The Diversity and Abundance Of Natural Enemies: Parasitic Wasps in Urban Deciduous Forest Fragments

by

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Of Natural Enemies:

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ABSTRACT

This study evaluated the diversity and abundance of this important group of bio-control agents in Northern Delaware forest fragments. Parasitic wasps from six forest fragments surrounded by different types of land use were sampled using bowl traps. Collected wasps were identified down to family. The diversity was measured using Simpson's Diversity Index. An Analysis of Variance was run to see if surrounding land use had any impact on the diversity or abundance.

I found that there was an intermediate level of parasitoid diversity over all. The six most abundant families found were Ichneumonidae, Braconidae, Diapriidae, Pompilidae, Tiphiidae, and Platygastridae. Furthermore, the surrounding land use did not have an impact on the diversity and abundance. More field seasons need to be conducted and more taxonomic resolution is necessary in order to determine the diversity and abundance of parasitic wasps in Northern Delaware forest fragments.

Chapter 1

INTRODUCTION

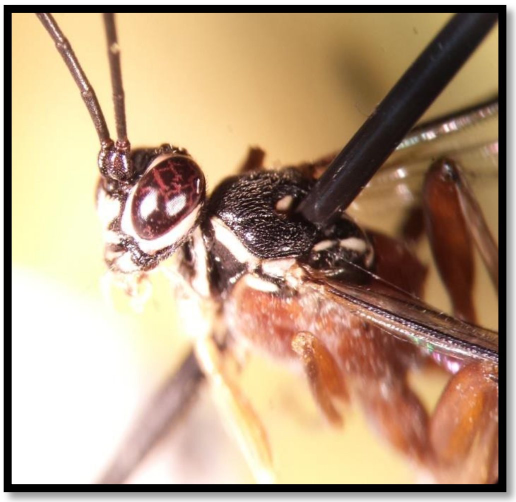
Biodiversity is fundamental to the sustainability and health of ecosystems. Native insects play many important roles in ecosystems, biological control being one of the most important examples. Natural enemies, in particular parasitic wasps, effectively hinder pest outbreaks and help maintain low pest populations.

Parasitic wasps play a key role in reducing crop and pest forest damage (Royal Entomological Society 2014). Natural enemies have saved an estimated $80 billion and $10 billion worldwide in crop and forest damages, respectively (Cracraft & Grifo, 1999). These wasps will typically lay their eggs in or on an arthropod host and as the eggs hatch and grow they use their hosts for sustenance (Bonet, 2008). This process reduces the hosts' population size, helping to maintain a healthy and manageable population of the host species (Welsh, 2012).

Life Cycles of Parasitic Wasps

Ichneumonidae

One family of parasitic wasps, Ichneumonidae, is the largest family in Hymenoptera and one of the largest families in Insecta with over 60,000 described species (Wahl 1993). Ichneumonid wasps target a wide range of hosts, from caterpillars to spider eggs (UF Florida Natural Area Teaching Laboratory 2014). Pests that these wasps target are not only crop pests but can also cause serious damage to other ecosystems such as forests. Ichneumonid wasps are both ectoparasites and endoparasites of a wide variety of insects from Lepidoptera, Hymenoptera, Diptera, Coleoptera, Neuroptera, and Mecoptera, as well as spiders and spider egg sacs. They are mainly solitary, meaning one host per individual, however, they can be gregarious (Triplehorn & Johnson 2005).



Braconidae

Braconid wasps have a diverse life cycle. Some are ectoparasites and some are endoparasites. They attack different hosts in all life stages of development. Braconid wasps can be solitary or gregarious. They attack a wide variety of hosts including Lepidoptera, Hemiptera, Hymenoptera, Coleoptera, Diptera, Neuroptera, Mecoptera and Psocoptera. Some Braconid wasps are hyperparasitoids. One subfamily is polyembryonic. (Triplehorn & Johnson 2005).

Diapriidae

Diapriidae are small Hymenopterans that are mainly parasites of Diptera including fungus gnats and other flies that feed on fungus. Some however are hyperparasites of Dryinidae. Others still are parasites of ants or ant associates (scientists are still not sure). (Triplehorn and Johnson 2005).

Pompilidae

Pompilidae is also known as the spider wasp. They create a cell or nest in the ground, rotten wood, or in crevices in rocks. They paralyze the spider and lay an egg on the spider. Sometimes they create the nest before capturing the spider, but usually it is after they capture the spider. (Triplehorn & Johnson 2005). Some species paralyze the spider in their own nest and oviposit on it (Bugguide.net). One genera of Pompilidae make above ground mud nests (Evans & Shimizu 1996).

Tiphiidae

Not too much is known about the immature stage of the life cycle of Tiphiidae. Some Tiphiids are parasites of scarab beetles. While others are parasites of tiger beetles. To help control the Japanese beetle population, a species of Tiphiidae, *Tiphia popilliavora* was introduced (Triplehorn & Johnson 2005).

Platygastridae

Platygastrid wasps are egg parasites that attack a wide array of insects as well as spiders (Austin et al. 2005). Most platygastrid wasps are koinobiont endoparasites (Kim et al. 2011). This means that the adults lay their eggs in the eggs of their host species. The host species continues to develop and grow until the platygastrid wasp reaches maturity (Iowa State University 2018). Most attack a wide range of hosts from Auchenorrhyncha, Sternorrhyncha, and Cecidomyiidae (Austin et al. 2005). Some species are polyembryonic with up to 18 individuals emerging from a single egg (Triplehorn & Johnson 2005). Scelionid wasps are a subfamily of Platygastridae and are idiobiont endoparasites (Austin et al. 2005). These wasps attack the host at the egg stage and prevent further development from the host species (Iowa State University 2018). They attack a wide range of insects from Orthoptera, Mantodea, Hemiptera, Embiidina, Coleoptera, Diptera, Lepidoptera, and Neuroptera (Triplehorn & Johnson 2005).

Hypothesis/Objectives

Hypothesis

Natural enemy diversity and abundance will be greater in habitats with higher disturbance and complexity. A study by Lassau and Hochuli (2005) showed that the greater the complexity of the habitat, the greater the diversity of parasitic wasps.

Objectives

The primary objective of this research is to measure the diversity and abundance of parasitic wasps, within urban forest fragments located in northern Delaware. Parasitoids are one of the most numerous and ecologically diverse groups of insects in temperate regions (Hilszczanski et al., 2005). The secondary objective of this research is to correlate diversity and abundance to surrounding land use.

Chapter 2

METHODS AND MATERIALS

Collection Techniques:

To obtain the specimens in which to measure the diversity and abundance of parasitic wasps within forest fragments, specimens were collected throughout the summer field season. A total of six sites were chosen based on surrounding land use (urban/suburban, agriculture, and forested) from the departmental-wide FRAME (Forest Fragments in Managed Ecosystems) project, which monitors urban and suburban forest fragments on a long-term basis in order to identify key components involved with maintaining high biodiversity. FRAME sites are set in a grid of points at 25-meter intervals. At each site three bowl traps of differing colors (white, blue, and yellow) were set at five randomly chosen points, for a total of 15 bowls per site and 90 bowls total. Each bowl trap was filled with a solution consisting of propylene glycol, bleach, and Dawn soap, to preserve the specimens. Each site was sampled every two weeks from the end of March through mid-September of 2014. Specimens were collected, and the bowl traps refilled with the solution upon each visit. The collected specimens were washed, dried, sorted, pinned, labeled, and identified down to family.

Statistical Analysis

The diversity was calculated using Simpson's Diversity Index $[1 - \sum(Pi)^2]$ and the Probability of Interspecific Encounter (PIE) $\left[\frac{N}{N-1}\right][1 - \sum(Pi)^2]$ manually via Excel. An Analysis of Variance (ANOVA) was run via R.

Chapter 3

RESULTS

Specimens collected from the six FRAME sites (Chrysler Woods, Ecology Woods, Iron Hill 2, Rittenhouse, Sunset Lake 1, and White Clay Creek 1) yielded 23 different families with a total of 922 individuals. The most abundant family was Ichneumonidae with 565 individuals. The following families were represented by fewer individuals: Pompilidae (150), Diapriidae (67), Braconidae (58), Tiphiidae (31), Platygastridae (14), Evaniidae (8), Crabronidae (6), Dryinidae (6), Eucoilidae (2), Pteromalidae (2), and Rhopalosomatidae (2). The remaining 11 families were each represented by only one individual. The breakdown of number of individuals per family per site is found in figure 7. Rittenhouse had the most individuals (307) and the most Ichneumonid wasps (182) and Iron Hill 2 had the most families (13). White Clay Creek 1 had the highest percentage of Ichneumonid wasps with 75.45%. Sunset Lake 1 and Ecology Woods tied with the lowest percentage of Ichneumonid wasps at 48.65%. These data can be found in figures 1 through 6.

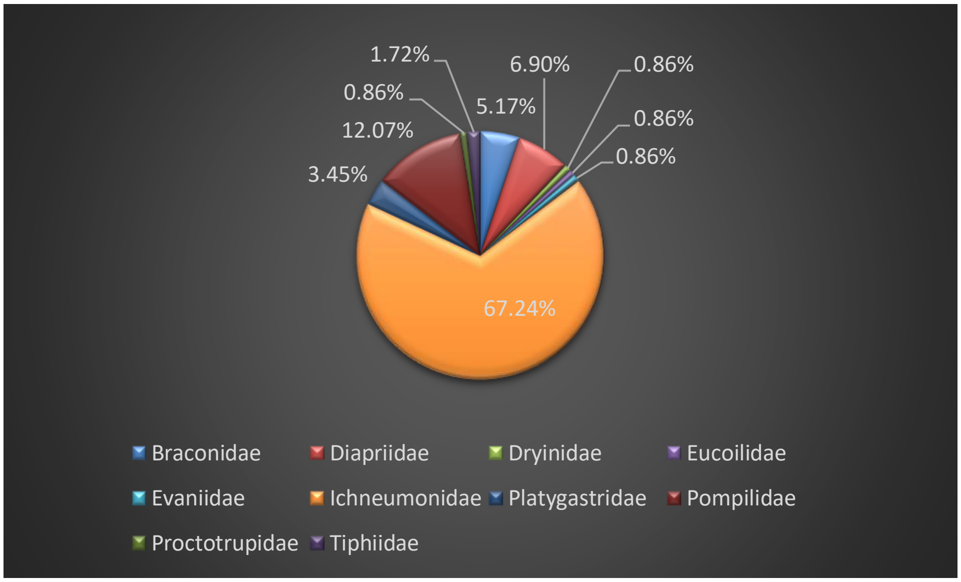


Figure 1 The percentage that each parasitoid family makes up of the total wasp specimens for the site Chrysler Woods.

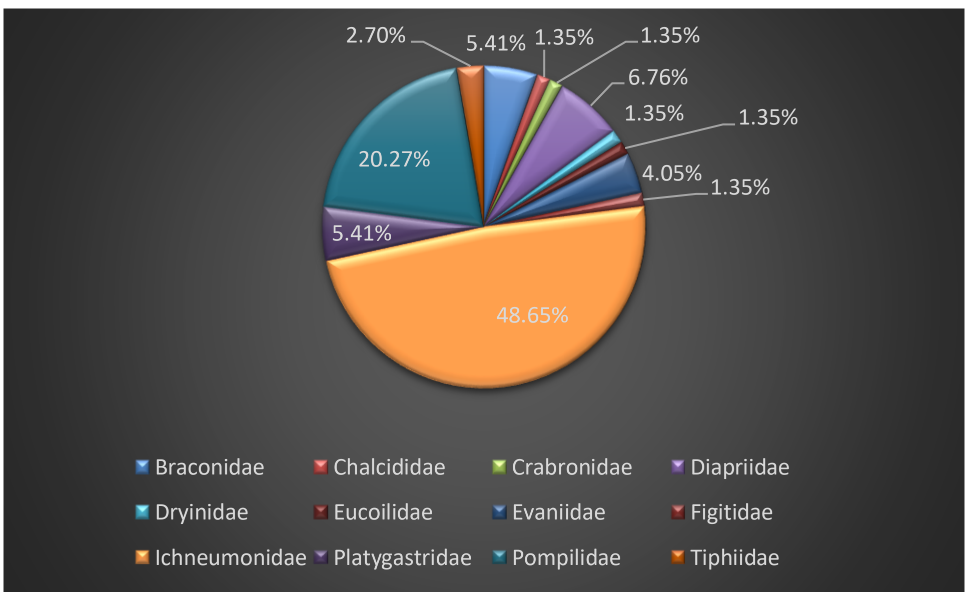


Figure 2 The percentage that each parasitoid family makes up of the total wasp specimens for the site Ecology Woods.

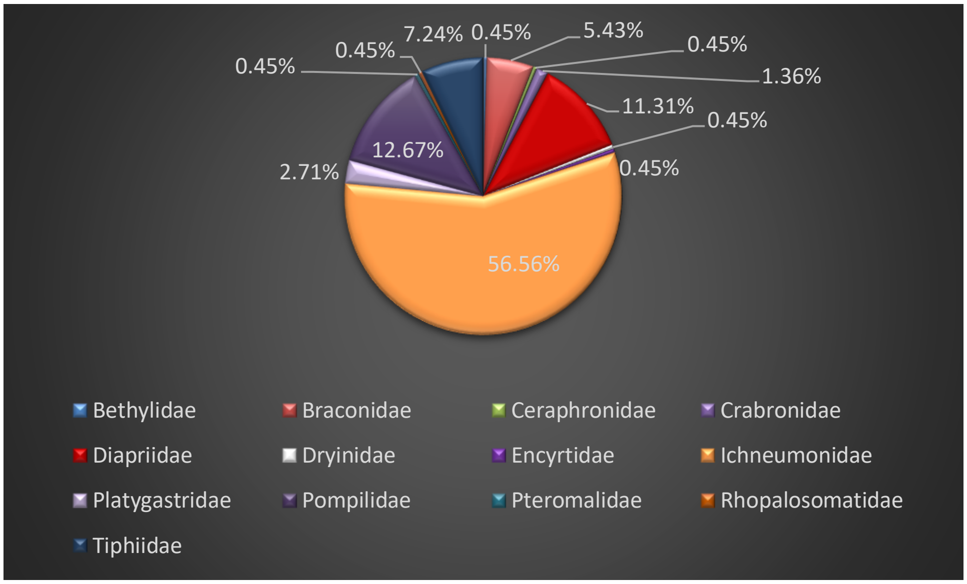


Figure 3 The percentage that each parasitoid family makes up of the total wasp specimens for the site Iron Hill 2.

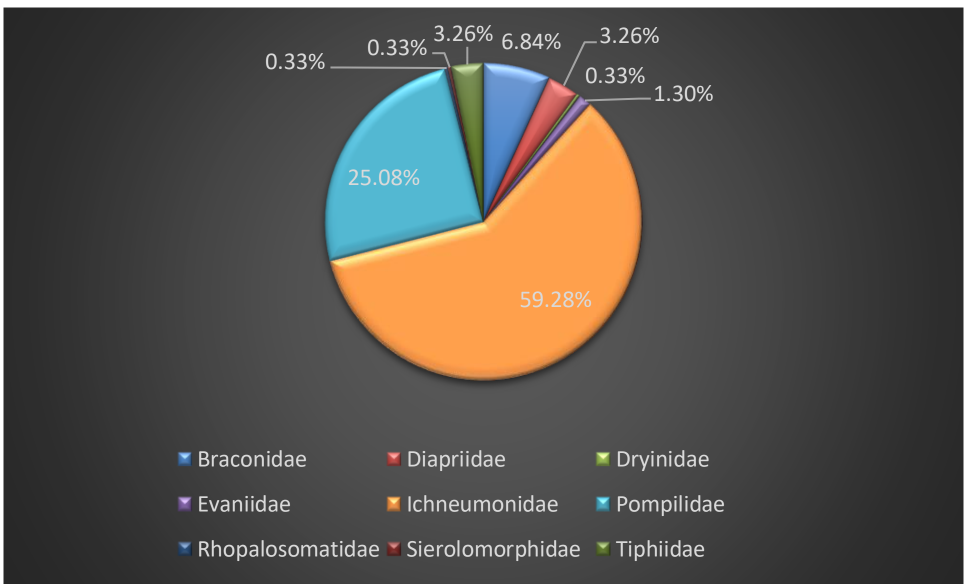


Figure 4 The percentage that each parasitoid family makes up of the total wasp specimens for the site Rittenhouse.

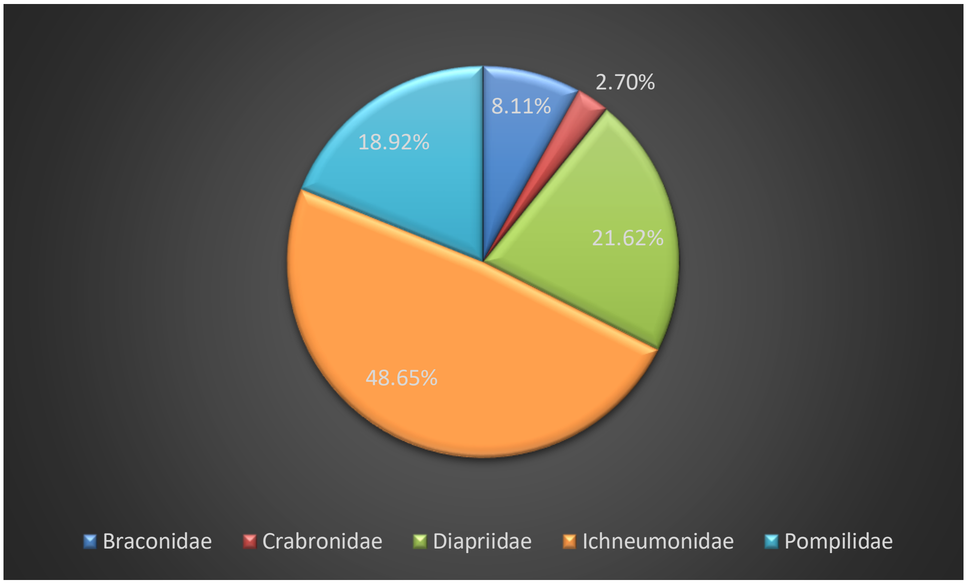


Figure 5 The percentage that each parasitoid family makes up of the total wasp specimens for the site Sunset Lake 1.

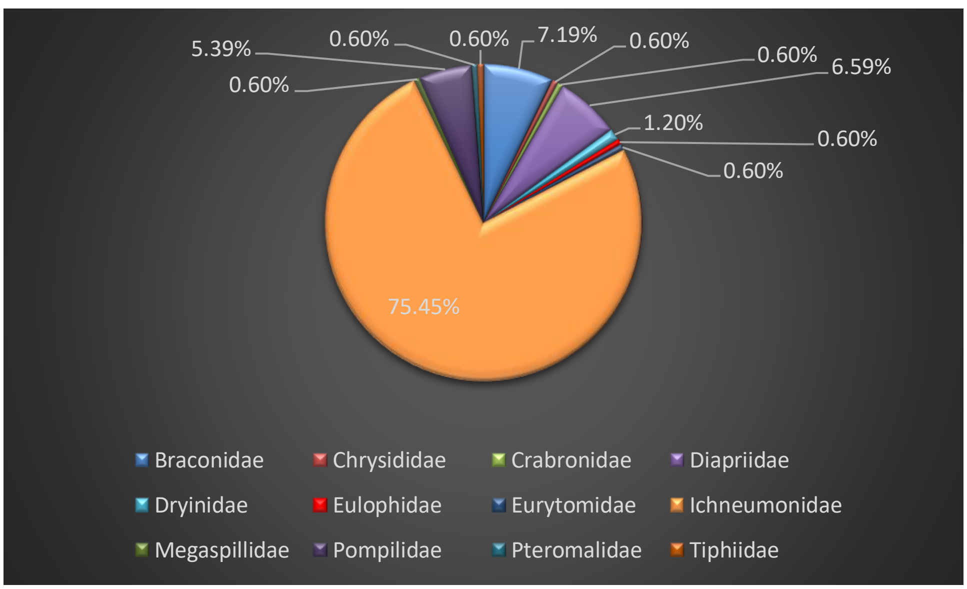


Figure 6 The percentage that each parasitoid family makes up of the total wasp specimens for the site White Clay Creek 1.

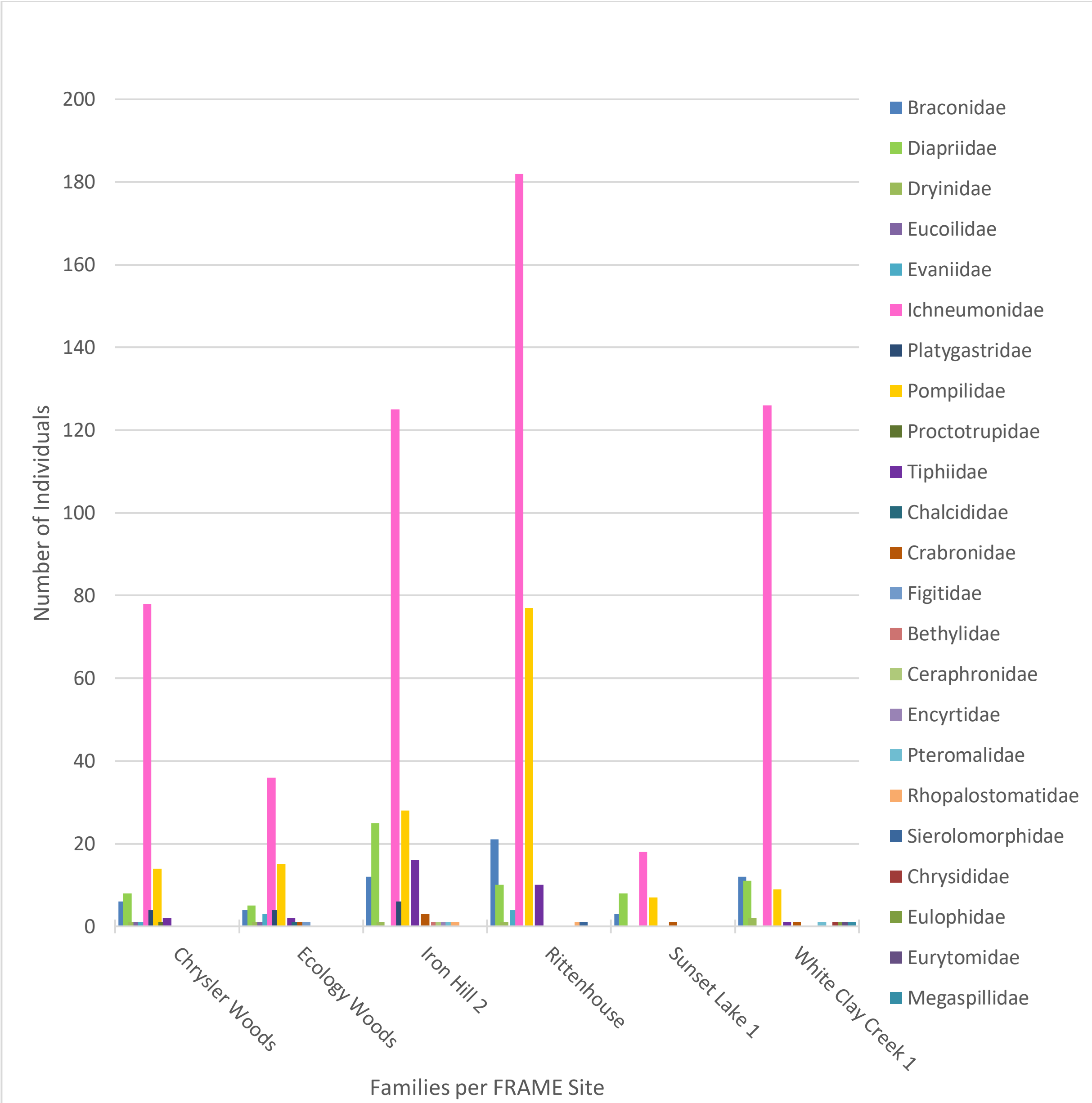


Figure 7a The number of individuals per parasitoid family for each of the six FRAME sites.

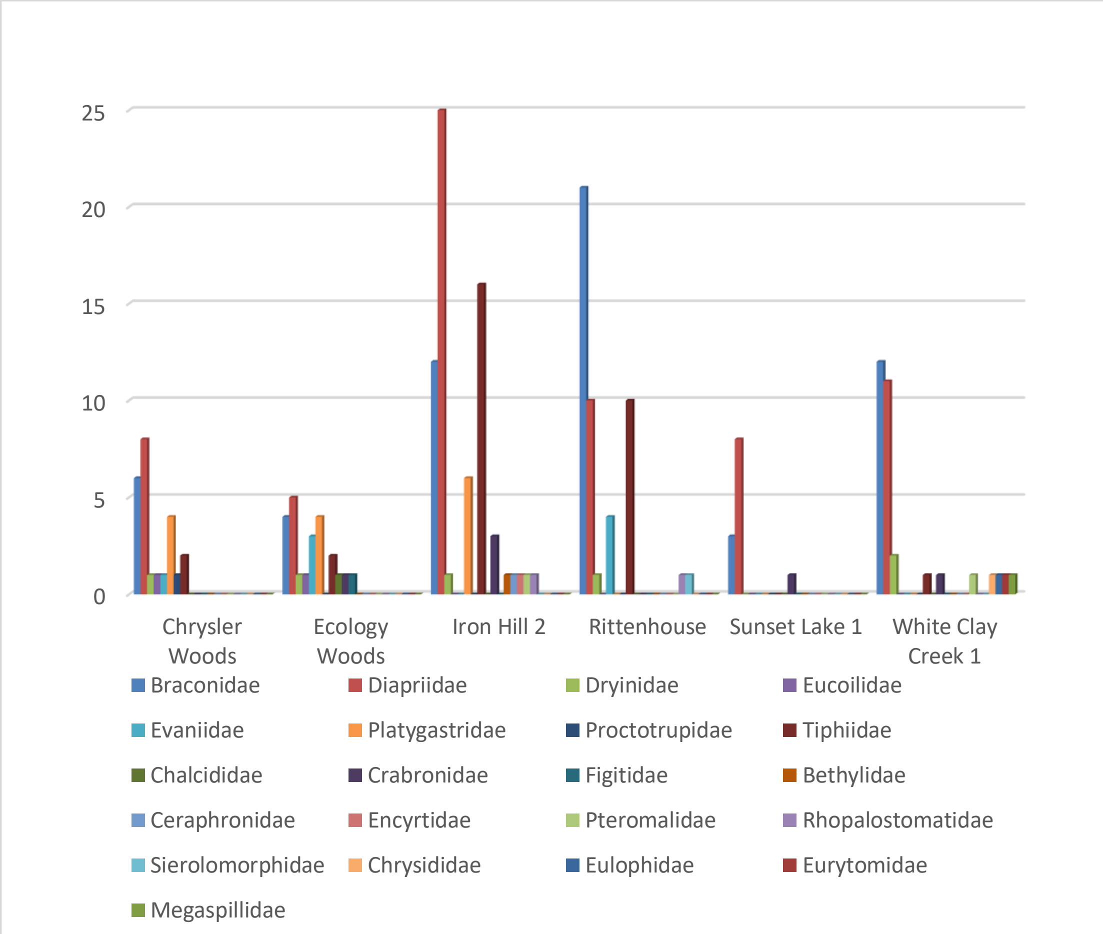


Figure 7b The number of individuals per parasitoid family for each of the six FRAME sites without Ichneumonidae and Pompilidae.

The diversity as calculated by Simpson's Diversity Index was 0.587, showing that there was average diversity over all sites shown in Table 1. Ecology Woods had the highest diversity over all the FRAME sites at 0.709 and White Clay Creek 1 had the lowest diversity at 0.418. The site that had the highest Probability for Interspecific Encounter (PIE) was Ecology Woods at 0.718 and the lowest was White Clay Creek 1 at 0.420. The ANOVA had a *p* value of 0.2324, shown in table 2.

Table 1 The total number of families of parasitic wasps, the Simpson's diversity index, and the Probability of an Interspecific Encounter (PIE) and PIE as a percentage for each site and for all the sites.

Site	Total Number of Families	Simpson's Diversity Index	PIE	PIE as a percentage
Chrysler Woods	10	0.524	0.529	52.9%
Ecology Woods	12	0.709	0.718	71.8%
Iron Hill 2	13	0.642	0.645	64.5%
Rittenhouse	9	0.579	0.581	58.1%
Sunset Lake 1	5	0.673	0.692	69.2%
White Clay Creek 1	12	0.418	0.420	42.0%
All Sites	23	0.587	0.587	58.7%

Table 2 The Analysis of Variance for the surrounding land use by family per point.

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	2	11.66667	5.83333	1.5411
Error	27	102.20000	3.78519	Prob > F
C. Total	29	113.86667		0.2324

Chapter 4

DISCUSSION

These results show a mid-level diversity index for the six FRAME sites sampled. However, this could be due to only identifying individuals down to the family level. Since Ichneumonidae is a large family, diversity would become greater with identification to the genus or species level.

Additionally, other factors such as rainfall could have caused specimens in the bowl traps to be washed out thus impacting the results. To improve family diversity more trap types should be used in conjunction with larger bowl traps to account for these variables. Using more types of traps (such as Malaise traps) in conjunction with larger bowl traps at different elevations should increase diversity. Pucci (2008) found that some families of parasitic wasps were more prevalent at a higher elevation, the canopy, using pan traps in a temperate forest than at the ground level. Therefore, using pan traps at different elevations should increase the diversity and/or abundance of future studies. Malaise traps are used to sample specific taxa of parasitic wasps (Fraser 2008), therefore, to have a more complete sampling multiple trap types are needed.

I determined that surrounding land use does not have an impact on the diversity and abundance. However, my findings might change with a larger sample size and with the specimens identified down to genus or species. There are also implications for time to be an added component to the study. When collecting the samples from the field, the date that the bowl traps were filled and collected was recorded. It would be interesting to see how the diversity changed and what families were present at different times during the season. However, more field seasons would have to be conducted in order to further the study.

Another consideration for future study is host populations. Since parasitic wasps are usually highly specialized (Shaw 2006) and found in all of the habitats that their hosts are found in (Dellinger & Day 2014), it would be beneficial to measure the diversity and abundance of the host species as well. This could be taken a step further as well with vegetation sampling to see what the vegetation composition is and correlate this with the diversity and abundance of the parasitic wasps found in that area.

Research conducted on parasitic wasps has focused mainly on tropical, boreal, and old growth forests or specific species of wasps and their hosts. A study by Arnan et al (2011) focused on the order Hymenoptera in old growth forests, while a study by Pickering & Sharkey (1995) looked at the diversity and trophic interactions of parasitic wasps in tropical lowland forests; yet another study by Hilszczanski et al (2005) focused on parasitoids of saproxylic beetles in boreal spruce forests. Therefore, it would be beneficial to continue this study considering there is a lack of study of parasitic wasps in urban deciduous forest fragments.

Parasitic wasps are an integral part of the ecosystems in which they reside. As natural enemies it would be beneficial to continue the study and see how the diversity and abundance would change. Furthermore, I would highly recommend adding the time, host, and vegetation components to the study, especially considering the lack of research for parasitic wasps in deciduous forests.

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