimate range is the range of the richness estimate values divided by the observed species.

	Riparian	Forest	Ridge-top
Individuals	289	345	240
S observed (Mao Tau significance)	66 a	57 b	47 b
Singletons Mean	18 a	24 b	16 c
Doubletons Mean	14 a	10 b	10 b
Uniques Mean	23 a	25 b	18 c
Duplicates Mean	13 a	10 b	10 b
ACE Mean	80.23 a	95.08 b	63.59 c
ICE Mean	87.65 a	92.55 b	66.65 c
Chao 1 Mean	77.57 a	85.8 a	59.8 a
Chao 2 Mean	86.35 a	88.25 a	63.2 a
First-order jackknife	88.81 a	81.79 a	64.85 b
Second-order jackknife	98.75 a	96.62 a	72.8 b
Bootstrap Mean	76.64 a	67.8 b	55.11 c
Michaelis-Menton Means	92.25	73.81	63.53
Average of above 8 estimates	86.03 a	85.21 a	63.69 b
Shannon Diversity Index	3.77 a	3.2 b	3.29 c
Inventory completeness ^a	73%	58%	66%
Estimated completeness ^b	67-86%	59-84%	65-85%
Adjusted Estimate Range	0.33	0.51	0.36

a, b, c = significant differences among estimates for the three habitats have different letters.

^a = percentage of species that are not singletons.

^b = percentage of species estimated to exist in the habitats that are actually recorded.

Completeness Indices

In the riparian and ridge-top habitats, both the estimated and inventory completeness indices are similar and inventories for both of these habitats appear to be more complete than for the forest habitat (Table 2). The riparian habitat inventory completeness (73%) was the highest of all three habitats, and falls within the minimum and maximum values of the estimated completeness range. The forest habitat had the lowest inventory completeness and falls below the range of estimated completeness. The ridge-top habitat had intermediate inventory completeness and fell just inside the lower bound of the estimated completeness range. These results are consistent with the results of the 8 species estimators.

Shannon Diversity Index

All three habitats are above 3 on the Shannon scale (0 to 4.6) (Table 2). In comparison to each other, the riparian habitat has the highest Shannon value, the ridge-top has an intermediate value, and the forest has the lowest. The forest habitat, while not representing the lowest species richness, represents the habitat with the lowest diversity and evenness. The rank abundance curves for the riparian and ridge-top habitats are more evenly spread (Figs. 3 and 4), than the rank abundance curve for the forest habitat (Fig. 5).

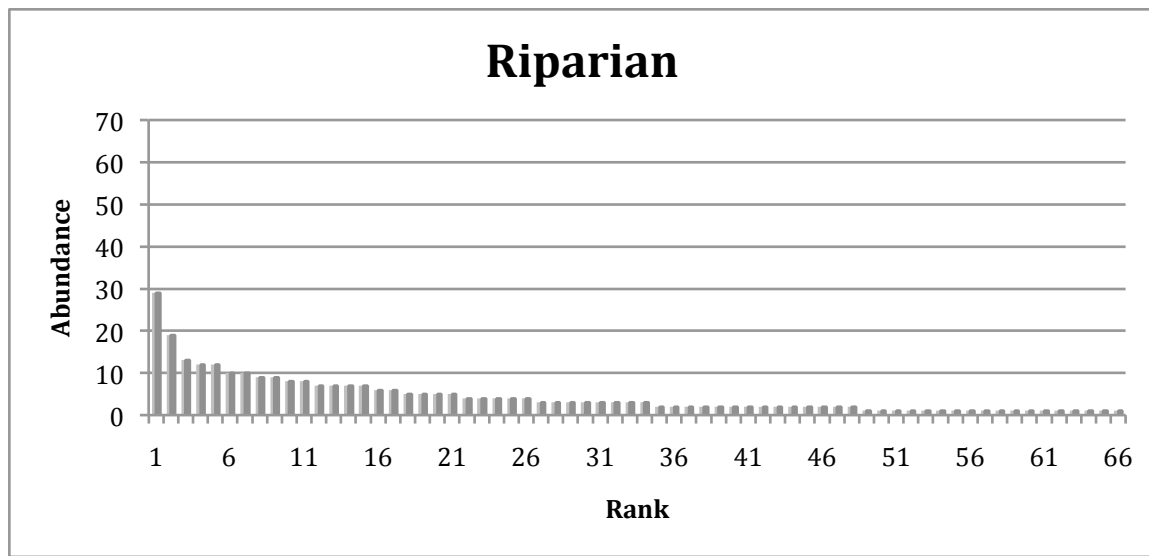


Figure 3. Rank abundance of species collected in the riparian habitat.

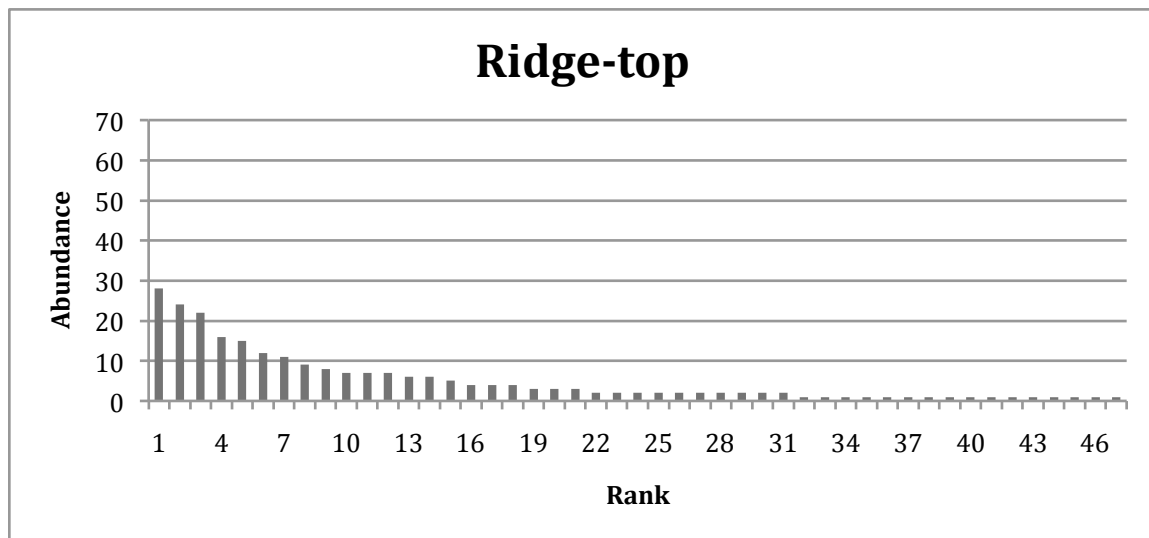


Figure 4. Rank abundance of species collected in the ridge-top habitat.

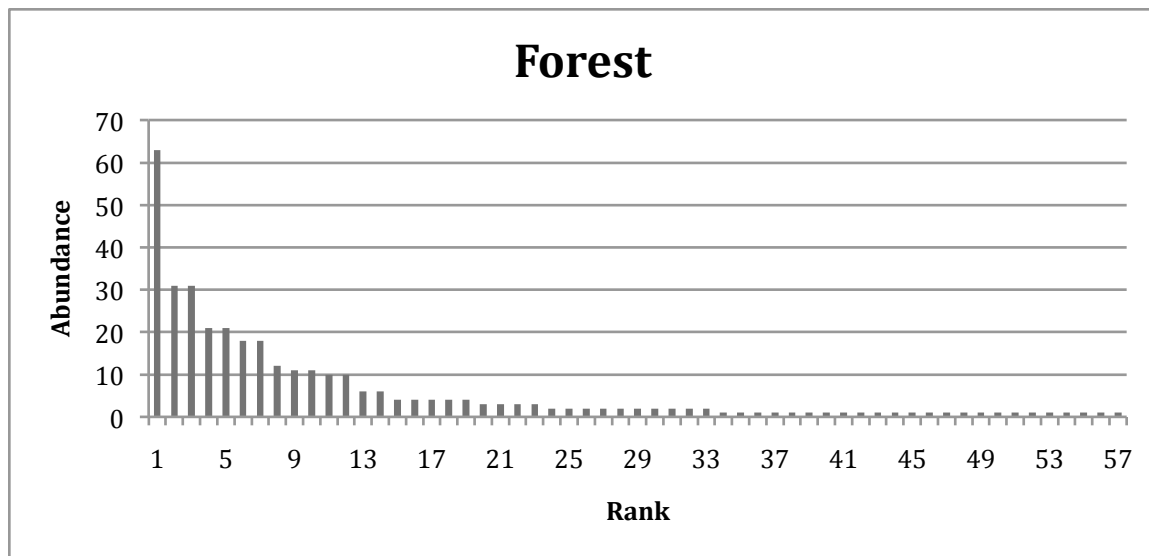


Figure 5. Rank abundance of species collected in the forest habitat.

Community structure

The complementarity values and similarity indices (Table 3) suggest that these 3 habitats have different community structures, with only 22 of 96 (23%) species being collected in all 3 communities. The forest and ridge-top habitats, which also had the lowest number of shared species, were the most distinct from each other with a complementarity value of 65%. The riparian and forest habitats, despite having the largest number of shared species, had an intermediate complementarity of 61%. The forest and ridge-top habitats were the least distinct from each other with a complementarity of 56%. All indices used suggest that the forest and ridge-top habitats are the most similar, followed by the riparian and forest habitats, with the riparian and ridge-top habitats being the least similar (Fig. 6). The Morisita-Horn index suggests that

the three habitat combinations have similar values, but maintain a rank consistent with the other indices (Table 3). The forest/ridge-top and forest/riparian comparisons also have similar values, whereas the riparian/ridge-top comparison is somewhat below these. The only index value that strays from this pattern is the Bray-Curtis index for the forest-ridge-top comparison, which seems to be much higher than the other two habitat comparisons (Table 3).

Table 3. Observed shared species richness, estimated shared species richness, complementarity values, and similarity indices for the three habitat combinations.

	Riparian : Forest	Riparian : Ridge-top	Forest : Ridge-top
Obs. Species Richness	66 : 57	66 : 47	57 : 47
Obs. Shared Species	35	29	32
Complementarity	61%	65%	56%
ACE Individual Estimates	80.23 : 95.08	80.23 : 63.59	95.08 : 63.59
Chao Shared Estimate	49.12	36.77	53.91
Jaccard Classic	0.397	0.345	0.444
Sørensen Classic	0.569	0.513	0.615
Chao-Jaccard Abund.	0.755	0.638	0.782
Chao-Sørensen Abund.	0.86	0.779	0.877
Bray-Curtis	0.421	0.359	0.655
Morisita-Horn	0.454	0.436	0.485

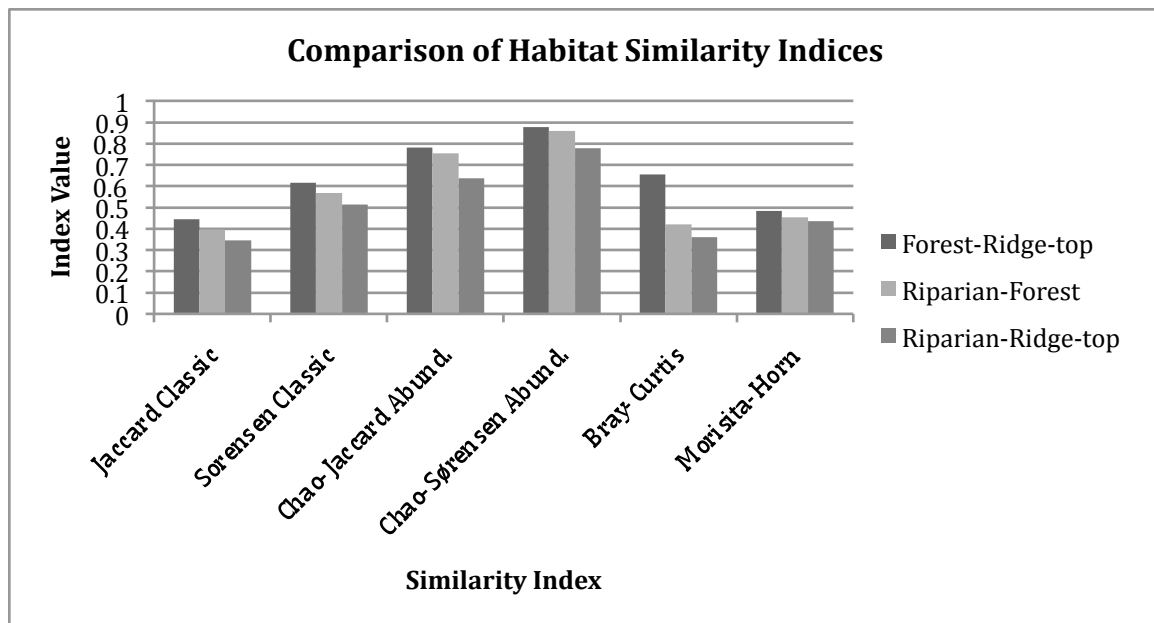


Figure 6. Comparison of habitat similarity indices for the three habitats.

Dominant and Noteworthy Species

The family Linyphiidae (commonly known as sheet weavers or money spiders) represented the largest number of species (17 species), followed by Corinnidae (sac spiders, 14 species), Gnaphosidae (ground spiders, 14 species), and Lycosidae (wolf spiders, 14 species). *Schizocosa saltatrix* was represented by the greatest number of specimens (86 individuals, 10% of total individuals). This species was found primarily in the forest (22 specimens) and ridge-top (63 specimens) habitats with only one specimen captured in the riparian habitat. Other species with high numbers of individuals were *Phrurotimpus alarius* (55 specimens), *Lathys maculina* (52 specimens), *Cicurina arcuata* (51 specimens), and *Schizocosa ocreata* (49 specimens). *Sphodros rufipes*, or the red-

legged purseweb spider, is an uncommon mygalomorph species that was captured only in the riparian habitat (Table 1).

Results From Individual Habitats

Riparian

The riparian habitat yielded 289 spiders representing 35 genera and 66 species, and contained 19 endemic species. The 8 species richness estimates suggest there are between 10 and 32 species remaining to be documented in the riparian habitat (Table 2). This suggests sampling has accounted for 67 to 86% of the actual number of species in this habitat. The observed species accumulation curve terminates below the estimated accumulation curves and has not yet reached an asymptote suggesting new species were still being collected when the study ended (Fig. 7). Though not all estimated accumulation curves have reached an asymptote, most appear to be leveling off. The rare species accumulation curves (singleton, uniques, doubletons, and duplicates) have ceased increasing, and the singleton and uniques curves have begun decreasing.

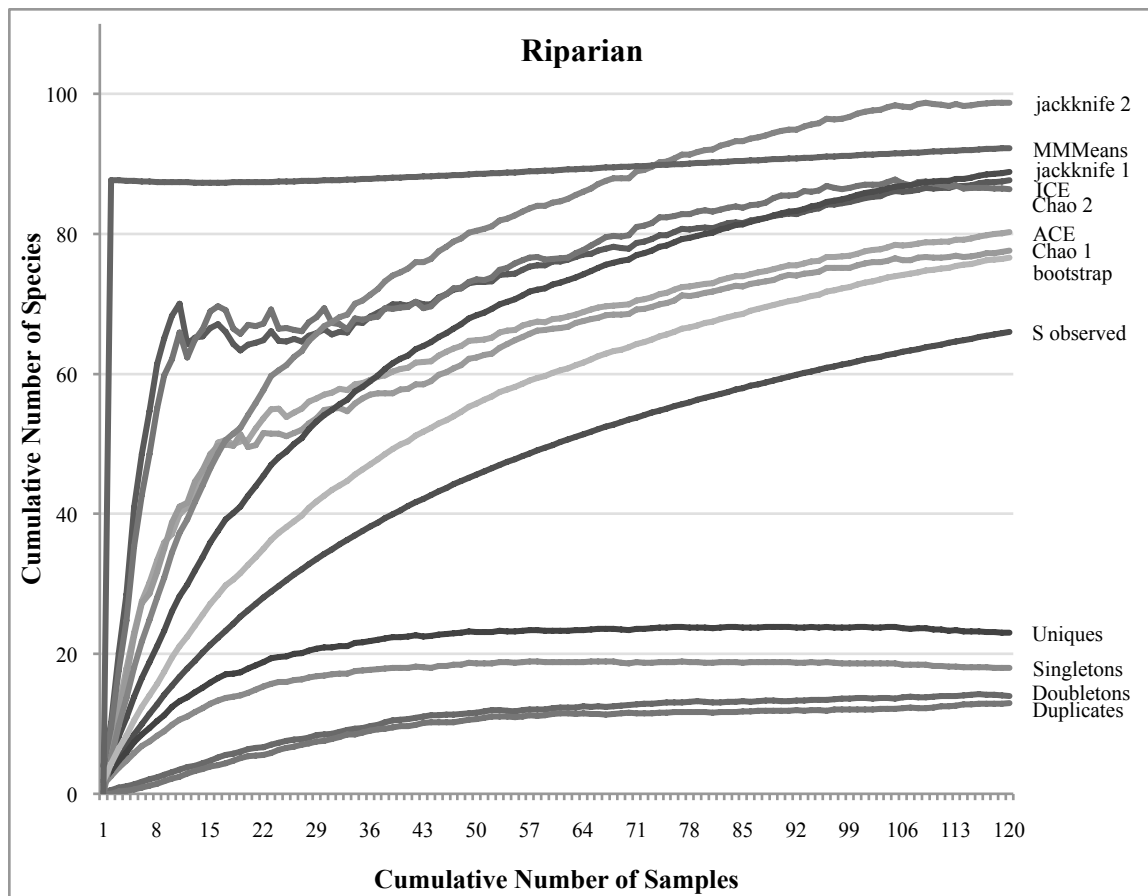


Figure 7. Accumulation curves for the riparian habitat generated by 8 species estimators, observed species accumulation curve (S observed), and rare species accumulation curves. (ACE = abundance-based coverage estimator, ICE = incidence-based coverage estimator, MMMeans = Michaelis-Menton means.)

Forest

The forest habitat yielded 345 spiders representing 36 genera and 57 species, and contained 12 endemic species. The 8 species richness estimates suggest there are between 10 and 39 species remaining to be documented in the forest habitat (Table 2). This suggests my study has accounted for 59 to 85% of the species in this habitat. The observed species accumulation curve terminates below the estimated accumulation curves and has not yet reached an asymptote (Fig. 8). None of the estimated species accumulation curves appear to be leveling off asymptotically, and the rare species accumulation curves are all still increasing.

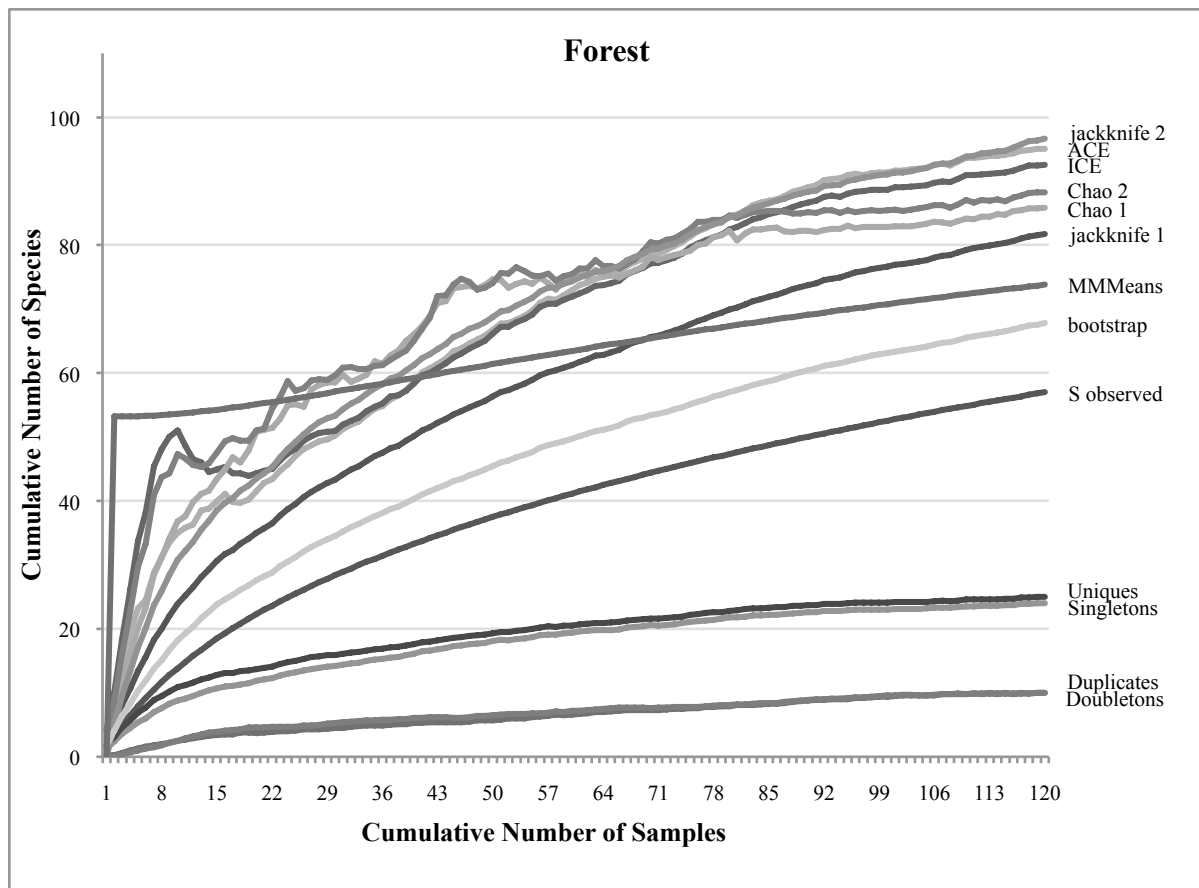


Figure 8. Accumulation curves for the forest habitat generated by 8 species estimators, observed species accumulation curve (S observed), and rare species accumulation curves. (ACE = abundance-based coverage estimator, ICE = incidence-based coverage estimator, MMMeans = Michaelis-Menton means.)

Ridge-top

The ridge-top habitat yielded 240 spiders representing 35 genera and 47 species, and contains 7 endemic species. The 8 species richness estimates suggest there are between 8 and 25 species remaining to be documented in the ridge-top habitat (Table 2). This suggests my study has accounted for 65 to 85% of the species in this habitat. Five of the 8 estimators (ACE, Chao 1, Chao 2, first-order jackknife, Michaelis-Menton means) appear to be leveling off asymptotically (Fig. 9). The uniques and singletons rarity curves have leveled off, however the duplicates and doubletons curves are still increasing.

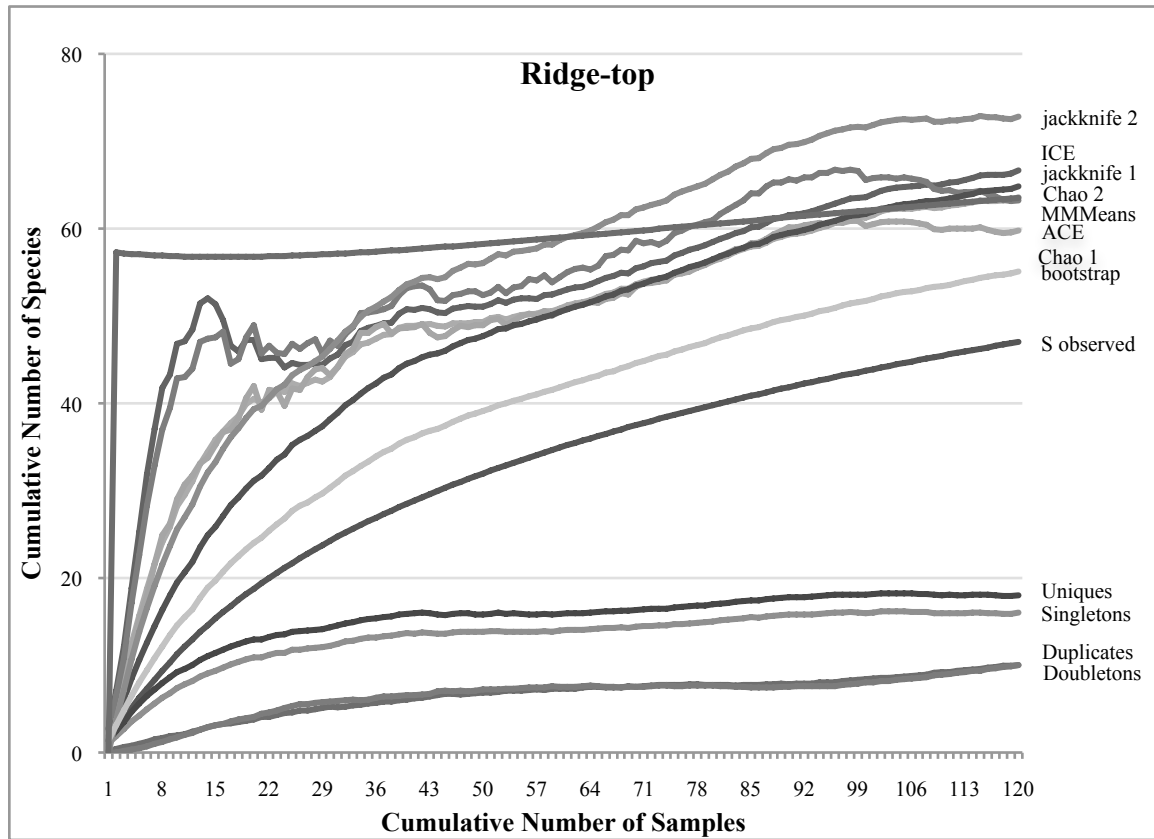


Figure 9. Accumulation curves for the ridge-top habitat generated by 8 species estimators, observed species accumulation curve (S observed), and rare species accumulation curves. (ACE = abundance-based coverage estimator, ICE = incidence-based coverage estimator, MMMeans = Michaelis-Menton means.)

Trap Cover Color

Red and blue cover plates were compared to determine if different color trap covers resulted in differences in the number of spiders captured. A two-sample t-test was conducted for red (n=72) and blue trap covers (n=288) in the three habitats. No significant differences were found between the numbers of spiders caught in traps having red versus blue covers (p=0.99).

Discussion

It is impossible to sample arthropod species in any given habitat and record all species present (Colwell and Coddington 1994). Most projects have a limited amount of time and funding and it is important to obtain a data set that yields results that can be used to make predictions. When compared to other studies it may seem that the 873 specimens collected in this study is a limited number from which to draw conclusions about the characteristics of these spider communities. However, other similar studies either include more than just epigeic spiders or include more habitats, compared to my study of the epigeic spider community in 3 habitat types. Toti et al (2000), whose study used 5 different trapping methods continuously over 3 days and collected all types of spiders, caught nearly 3 times as many spiders in their survey of Appalachian grass and heath bald habitats. My study found the same number of families and only 32 fewer species. Muma (1973) surveyed 4 habitat types using continuous pitfall traps (4 traps per habitat) over 2 years and despite capturing more than 7 times the number of individuals as my study, I observed the same number of families, and only 30 fewer species. Like my study, Toti et al. (2000) and Muma (1973) were conducted in the Southeastern United States.

Trapping Totals and Species Richness

The riparian habitat had the highest number of observed species, but was not the habitat with the most individuals. The riparian habitat, with its thick canopy and understory and more complex vegetation may provide more microhabitats that support more species but not be able to host as many individuals of each species from the epigeic

spider community. The ridge-top habitat is an open, dry, rocky environment with less complex vegetation than the other habitats. These characteristics may lead to lower prey availability and therefore less diversity and fewer individuals. These results are consistent with the study by Halaj et al. (1998), which reported that increased foliage complexity accounted for a large percentage of species abundance and diversity.

The observed species accumulation curves for all three habitats terminate below the estimated accumulation curves and have not yet reached an asymptote suggesting new species were still being collected in all habitats when the study ended. However, several of the estimated species curves appear to be leveling off in both the riparian and ridge-top sites, which suggests accurate estimates can be made about richness in these habitats. Almost all the estimated accumulation curves for the riparian habitat are asymptotic, clustered, and become smooth as species accumulate (Fig. 7). As more samples are collected, species represented by only a single individual and species found in only one sample are decreasing as more individuals are captured and species are found in more than one sample. The asymptotic behavior of these curves and the decline of the singletons and uniques rarity curves in the riparian habitat suggest the species total for this habitat is nearing completion. This is also supported by the riparian habitat having the lowest adjusted estimate range, evidence that the species total for this habitat is closer to completion than either the forest or ridge-top habitats. Several of the estimated species accumulation curves for the ridge-top habitat are clustered and show smooth asymptotic behavior. The singletons and uniques rarity curves are leveling off in this habitat, which along with an adjusted estimate range value similar to the riparian habitat is also evidence

suggesting the species total for the ridge-top habitat is nearing completion. The forest habitat appears to be the habitat with the least complete species total. Although several of the 8 species estimators appear to be reaching an asymptote, they have not become smooth as more samples accumulate, and the estimates are evenly spread out along their range. The forest habitat also has a much larger adjusted estimate range than the other habitats, further evidence suggesting that this habitat needs more sampling before accurate estimates about species richness can be made.

Shannon Index

The riparian zone has the highest diversity and evenness with the number of individuals distributed among multiple species (Table 1). The ridge-top habitat has a similar, though statistically different Shannon index value as the forest habitat. The forest habitat has a more skewed distribution (many individuals represented by a few species) than either the riparian or ridge-top habitats. For example, *S. saltatrix* had the highest number of individuals totaling 63 specimens (18% of the total number of individuals captured) in the forest habitat, more than double the number of individuals as the species with the next highest number of individuals in any of the habitats. The riparian and ridge-top habitat rank abundance curves are more evenly spread than are those for the forest habitat, which supports the results of the Shannon indices for the 3 habitats. These results are further evidence to suggest that the riparian habitat hosts a more diverse species assemblage than the other habitats.

Community Structure

The forest/ridge-top combination had higher complementarity indices and similarity indices when compared to the riparian/forest combination despite the lower number of shared species. This may be explained by some species occurring in much higher numbers in the forest and ridge-top habitats. For example, *S. saltatrix* was captured in high numbers in the forest and ridge-top habitats but only a single individual was captured in the riparian habitat (Table 1). *Lathys maculina* also follows this pattern; the forest and ridge-top habitats contained high numbers of individuals of this species and fewer individuals were collected in the riparian habitat (Table 1). This is further evidence to suggest the riparian habitat is capable of hosting a larger diversity of epigeic spider species than the less vegetatively complex forest and ridge-top sites.

Dominant and Noteworthy Species

Schizocosa saltatrix, the species with the highest number of specimens, was found primarily in the forest and ridge-top habitats with only one specimen captured in the riparian habitat. This spider species is generally found in hardwood forests, is a cursorial hunter that actively searches for food, and adults mature in the spring months (Dondale and Redner 1978). The complex vegetation and leaf litter layer may prevent these highly cursorial spiders from occupying riparian habitats, whereas the open canopy and low density of understory of the ridge-top, and to some extent the forest sites, provide preferred habitat. Wagner et al. (2003) found that smaller spiders such as Linyphiidae are more common in the lower layers of thick litter, whereas larger cursorial spiders are

found above these layers. The abundance of *S. saltatrix* and lack of species diversity in the ridge-top habitat may be related to the sparse understory and limited leaf litter layer.

Sphodros rufipes, commonly known as the purseweb spider, is an uncommon species of mygalomorph from the eastern United States (Gertsch and Platnick 1980). A single male was captured in the Rock House Creek riparian habitat site, and a single female was located by visually searching less than 2 meters from the trap containing the captured male. Currently this species is listed under the global conservation status with a G4 rank indicating that it is apparently secure, uncommon, but not rare, and with some cause for long-term concern due to declines or other factors. Currently this species is not protected in South Carolina, however some southeastern states have *S. rufipes* included on their state lists of protected animals with rankings between S3 (watch, Florida) and S1 (highly rare, Maryland). Though not enough is known about these spiders to accurately label them for a specified level of protection, KMNMP may have an active population, which would be useful knowledge should the species become threatened.

Collecting Methods

In this study, I used pitfall traps as the method of collecting spiders. This fit my goal of sampling epigeic spider assemblages over a full year. Occasionally, individuals from groups other than epigeic spiders fell into the traps by accident, but this was rare and all were juveniles. Therefore they were left out of the analyses. There is also a discrepancy of wandering males within spider communities. Despite the fact that this issue may cause differences in relative abundance I chose to accept species with 1) both sexes mobile, and 2) species with wandering males as part of my study of epigeic spider

assemblages, since both types have an equal chance of being collected as long as one life history stage is constant in its wandering habits.

A comparison of trap cover color was included in my study. There were no significant differences in the number of spiders caught in traps red versus blue covers, suggesting that spiders were neither attracted to nor repelled by these trap cover colors. Though Haskins et al. (1982) reported significant differences between spiders captured in transparent versus white trap covers, this may be due to the spiders seeking shelter under the white plates, which cause a shadow. All trap covers in my study were non-transparent.

Conclusions

Summary

Based on the asymptotic behavior of the 8 species richness estimators, inventory and estimated completeness indices, and the adjusted estimate range, the riparian habitat was closest to having a complete species inventory record in my study. These values also suggest that the ridge-top habitat is trending toward a complete species inventory, despite not all estimators and rarity curves having begun to leveling off. The forest habitat requires further sampling in order to approach a complete species inventory and make predictions about species richness. The Shannon diversity index suggests the riparian habitat is more diverse, with the number of individuals more evenly spread among the species present, than was observed in either the forest or ridge-top habitats. The complementarity values and similarity indices suggest that the forest and ridge-top habitats have the most similar community structures. Comparisons of trap cover color show no differences in the number of spiders captured when traps had either blue or red covers.

Suggestions/Recommendations

Some species may be suitable for use as indicator species both for the park as a whole and for individual habitats. *Cicurina arctuata* was captured in high numbers in the riparian habitat, *Schizocosa saltatrix* and *Epiceraticelus fluvialis* were trapped in high numbers in the forest site, and *Zelotes lymnophilus* was captured in high numbers exclusively in the ridge-top habitat. I recommend these species be considered as potential

indicator species in these habitats. *Zelotes duplex* was captured evenly across the park and may be a useful biological indicator for the whole park.

Other common organisms collected as by-catch include beetles (Coleoptera), centipedes (Chilopoda), millipedes (Diplopoda), crickets (Gryllidae), and ants (Formicidae). Future research may wish to continue exploring the ecological relationships of spiders and other arthropods captured in this study and other studies in order to create a comprehensive history of the park's epigeic fauna for use in park management. Spider specimens collected show seasonal trends and may allow insight into the dynamics of these organisms' life histories based on weather and climate patterns (Appendix A).

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Appendix A. Spider species and individuals captured in each month from August

(Au) 2009 through July (Jl) 2010.

Species	Month											
	Au	S	O	N	D	J	F	M	A	M	Jn	Jl
<i>Agelenopsis emertoni</i>										1		
<i>Agelenopsis kastoni</i>									1			
<i>Agyneta angulata</i>	1			1	2	1			5	1		1
<i>Agyneta barrowsi</i>								2				
<i>Agyneta micaria</i>	1	1	1	1					1			
<i>Agyneta unimaculata</i>		1		1				1	2			
<i>Allocosa funerea</i>											2	
<i>Allocosa furtiva</i>												2
<i>Allocosa mulaiki</i>										4		
<i>Allocosa noctuabunda</i>		1										
<i>Anahita punctulata</i>				1						2	1	
<i>Anasaitis canosa</i>	1	2	1							2	1	2
<i>Antrodiaetus unicolor</i>				1	1						1	
<i>Anyphaena celer</i>					1	1	2	3				
<i>Appaleptoneta silvicultrix</i>	2							2				
<i>Ariadna bicolor</i>		3										
<i>Atypus snetsingeri</i>									9			
<i>Bathyphantes pallidus</i>						1				1		
<i>Callilepis pluto</i>											1	2
<i>Castianeira alata</i>											7	
<i>Castianeira amoena</i>	6	4	4									
<i>Castianeira cingulata</i>	1											
<i>Castianeira crocata</i>										7	4	
<i>Castianeira descripta</i>	1		1	3	1				1			
<i>Castianeira floridana</i>											2	
<i>Castianeira longipalpa</i>	1	1	1	3						13		3
<i>Castianeira variata</i>											2	1
<i>Centromerus denticulatus</i>					1		2	3				
<i>Centromerus latidens</i>						1	2	1				
<i>Cesonia bilineata</i>		1								2		
<i>Cicurina arcuata</i>				1	4	1	6	7	1	1		
<i>Cicurina brevis</i>						1						
<i>Cicurina minima</i>						1						
<i>Cybaeus signifer</i>					1							

<i>Drassyllus aprilius</i>	2	1				1	2	4	1	1
<i>Drassyllus covensis</i>							4	11	5	1
<i>Drassyllus dixinus</i>									6	
<i>Drassyllus dromeus</i>								7		
<i>Drassyllus eremitus</i>								1	6	
<i>Drassyllus novus</i>							1	1		
					3					
<i>Epiceraticelus fluvialis</i>					1	5	1			
<i>Erigone autumnalis</i>		1								
							1			
<i>Gladicosa gulosa</i>		1	2	1			9		1	
<i>Gladicosa pulchra</i>							1			
<i>Gnaphosa fontinalis</i>	3	2						1	11	12
<i>Habronattus sp.</i>									1	
<i>Hogna carolinensis</i>		1	1							1
							2	2		
<i>Lathys maculina</i>			3	2		3	0	0	3	1
<i>Lepthyphantes sabulosa</i>					1	1	1			
<i>Litopyllus temporarius</i>									2	
<i>Linyphiidae Species A</i>			1							
<i>Linyphiidae Species B</i>			1	1			1	4		
<i>Linyphiidae Species C</i>				4	1					
<i>Linyphiidae Species D</i>							1			
<i>Lycosidae Species A</i>									1	
<i>Maevia inclemens</i>										3
<i>Myrmekiaphila torreyi</i>			3	2						1
<i>Naphrys pulex</i>	2							1	2	4
<i>Neoantistea agilis</i>					1	7	2	2	3	
<i>Salticidae Species B</i>								2	1	
<i>Origanates rostratus</i>				1	7	6	2			
<i>Ozyptila monroensis</i>				1					3	1
<i>Pardosa sp.</i>								1		2
<i>Phidippus cardinalis</i>									1	
								1		
<i>Phrurotimpus alarius</i>	3	1						9	28	3
<i>Phrurotimpus borealis</i>		1							3	2
<i>Psilochorus pullulus</i>		1								3
<i>Rabidosa punctulata</i>				1						
<i>Salticidae Species A</i>									1	
<i>Schizocosa crassipes</i>										1
<i>Schizocosa ocreata</i>	7	5							4	19
										14

							6					
<i>Schizocosa saltatrix</i>						2	2	17	4	1		
<i>Scotinella emertoni</i>	1								3	5		
<i>Scotinella redempta</i>			1				1	1	1	1		
<i>Scotinella</i> Species A									1			
<i>Scotinella</i> Species B									1			
<i>Sitticus sylvestris</i>									1			
<i>Sosticus insularis</i>			1									
<i>Souessoula parva</i>							1					
<i>Sphodros rufipes</i>								1		1		
<i>Strotarchus piscatorius</i>										1		
<i>Tegenaria domestica</i>				2								
<i>Theridiosoma savannum</i>						4						
<i>Thiodina sylvana</i>												1
<i>Titanoeca nigrella</i>									3			
<i>Varacosa avara</i>				5	1	1	1	1	1			
<i>Wadotes bimucronatus</i>							4	1	1			
<i>Wadotes dixiensis</i>				3			1					
<i>Wadotes mumai</i>							1					
<i>Wubana drassoides</i>				1			2					
<i>Xysticus elegans</i>										1		
<i>Xysticus ferox</i>										1	2	1
<i>Xysticus fraternus</i>										4		
<i>Zelotes duplex</i>	5								1	12	11	8
<i>Zelotes hentzi</i>	1	8	4	1			1	1	7	1		
<i>Zelotes lychnophilus</i>	1								1	12	10	