A Comparison of Cursorial Arachnofauna at the Pierce Cedar Creek Institute and Hope College Nature Preserve

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Abstract

Spider communities were compared along a moisture gradient (Dry, Dry Mesic and Mesic Southern Forests) at Pierce Cedar Creek Institute (PCCI) and with and without *Vinca minor*, the invasive plant species, at the Hope College Nature Preserve (HCNP). Pitfall traps were used to sample the cursorial spider communities which were identified to family and then compared to each other with graphs and the similarity indices: Jaccard's Coefficient and the Bray-Curtis index. At PCCI I found a moisture gradient. Also from Dry to Dry Mesic I found the relative abundance of crab and wolf spiders decreased while running spiders and vagrant web builders increased. At the HCNP I found that *V. minor* changed the guild and family structure with wolf spiders being found common in sites with *V. minor*. Also *V. minor* was associated with a reduction in the total abundance of spiders.

Introduction

Spiders are important indicators for forest ecosystems. Spiders annually consume 43.8% of the arthropod biomass in Tennessee deciduous forests (Moulder, 1972). By studying spiders it allows us to determine if certain characteristics of the environment affect the ecosystem.

There are many abiotic and biotic characteristics that effect ecosystems each of which could more closely affect the ecosystem. Soil moisture is one of those abiotic characteristics. It has been shown in the past that soil moisture associates with spider taxa (Graham, et al. 2003). In this study, I aimed to determine if soil moisture affects different deciduous forest cursorial spider communities. My results will show if soil moisture is an important characteristic that affects an ecosystem.

Invasive plants are plants that are not native to an area. Some of these plants are known to have a noticeable effect on an ecosystem. These affects could have detrimental side effects to the overall ecosystem. *Vinca minor* is an invasive plant that is present in at least 36 states, has escaped cultivation, and is invading natural ecosystems (Swearingen, et al. 2002). It forms a dense blanket of groundcover that changes the plant community in the area (Swearingen, et al. 2002; K.G. Murray, pers. comm.)). In this study, *Vinca minor* was studied to see if it has an effect on the ecosystem of a Mesic Beech-Maple Forest by comparing the spider communities at sites with and without *V. minor*. Given this it may have profound effects on the arthropod assemblage living at the soil/litter interface.

Materials and Methods

In this study, I asked three different questions. First, I questioned if spider communities change along a moisture gradient. Second, I asked if the invasive herb species, *V. minor*, affects the forest floor effected spider communities. Finally, I asked if the Mesic Southern Forest at Pierce Cedar Creek Institute (PCCI) and the Mesic Beach Maple Forest at Hope College Nature Preserve (HCNP) have similar spider communities.

Field Sites

We sampled cursorial spiders at two locations in Southwestern Michigan. The HCNP is a dune successional forest along the eastern shore of Lake Michigan, 12 km SW of Holland. It is dominated by American beech (*Fagus grandifolia*) and Sugar maple (*Acer saccharum*) and to a lesser degree, black cherry (*Prunus serotina*). Portions of the HCNP forest have been invaded by the herb, *Vinca minor*, a common ornamental used by house owners adjacent to the forest.

The PCCI is located 12 km SW of Hastings. We worked in three forest habitats: dry southern forest, dominated by white oak (*Quercus alba*) and black oak (*Quercus velutina*); dry-mesic southern forest, dominated by Red oak (*Quercus rubra*), white ash (*Fraxinus americana*), and bitternut hickory (*Larga cordiformis*); and mesic southern forest, dominated by American beech and sugar maple. A floristic survey of the forests at PCCI was recently completed (Slaughter and Skeon 2003).

Pitfall Sampling

To sample the cursorial spider communities, ten or nine pitfall traps were used at each site. The pitfall traps consisted of a polypropylene cup (15 cm dia) placed within a metal sleeve which was inserted flush with the soil surface of the ground (Bultman et al, 1982). About a 5 cm. depth of propylene glycol, anti-freeze, was used as the preservative at the bottom of the trap. The traps were then covered with a square wooden roof, raised 3 cm above the soil surface by four legs (Bultman et al., 1982). The pitfall traps were placed along a straight path at the Mesic and Dry sites and separated into two transects at the Dry Mesic site. At HCNP the traps were for the most part spread out into two transect lines at the site without *V. minor* and the site with *Vinca minor*. All traps were placed at 10 meter intervals. Every week from 6 June 2005 to 24 August 2005, the pitfall samples were filtered and any spiders found were placed into jars with 70 % ethanol to be identified later. After the collections each week, the traps were charged and made ready for the coming week. Once back at the laboratory, Kaston (1981) was used to identify spiders to the family level.

The use of pitfall traps has been questioned due to certain variables influencing the results like weather, differential species activity and trap placement. Proponents defend the method because of its versatility in different habitats and continuous sampling. In recent studies it has shown to be an adequate estimator of the number of species of cursorial spiders over a wide range of habitats. Pitfall traps do not estimate the density of cursorial spiders but instead estimate the “active density” or the number of cursorial spiders moving in an area for a given time (Bultman et al., 1982).

Assessing Soil Moisture

To verify that a moisture gradient existed at PCCI, soil moisture levels were determined twice during the study, once on 22 June 2005 and again on 13 July 2005. Soil samples were taken with PVC pipe that was stuck into the ground at an angle to a depth of 10.5 cm to 25 cm. Samples were then put into a zip lock bag and brought back to the laboratory weighed, dried and then weighed again. These data were then used to calculate percent soil moisture of the samples. The results were then graphed to observe whether a moisture gradient existed.

Measures of Community Organization

After all of the spiders were identified, guild and family compositions of each site were compared graphically and with two similarity indices.

Jaccard's coefficient:

$$Sj = a/(a + b + c)$$

Where a is the number of families collected at both sites A and B, b is the number of families collected at site B but not A, and c is the number of families collected at site A but not B.

Bray Curtis similarity index:

$$1 - \frac{\sum_{i=1} |N1_i - N2_i|}{\sum_{i=1} N1_i + N2_i}$$

Where $N1_i$ and $N2_i$ are the numbers of the ith families at sites 1 and 2, after log transformation of the data (ln(X+1)) was calculated.

Results

Effect of a Moisture Gradient

A moisture gradient was found at PCCI with increasing soil moisture from Dry to Mesic Forests (Figure 1). Spider guild composition at PCCI differed between Dry and Dry Mesic: wolf and crab spiders decreased in abundance (19.02%, 37.11%, respectively) while running spiders, vagrant web builders, and jumping spiders increased in abundance (23.78%, 31.80%, 0.56%, respectively) (Figure 2). Spider family composition at PCCI changed from Dry to Dry Mesic: Thomisidae, Clubionidae, Lycosidae, and Anyphaenidae decreased in abundance (35.06%, 4.51%, 18.28%, 0.81%, respectively) while Hahniidae, Gnaphosidae, Agelenidae, and Salticidae increased in abundance (30.71%, 29.07%, 0.73%, 0.57%, respectively) (Figure 3). Dry Mesic showed the highest amount of families present when compared to Dry and Mesic (Figure 3). All three sites differed at the family level according to Jaccard's Coefficient and the Bray Curtis Index (Table 1). The Dry and Dry Mesic the sites differed by 33%-35% (Table 1).

All three sites showed varied spider abundance with Dry Mesic having the most spiders, Dry having the next highest spider abundance and finally Mesic with the lowest spider abundance (Figure 4). Dry Mesic was the most similar PCCI site to HCNP's site that lacked *V. minor* (Figure 2 & 7). Very few spiders were collected at Mesic over the sampling period (Figure 4). Many of the pit fall traps at this site were disturbed by raccoons.

Invasive Plant

The presence of *Vinca minor* was associated with lower total spider abundance (Figure 5). Furthermore, the spider community guild composition at HCNP was altered in the presence of *V. minor*: vagrant web builders, crab spiders, running spiders, and jumping spiders all decreased in relative abundance (26.68%, 7.81%, 3.22%, 0.32%, respectively) while wolf spiders became common (38.03%) (Figure 6). The spider community family composition at HCNP was also altered in the presence of *V. minor*: Lycosidae, Anyphaenidae, Gnaphosidae, and Pisauridae increased in abundance (36.93%, 0.89%, 0.22%, 0.24%, respectively) while Hahniidae, Thomisidae, Clubionidae, Agelenidae, and Salticidae decreased in abundance (20.02%, 7.48%, 4.04%, 5.44%, 0.30%, respectively) (Figure 7). Of note is that lycosids were completely absent from the traps at the undisturbed parts of HCNP, but became quite common in the traps located where *V.* minor had invaded. The sites differed by 23-18% when comparing them with the similarity indices Jaccard's Coefficient and the Bray Curtis Index (Table 2).

<u>Discussion</u>

At PCCI, the Mesic Southern Forest site had very few spiders collected from it (Figure 4). This is most likely due to the site being disturbed during the sampling period. There were a couple of reasons for the disturbances. Raccoons knocked the trap covers off the pit fall traps and sometimes pulled up the plastic sleeve from the ground. Also this site was put at a bottom of a hill and because of that a high amount of water and mud disturbed the traps. Due to these disturbances, I have less confidence in these data. Consequently, I will not consider them further in this discussion.

As moisture levels increased it was expected that spider diversity and abundance would also increase. I reasoned that as moisture levels increased plant biomass would rise. With the increased plant biomass, there would be more insects due to the surplus in resources. With high levels of insects, spiders would increase in spider diversity and abundance. This hypothesis was supported with Dry Mesic forest showing higher abundance than the Dry forest (Figure 4). Dry and Dry Mesic sites differed by 33% and 35% on the families level according to the Jaccard's Coefficient and the Bray Curtis Index. Hahniidae, Gnaphosidae, Agelenidae, and Salticidae increased in abundance (Figure 3). Yet, members of the Thomisidae, Clubionidae, Lycosidae, and Anyphaenidae all decreased in abundance. At the family level the Dry forest was actually more diverse that the Dry Mesic (eight compared to seven families present). This does not support my hypothesis. It is possible that particular abiotic requirements allowed some families to thrive and others to not. This trend has been found on the species level where *Trochosa terricola* and *Pirata piraticus* increased in abundance, while the abundance of *Pardosa fuscula* and *Pardosa moesta* decreased as soil moisture increased (Graham, et al. 2003).

Spiders in the Thomisidae show the largest decrease in abundance as soil moisture increased (Figure 3). This trend may be a result of greater soil moisture, however other factors maybe also be responsible. Gnaphosids and hahniids showed a striking increase in relative abundance from Dry to Dry Mesic (Figure 3). Hahniids could have possibly thrived due to the greater amount of litter, which provides means of attachments for their webs, which accumulated more in the Dry Mesic compared to the Dry Forest (D. DeWitt, pers. obs).   Cursorial spider abundance has been shown to be correlated with litter development (Bultman et al. 1982).

Vinca minor is an invasive plant which has invaded the HCNP forest floor creating almost a blanket of plant biomass. An invasive plant is one that is non-native to the area. *Vinca minor* in particular has been shown to reduce the recruitment of canopy trees by shading out sunlight (K.G. Murray, unpublished data). *Vinca minor* most likely changes the abiotic characteristics of the Mesic Beech Maple Forest's floor. Due to this, spider communities could be affected. The Mesic Beech Maple Forest without *V. minor* is 23-18% different from the forest with *V. minor* when comparing them at the family level using Jaccard's Coefficient and the Bray Curtis Index (Table 2). In the *V. minor*, wolf spiders became common while at the same time vagrant web builders, crab spiders, running spiders, and jumping spiders decreased in relative abundance (Figure 7). These data indicate that *V. minor* is causing a change to the forest floor spider community.

Future Work

The results presented here are a preliminary analysis of the data. The next step is to identify each spider to the species level and to include the data from the last three sampling dates. This will be undertaken during the fall 2005 semester. Having done this, I will reanalyze the full data set using the techniques in this paper.

Acknowledgements:

First and foremost I would like to acknowledge my advisor Dr. Bultman. I would also like to acknowledge the faculty at Hope College who have guided me through this project: Dr. Brady, Dr. Swarthout, and Dr. Peterson, Jamin Dryer for his help, and Alex Palacious for his invaluable assistance. Finally I would like to acknowledge the Pierce Cedar Creek Institute and URGE grant for making this possible.

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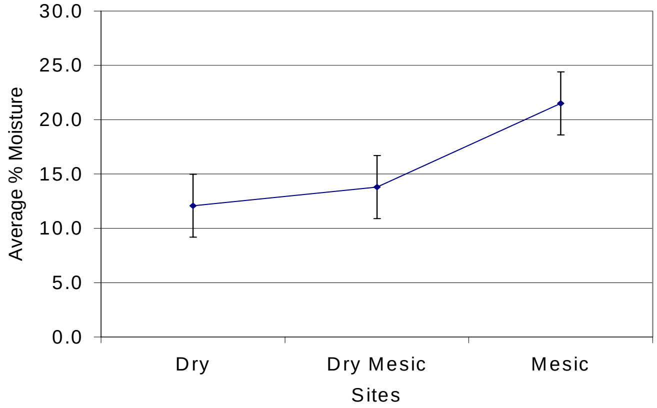
Figure 1. Average % moisture at each different forest type at PCCI. A. Data collected on 6/22/2005. B. Data collected on 7/13/2005. Each dot represents the average of five different soil samples.

A.)



B.)

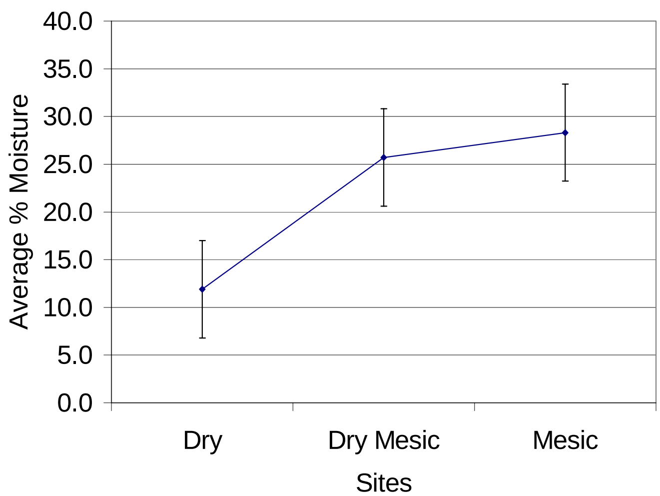


Figure 2. Guild composition of the spider communities at PCCI.

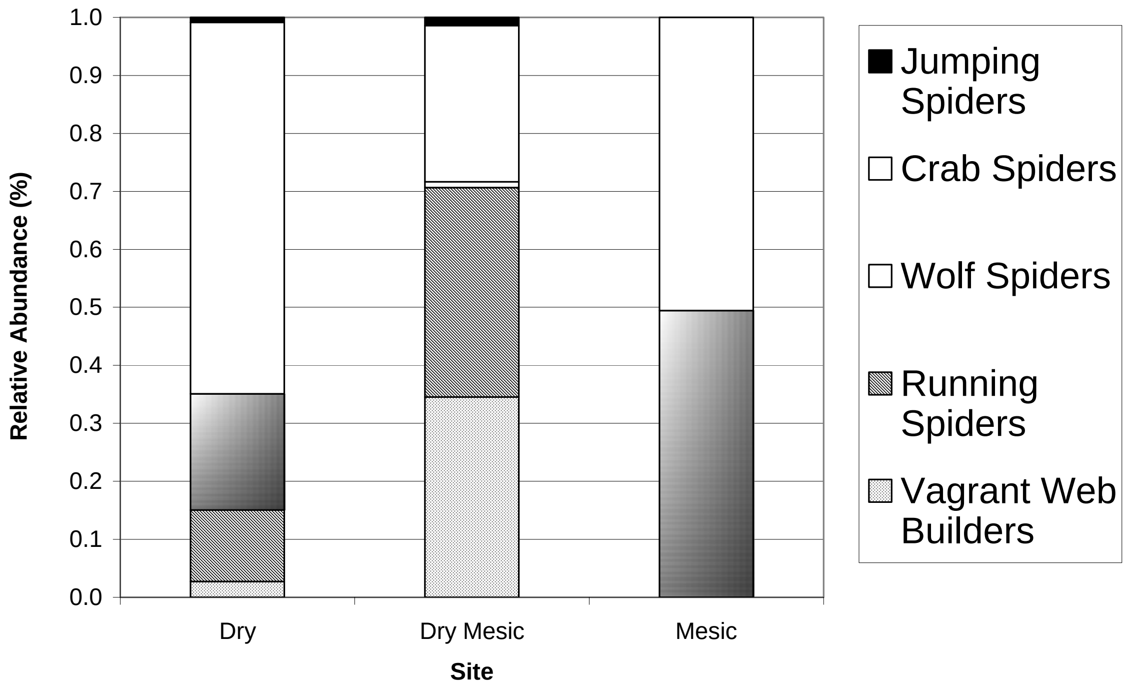


Figure 3. Family composition of spider communities at PCCI.

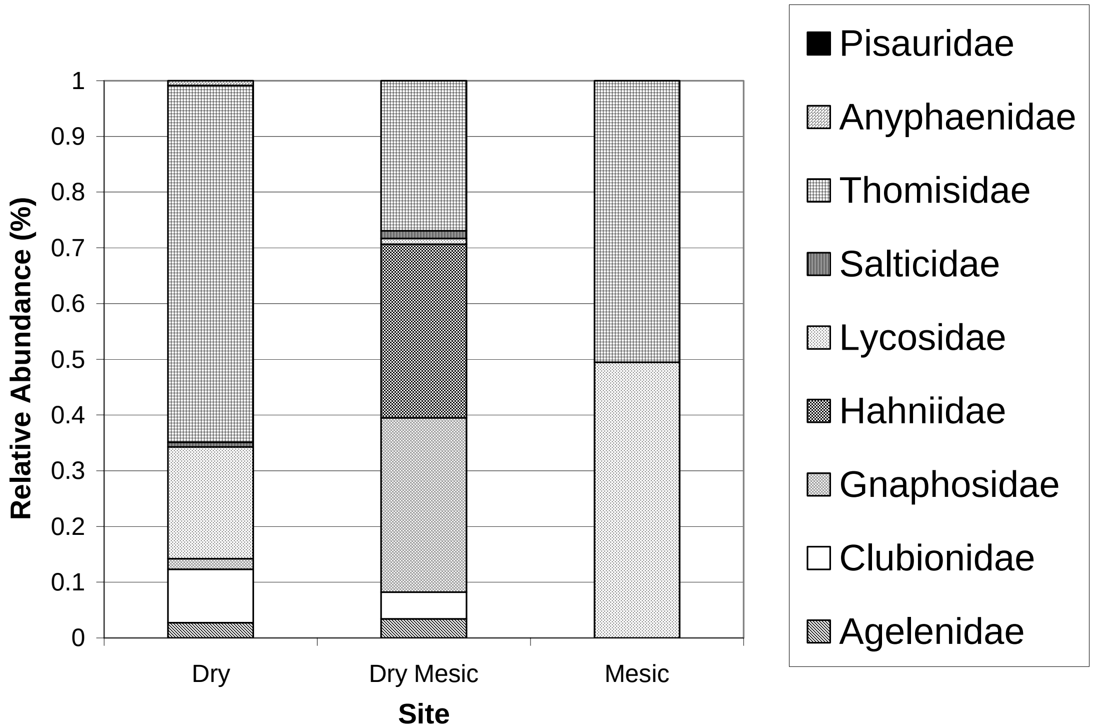


Figure 4. Total spiders per site vs. collection date between 6/8/2005 and 7/20/2005 comparing the three different forest types at PCCI: Dry, Dry Mesic and Mesic.

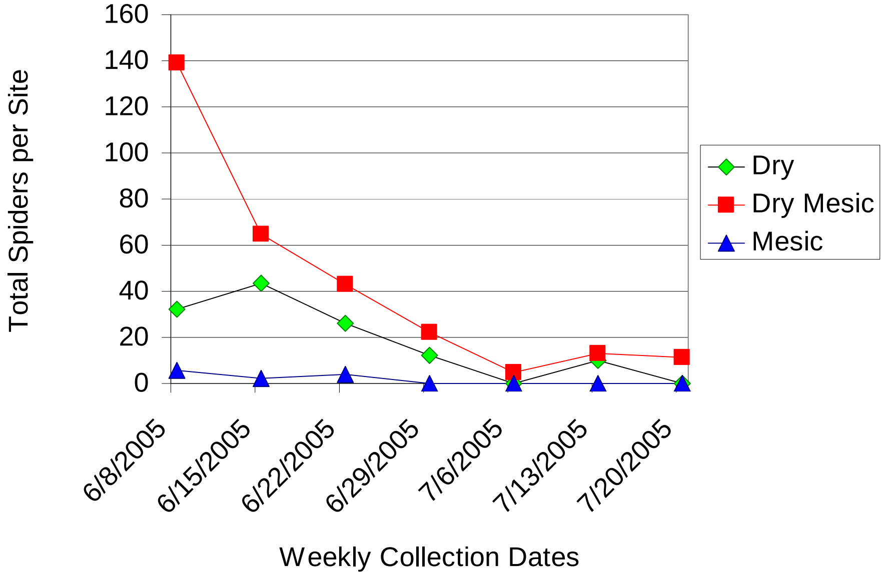


Figure 5. Total spiders per site vs. collection date between 6/8/2005 and 7/20/2005 comparing the two different habitat types at Hope College: with *Vinca minor* and without *Vinca minor*.

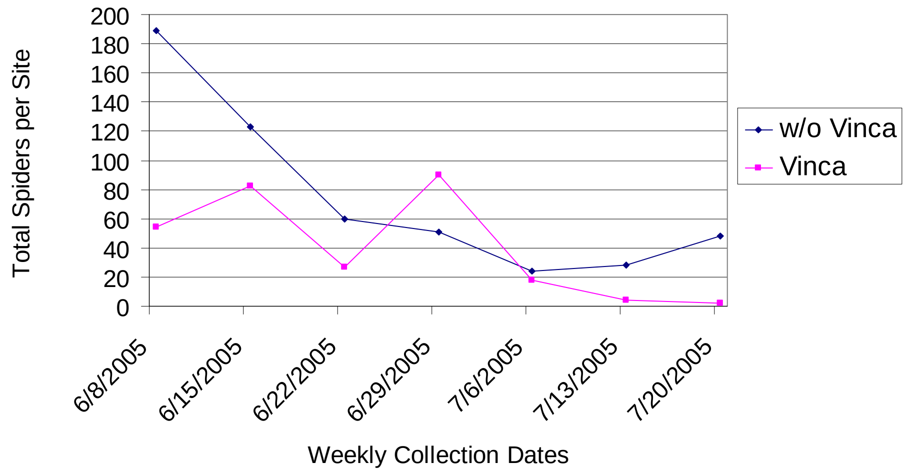


Figure 6. Guild composition of the spider communities at HCNP.

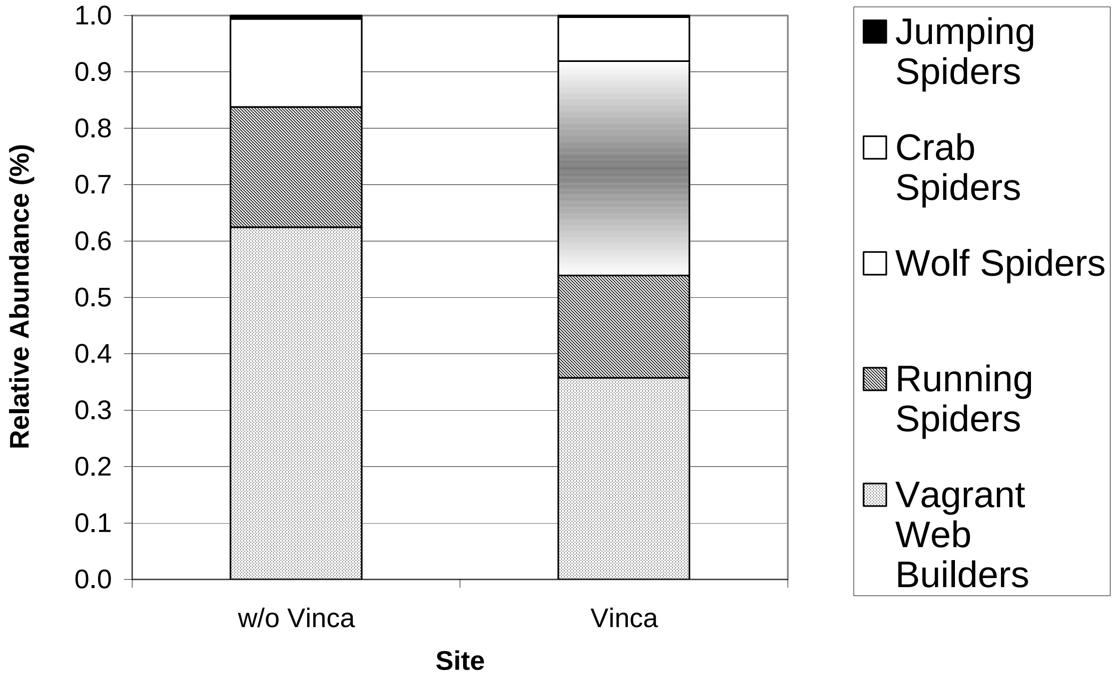


Figure 7. Family composition of spider communities at HCNP.

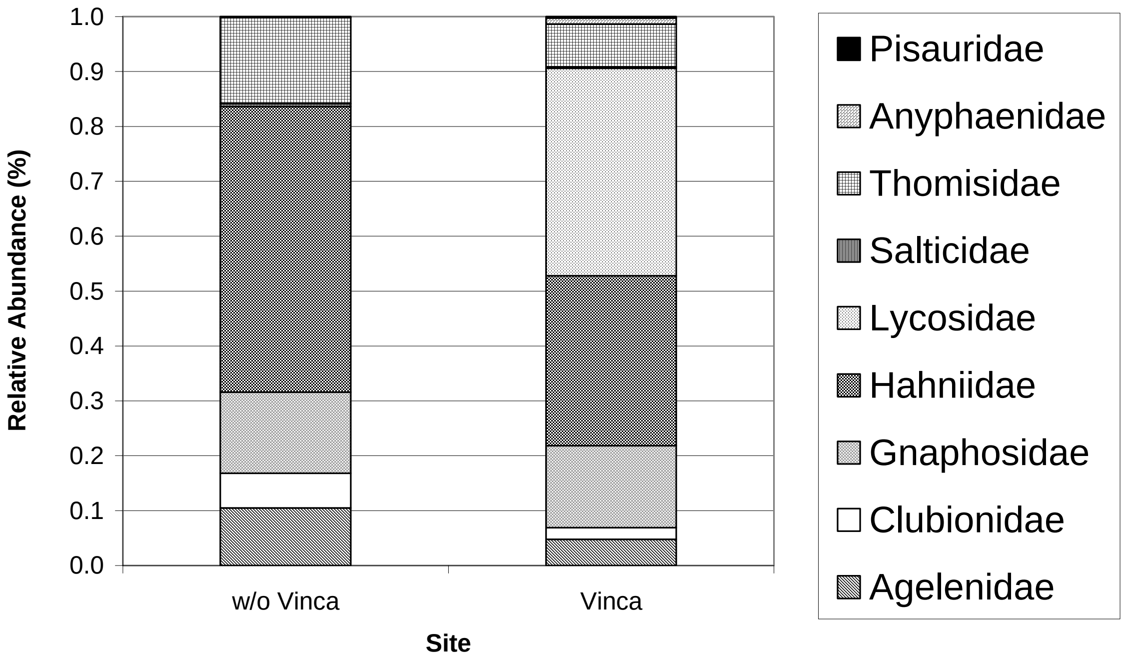


Table 1. Comparison between the different spider communities at Pierce Cedar Creek Institute using Jaccard's Coefficient and the Bray Curtis Index.

	Similarity Index	Dry	Dry Mesic	Mesic
Dry	Jaccard's Coefficient	-	.667	.583
	Bray Curtis Index	-	.649	.414
Dry Mesic	Jaccard's Coefficient	.667	-	.583
	Bray Curtis Index	.649	-	.256
Mesic	Jaccard's Coefficient	.583	.583	-
	Bray Curtis Index	.414	.256	-

Table 2. Comparison between the different spider communities at Hope College Nature Preserve using Jaccard's Coefficient and the Bray Curtis Index.

	Similarity Index	Vinca	w/o Vinca
Vinca	Jaccard's Coefficient	-	.818
	Bray Curtis Index	-	.770
w/o Vinca	Jaccard's Coefficient	.818	-
	Bray Curtis Index	.770	-