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Spider diversity over time at Hogarth Plantation using pitfall traps

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SPIDER DIVERSITY OVER TIME AT HOGARTH PLANTATIONS USING PITFALL TRAPS

by

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ABSTRACT

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Keywords: Araneae, biodiversity, bioindicators, Boreal forest, Great Lakes St. Lawrence forest, Pigeon River Ecoregion, pitfall trap, plantation, spiders, taxonomy

Biodiversity assessments are conducted using various methods featuring diverse assemblages of biota and whose results have seemingly endless important applications. In this assessment pitfall traps were used to research diversity of spider families over time for a boreal forest ecosite in northwestern Ontario. Applications of the resulting data discussed include delineating ecoregions, evaluating sampling techniques, assessing sustainability of forest management practices, and furthering taxonomic and systematic research. Lab identification methodologies were used to catalogue individual spiders collected during the study period into their associated families. The resulting family compositions were analyzed and compared to knowledge on the families biology to assess the significance of the data. From which, conclusions were formed on the study sites.

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Finally, I wish to pay recognition to my family who nurtured my passion for the environment from a young age, passing along care and curiosity to all earth I tread. I don't know where I'd be without Skeleton and Sugar Lakes.

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INTRODUCTION

In the summer of 2018, Lakehead University (LU) assistant professor Dr. D. C. Henne conducted pitfall trap surveys at two LU Faculty of Natural Resource Management owned woodlots in the Hogarth Plantation located in the District of Thunder Bay, Ontario. Specimens collected belonging to the Aranea order were isolated and used by an undergrad student of the same faculty to assess the diversity of spider (Araneae) families at Hogarth Plantation over time. Two woodlots were selected to act as the study sites known as Hogarth 1 and Hogarth 2. Hogarth 1 was surveyed on June 27th, July 10th, and August 17th while Hogarth 2 was surveyed on July 3rd, July 13th, and August 17th. Hogarth Plantation is located approximately 10 km west of the city of Thunder Bay in Northwestern Ontario in the Ontario Shield ecozone. The plantation falls in ecoregion 4W (Pigeon River Ecoregion) which is composed of boreal and Great Lakes-St. Lawrence vegetation communities and used predominantly for forestry, eco-tourism, and agriculture (Crins et al. 2009). Hogarth 1 and 2 sites are comprised of red pine of varying age classes with areas of open canopy featuring shrubs, grasses, and flowering plants. 5 to 10 Nordlander pitfall traps were set every 10 metres along a 40 metre transect.. The purpose of this study was to collect and identify spider families to gain insight on the assemblages unique to this boreal ecosite and how they change over time. The data resulting from this study has many applications such as delineating ecoregions, evaluating sampling techniques, assessing sustainability of forest management practices, and furthering taxonomic and systematic research which are discussed in the literature review following. Future research would involve performing more surveys in boreal ecosites as well as in other forest ecosites so as to compare assemblages. These comparisons could provide information on if assemblages of spider families are particular to their ecosite and if that relationship persists over different spatial scales.

LITERATURE REVIEW

Forest Ecosystem Classification

Ecological Land Classification systems are important, they delineate ecosystems from one another by comparing differences between biotic and abiotic features (Crins et al. 2009). Ecosystem and forest classification conform to a spatial hierarchy where scale dictates which hierarchal level they are labeled under (Crins et al. 2009). For example, Canada is divided into 15 ecozones which the province of Ontario only represents three of; the Hudson Bay Lowlands, the Ontario Shield, and the Mixedwood Plains (Crins et al. 2009). Ecozone designation is determined by linkages between ecosystems on a continental level while ecoregion boundaries are established by local climate and bedrock which drastically effects vegetation assemblages, biota present, substrates etc. within an ecoregion (Crins et al. 2009). Studying assemblages of spider families in conjunction with ecoregion boundaries could provide information on if assemblages of spider families are particular to the study ecosite and if that relationship persists over different spatial scales such as within ecoregions and how those assemblages change accordingly (Henne 2018). The ecosites of this study at Hogarth Plantation is located within ecoregion 4W (Pigeon River Ecoregion) in the Ontario Shield ecozone. The Ontario Shield is the largest ecozone in Ontario, occupying over half the province (Crins et al. 2009). This ecozone lays on Precambrian bedrock and has an overall all cold and moist climate (Crins et al. 2009). Substrates are diverse in the Ontario Shield though exposed bedrock accounts for a lot of it and lakes and rivers are plentiful across the ecozone (Crins et al. 2009). Forest types present in this ecozone is comprised of conifer dominant boreal forest and Great Lakes-St. Lawrence forest containing pine and oak species (Crins et al. 2009). The Pigeon River ecoregion has a cool a drier climate with the eastern region under Lake Superior's climatic influence (Crins et al. 2009). Ecoregion 4W being apart of the Ontario shield lays on Precambrian bedrock with substrates of clay, sand, and till in areas as well as exposed bedrock (Crins et al. 2009). Lakes with rocky shores are key features of this ecoregion (Crins et al. 2009). Forest cover includes a mixture of boreal and GLSL species such as pine, spruce, aspen, birch, with some oak, elm, ash, and red maple in toward the south east of the ecoregion (Crins et al. 2009). To further research on spider family assemblages (their compositions and distribution) in correlation with ecological land classification systems, more surveys in boreal ecosites as well as in other forest ecosites should be performed.

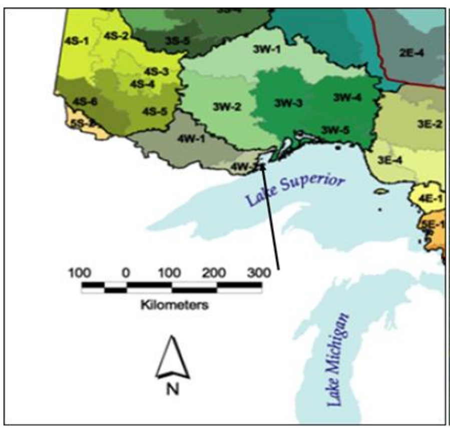
Canadian Spider (Araneae) Taxonomy and Systematics

Spider taxonomy and systematics has been a rapidly changing field of research. Constant revision and taxonomic overhaul of sorts have been conducted with increasingly large numbers new species being discovered. In 1979, Charles D. Dondale estimated 33 families of Araneae had species in Canada and the total number of species in Canada sat around 1400 (Bennet n.d.). In 1999 Bennett noted two families had been retracted from that estimation and 5 families added bringing the count of spider families in Canada to 38 and also made estimates on the number of species in Canada to be around 1500 (Bennet n.d.). In the 1980s and 1990s bounds were are only just being made in revising cryptic families, particularly ground-dwelling spiders (Gnaphosidae) who up until then had the least amount of information known on them of all the spider families across North America (Platnick & Dondale 1992). Major revision of the families Salticidae, Linyphiidae, Dictyoidea, and Amaurobioidea had yet to be made. Those gaps in spider classification in Canada resulted in very little being known in regards to the biology of Canadas spiders. And despite increased interest in araneology, spider surveys had not been conducted in most Canadian ecosystems. In more recent years (2000's and 2010's), the compilation and publication of national and regional spider species check-lists allowed presence data to be available to the masses which aided in progressing modern surveying in provinces which had otherwise not ben inventoried (Bennett et al. 2019). Subsequently, Environment Canada used one of these species lists as a base-line in which to build a collective assessment on the conservation status of spiders in Canada on a national and regional scale. Abundance and species distribution of spiders were contributed and from which an updated checklist was published (Bennett et al. 2019). This checklist stated that 1399 known spider species were found in Canada. This number had been replaced with 1477 spider species due to the rapid accumulation of new records which emerged after the publication of the updated national and regional checklists of Canadian spider species (Bennett et al. 2019). This number is estimated to only increase, with the rise in importance of DNA barcoding, at approximately 20 new species being added annually as of 2006 (Bennett et al. 2019). The study on spider diversity at Hogarth plantation using pitfall traps has yielded results directly applicable to the field of spider taxonomy and systematic. It also targets cryptic ground-dwelling spiders with the use of pitfall traps to collect samples. Given a more broad application of this study the data resulting would be useful in taxonomic revisions of ground-dwelling spiders in a supporting role to DNA barcoding.

MATERIALS AND METHODS

Location Description

The spider surveys took place in the District of Thunder Bay, Ontario approximately 10 kilometers west of the city by the same name. The experiment sites were located within two woodlots owned by Lake University Faculty of Natural Resources and Forestry known as Hogarth 1 and 2. Figure X shows Hogarth Forests proximity to the City of Thunder Bay. Hogarth Forest is located within the Ontario shield ecozone and ecoregion 4-W (Pigeon River Ecoregion) see figure X for geographical context within the Ecological Land Classification (ELC) system.



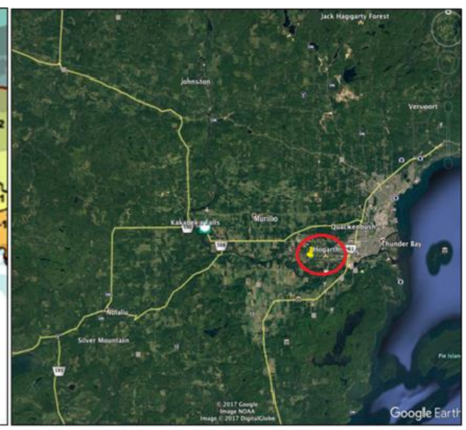


Figure 2. Location of forest ecoregion in NW Ontario. Arrow indicates location of the city of Thunder Bay, ON (Henne, 2018)

Figure 1. Location (circled in red) of spider biodiversity study areas near Thunder Bay, ON (Henne, 2018)

The Ontario Shield Ecozone is composed mainly of boreal forest with areas of Great Lakes-St. Lawrence (GLSL) forest and lays on Precambrian bedrock (Crins et al. 2009). Ecoregion 4W is located in the Quetico section of the GLSL Forest Region where the dominant forest cover-types includes boreal and GLSL species (Crins et al. 2009). The forest cover-types dominating the boreal forest includes white spruce (*Picea glauca* (Moench) Voss), black spruce (*Picea mariana* (Mill.) BSP), balsam fir (*Abies balsamea* (L.) Mill.), and tamarack

(*Larix laricina (*Du Roi) K. Koch) with some white pine (*Pinus strobus* L.), jack pine (*Pinus banksiana* Lamb.), trembling aspen (*Populus tremuloides* Michx.), balsam poplar (*Populus balsamifera* L.) and white birch (*Betula papyrifera* Marsh.) in southern potions of the boreal

Figure 3. Photographs of study sites A) Hogarth 1, B) Hogarth 2. Each pitfall was replicated 5-10 times along a transect in a random arrangement. Each trap was separated by 5 m (Henne 2018)

forest (Henne 2018). The GLSL forest cover-types includes primarily white pine (*Pinus strobus* L.) and red pine (*Pinus resinosa* Ait.) with some red maple (*Acer rubrum* L.), sugar maple (*Acer saccharum* Marsh.), and bur oak (*Quercus macrocarpa* Michx.) (Henne 2018).

Field Methods

Hogarth 1 and 2 sites, as seen photographed in figures X and X, where described as featuring red pine stands of differing age classes with areas of open canopy composed of flowering plants, shrubs, and grasses. Spiders were collected using Nordlander Pitfall traps. The Nordlander Pitfall trap design (see figure X) entails holes being drilled around the rim of a plastic container with a lid and buried so as to have the holes flush with the surface of the ground (Pearce et al. 2005). Traps often contain luring and/or preservation agents, and have a cover suspended over the trap to prevent the accumulation of rainwater and debris (Pearce et

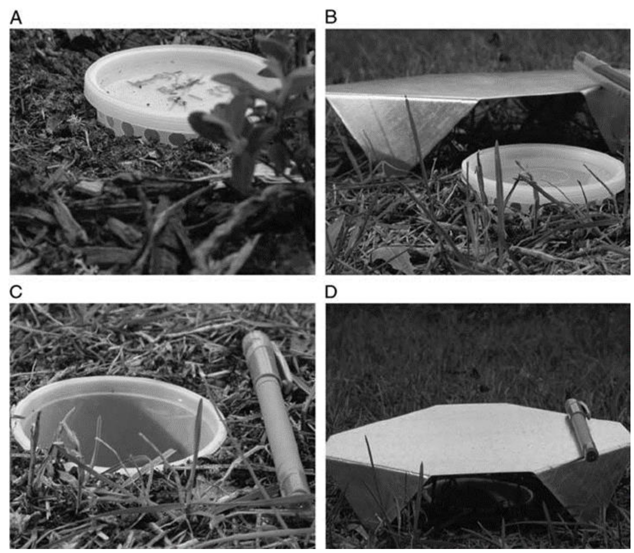


Figure 4. Design for a Nordlander Pitfall trap (Lindgren 2012)

al. 2005). Plastic cups with a volume of 237 ml where used at Hogarth 1 and 2 sites. The plastic cups contained a 25% propylene glycol to 75% water solution for the purpose of killing and preserving the specimens. 5 to 10 traps were set per sample site and were established along a 40 metre transect with traps at every 10 metres. Traps ran at the Hogarth 1 site on June 27th, July 10th, and August 17th of 2018 while at Hogarth 2 they ran on July 3rd, July 13th, and August 17th 2018. Specimens trapped were collected, labelled, and stored frozen in the propylene glycol-water solution in which they were trapped.

Lab Methods

Samples were thawed and sorted by morphospecies to isolate spiders (*Araneae*) from other invertebrates trapped such as ants (*Formicidae*), mites (*Trombidiformes*), harvestmen (*Opiliones*, and ground beetles (*Coleoptera*), spiders being the focal order of this study. Spiders were differentiated from insects by several key features; presence of 2 body segments, 8 legs, 2 pedipalps, spinnerets and silk glands, 8 eyes (sometimes 6), fanged chelicerae and poison glands (Kaston 1982). Spiders were placed into 3 ¼ oz plastic cups with 80% Ethanol and labelled with their associated site number, trap number, and date. This initial coarse level identification took place from January 28th 2019 until February 8th 2019 in the Entomology Laboratory (Faculty of Natural Resource Management, Lakehead University).

From April 7th 2021 until April 11th 2021 the spiders were identified to the family taxonomic rank at a private residence using a microscope lens attachment for smart phones and a headband magnifier. Due to evaporation of the 80% ethanol over time 80% isopropyl alcohol was added to the sample cups to continue preservation of the specimens. The process with which the spiders were identified by involved grouping individuals of visual similarity together from one trap first than taking photographs of each specimen using the clip-on macro lens and comparing a combination of identifying features to available resources. These key identifiers include eye count and pattern, body colouration and pattern, orientation of fangs, presence of teeth on chelicerae, proportion of the legs-to the body, over-all size, and length and count of spinnerets. Photographs of select spiders collected and key identification features of their families are described in figures 7, 8, 9, 10, 11 and 12. N/A was assigned to spiders <1mm as identification to family was not possible.

Once a spider was identified it was logged on a paper copy as well as inputted to an excel file both of which documented the families represented in a trap and how many individuals per family were present. This process was replicated for each trap, at each site, per date. Data sheets can be found in appendix X.

RESULTS

The data derived from identifying and creating counts for the families of spiders trapped at Hogarth 1 and 2 was consolidated in order to create cohesive charts representative of change over time. Individual trap family counts from the same site and date were merged as seen in table X and X. Pie charts (figures X,X,X,X,X,X) and bar graphs (figures X and X) were generated to visually depict the trends observed in spider family abundance at Hogarth 1 and 2 sites over the course of the months of June, July, and August and are referenced in the discussion section.

Table 1. Spider families and counts from Hogarth 1 site on June 27, July 10, and August 17 of 2018

Site	Date	Family	Number of individuals
Hogarth 1	6-27-2018	Agelenidae	2
		Clubionidae	6
		Corinnidae	2
		Gnaphosidae	12
		Lycosidae	220
		Salticidae	3
		Thomisidae	16
		N/A	14
			275
Hogarth 1	7-10-2018	Amaurobiidae	1
		Clubionidae	2
		Gnaphosidae	8
		Lycosidae	105
		Salticidae	3
		Theridiidae	2
		Thomisidae	7
		N/A	4
			132
Hogarth 1	8-17-2018	Amaurobiidae	1
		Agelenidae	3

		Anyphaenidae	1
		Clubionidae	1
		Gnaphosidae	13
		Lycosidae	123
		Thomisidae	3
		N/A	433
			578

Table 2. Spider families and counts from Hogarth 2 site on July 3, July 13, and August 17 of 2018

Site	Date	Family	Number of individuals
Hogarth 2	7-3-2018	Gnaphosidae	5
		Lycosidae	18
		Thomisidae	4
		N/A	2
			29
Hogarth 2	7-13-2018	Clubionidae	2
		Gnaphosidae	1
		Lycosidae	11
		Salticidae	4
		N/A	1
			19
Hogarth 2	8-17-2018	Amaurobiidae	1
		Clubionidae	1
		Corinnidae	2
		Gnaphosidae	3
		Hahniidae	25
		Lycosidae	54
		Miturgidae	1
		Pholcidae	1
		Salticidae	2
		Theridiidae	1
		Thomisidae	4
		N/A	251
			346

Immediate results to be noted are that over the course of the study 13 unique Araneae families were trapped and a total of 1,379 individuals spiders. Families represented in this study are as followed: funnel weavers (*Agelenidae*), hackledmesh weavers (*Amaurobiidae*), ghost spiders (*Anyphaenidae*), sac spiders (*Clubionidae*), antmimic and ground sac spiders (*Corinnidae*), ground spiders (*Gnaphosidae*), hahniid spiders (*Hahniidae*), wolf spiders (*Lycosidae*), prowling spiders (*Miturgidae*), cellar spiders (*Pholcidae*), jumping spiders (*Salticidae*) cobweb weavers (*Theridiidae*), and crab spiders (*Thomisidae*).

On the 27th of June, 2018 a total of 275 individual spiders were trapped at the Hogarth 1 site. 7 of the 13 families were present and their counts are demonstrated in table X. Lycosidae had the highest count at 220 followed by Thomisidae (16) and Gnaphosidae (12). N/A individuals were comparable to the high counts as well with 14 individuals. Meanwhile, at Hogarth 2 site on July 3rd, 2018 a total of 29 individual spiders were trapped with 3 families present. Again, Lycosidae had the highest family representation at 18 individuals while N/A had the lowest (2).

The samples collected from Hogarth 1, July 10th 2018, summed 132 individual spiders and derived from 7 separate families. The family representation was similar to those noted from Hogarth 1 on June 27th 2018. Lycosidae had the highest count at 105 individuals followed by Gnaphosidae (8) and Thomisidae (7). Time comparable, the Hogarth 2 site on July 13th of the same year had 19 individual spiders collected. These 19 spiders were from 4 different families with Lycosidae fronting the counts once again.

On August 17th, 2018 578 individual spiders were trapped at the Hogarth 1 site. The spiders belonged to 7 distinct families, though, the majority of the individuals were not able to be identified due to their small body size and therefore were classified as N/A. N/A made up 433 individuals of the total count for this site/date. The next grossly represented family was Lycosidae with 123 individuals. Similarly, the Hogarth 2 site trapped 346 individuals on the same day having 11 of the 13 unique families represented. 251 spiders of the total 346 were also classified as N/A rendering N/A the majority of the families composition for this site. The family Hahniidae was also observed for the first time in the study and in large quantities which was unique to this site and date with 25 individuals. Otherwise, the Lycosidae count was also high at 54 individuals.

DISCUSSION

Data on Araneae families composition and individual spider counts collected from Hogarth sites 1 and 2 from mid-June to mid-August 2018 have been inputted into bar graphs and pie charts with the purpose of analyzing trends relating to spider diversity overtime at Hogarth Plantation.

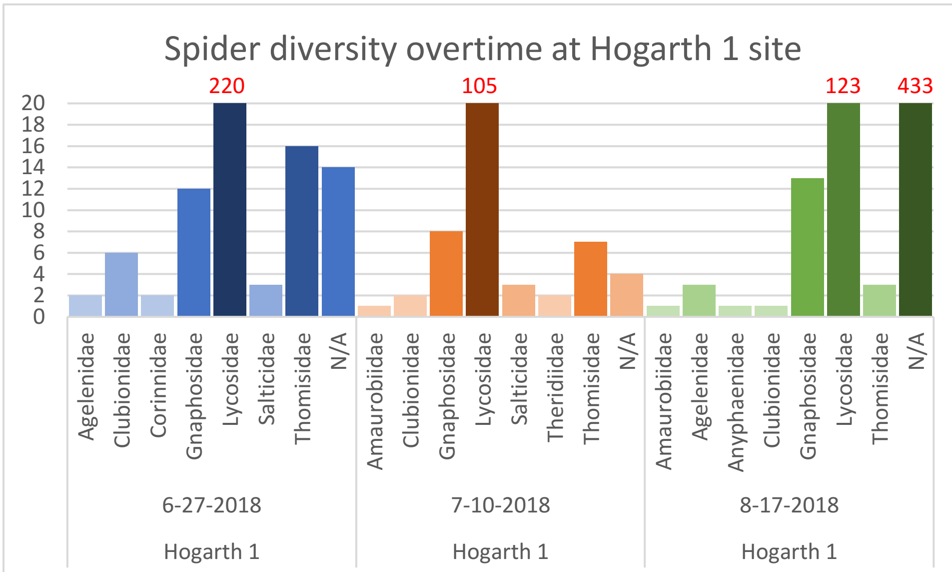


Figure 6. Diversity of spider families overtime at Hogarth 1 site (counts of individuals per family over time)

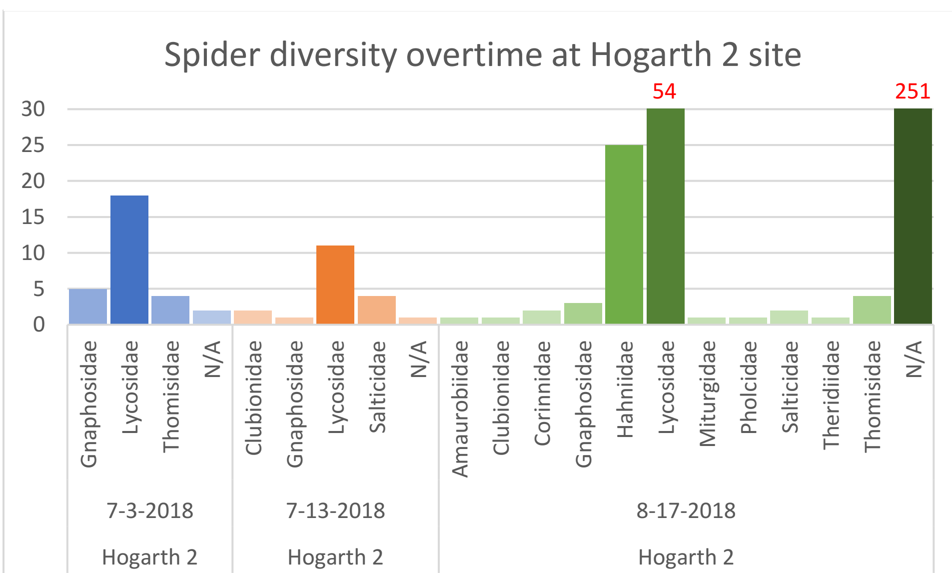


Figure 5. Diversity of spider families overtime at Hogarth 2 site (counts of individuals per family over time)

Upon inspection of figure X, which is specific to the Hogarth 1 site, Lycosidae is the family with the highest representation over the three study dates. This high level of representation was to be expected as wolf spiders are ground-dwelling spiders widespread across Canada and have the most diverse speciation of all the families in the country as well (Bennet n.d.). Their habitat is highly variable ranging from fields, to shorelines, open wooded-areas, and tundra. Bennet states that pitfall traps set in any open area in the Northwoods would be flooded with wolf spiders. Their peak abundance in late June (220 individuals) compared to proceeding months is explained by their increase in activity in spring as result of courtship and mating between males and females while the explosion in the N/A categories count (433 individuals) in August (see figure X) was the responsibility of the spiderlings being hatched (Bennet n.d.). Female wolf spiders are known to carry their egg sacs, attached at the spinnerets as well as the young spiderlings on specialized hair (setae) on their abdomens, a number of females with egg sacs were found in samples collected on August 17th at Hogarth 1 and 2 sites (Bennet n.d.). This trend is also demonstrated in the Hogarth 2 site data where Lycosidae is the most abundant family over the three study dates with the exception of the final date in August where the N/A category has increased exponentially and surpassed the counts of Lycosidae.

Figure 7. Lycosidae displaying 8 eyes in 3 rows (4 in front, 2 large posterior medians, 2 large posterior laterals) collected from Hogarth Plantation (Harrison 2021)

The next most common families trapped at Hogarth 1 and 2 sites are Thomisidae and Gnaphosidae. In figures X-X the family Thomisidae (crab spiders) is shown to make-up between 0 and 14% of all individual spiders caught in the study and Gnaphosidae (ground spiders) between 1 and 17%. These results were to be expected as crab spiders are well represented throughout Canada's boreal forest as well as their habitat needs correlating with the study site vegetation communities (Bennet n.d.). Crab spiders are typically found in fields, meadows, and woodlots diurnally hunting on the surface of flowers to ambush pollinators (Weber 2013). Hogarth Plantation being a woodlot and the study sites featuring open areas with flowering plants Thomisidae presence is to be expected. The collection of ground spiders when running pitfall traps is also typical. The family Gnaphosidae is composed of common ground-dwelling spiders with a preference for open dry habitats such as in grasslands, leaf litter, under rocks, and in the crevices of tree trunks (Platnick & Dondale 1992). They are present year-round, maturing in late spring and laying their eggs in late summer which explains their higher numbers on June 27th in Hogarth 1 and July 3th in Hogarth 2 compared to subsequent trapping dates. This trend runs parallel to that of Lycosidae and most other families collected in the study.

Figure 9. Thomisidae displaying 8 eyes in 2 curved rows (laterals on tubercles) and legs held forward in a crab-like position, collected from Hogarth Plantation (Harrison 2021)

Figure 8. Gnaphosidae displaying tubular spinnerets in pairs, collected from Hogarth Plantation (Harrison 2021)

Clubionidae and Salticidae are the next most represented families to Lycosidae, Thomisidae, and Gnaphosidae. Clubionidae (sac spiders) represent 0-11% of all individuals collected and Salticidae (jumping spiders) represent 0-21% of all individual spiders (see figures X-X). Most members of the Clubionidae family are nocturnal and therefore prefer the darkness provided by leaf litter or other plants in forests, swamps, and bogs (Dondale & Redner 1982). Sac spiders typically spend hours of daylight in silken tubular “sacs” of their own construction which inspired their name. Individuals of the Clubionidae family can be collected by pitfall traps therefore their presence in the samples at Hogarth 1 and 2 site wasn’t uncommon. The consistent presence of the family Salticidae is more uncommon though. Salticidae encompasses species of jumping spiders and is the largest family of Araneae globally (Bennet n.d.). Salticidae, although being as diverse as wolf spider across Canada, are typically not targeted by collection methodologies exclusive to pitfall traps. Jumping spiders are most active during the day, being agile and strongly visually orientated (Bennet n.d.). They are found in sunny locations among leaves and bark (Weber 2013). Jumping spiders highly developed vision is a result of their large anterior median eyes which they have the ability to move. Weber states they have the ability to identify their prey from over 30 cm away, that in conjunction with their strong agility presumably would lessen the effectiveness of pitfall traps in the capture of jumping spiders.

Figure 10. Salticidae displaying massive anterior median eyes and posterior laterals towards the back of the head, collected from Hogarth Plantation (Harrison 2021)

Other stalk and ambush spider families which were collected at Hogarth 1 and 2 sites include: Miturgidae (prowling spiders), Corinnidae (antmimic and ground sac spiders), and Anyphaenidae (ghost spiders). Web hunting spiders were also collected at the study sites, the families represented included Hahniidae (hanhid spiders), Pholcidae (cellar spiders), Theridiiae (cobweb weavers), Agelenidae (funnel weavers), and Amaurobiidae (hackledmesh weavers). Although the above listed families were present, their counts were limited and rendered them a less significant portion of the composition of families present at Hogarth 1 and 2 sites. As seen in figures X-X, the above listed families had counts of 0-3 individuals per date and site (with the exception of the family Hahniidae who had 25 individuals collected on one date). As consequence of their limited counts trend analysis of their abundance overtime could not be made. What the presence of these species does indicates is the varying level of diversity comparing the Hogarth 1 site to the Hogarth 2 site. The number of families in Hogarth 1 stayed constant at 7 families collected per date while in Hogarth 2 the number of families collected increased at each date sampling took place.

Figure 11. Hahniidae displaying long outer spinnerets and brown chevrons on its abdomen, collected at Hogarth Plantation (Harrison 2021)

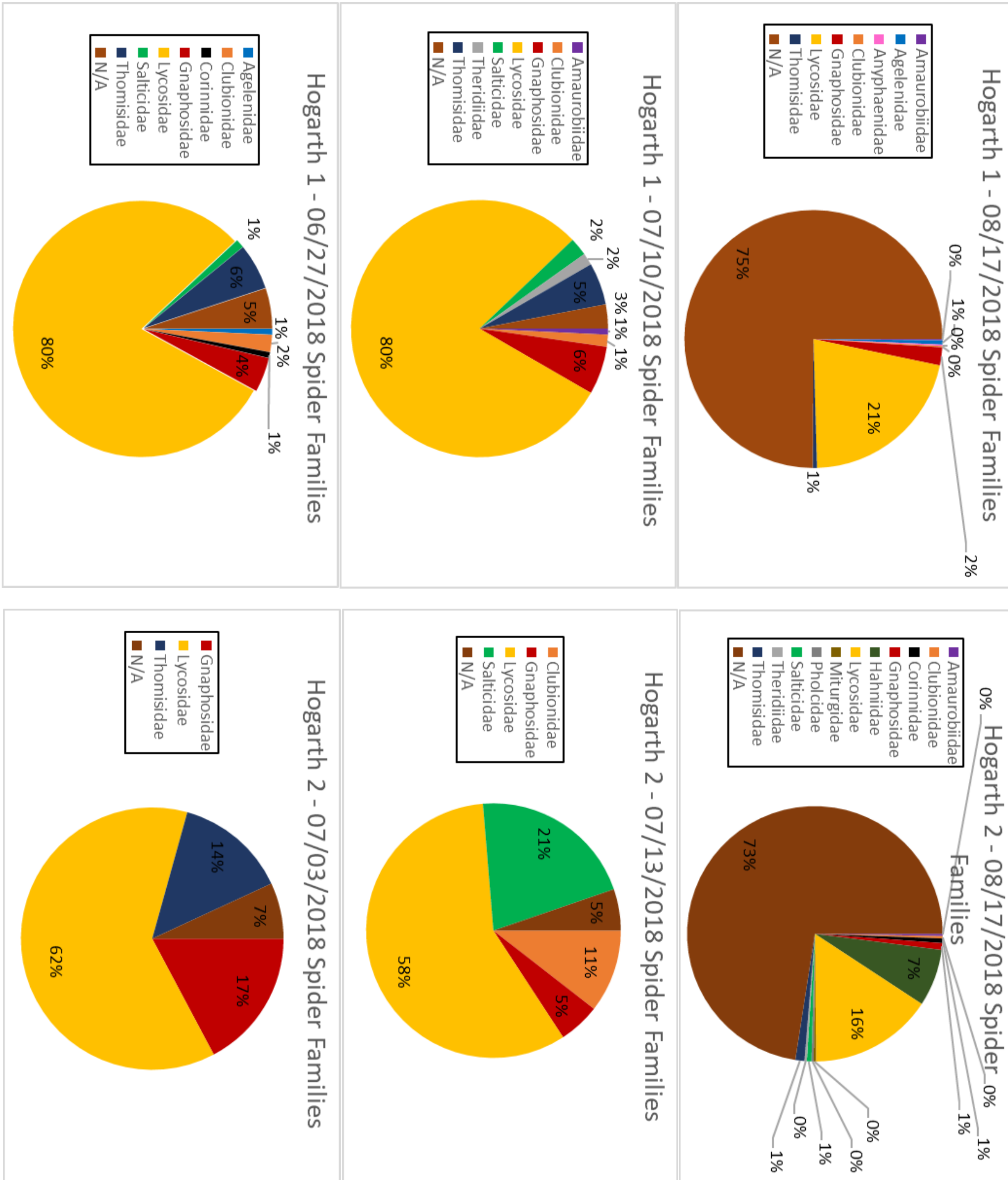


Figure 12. Hogarth 1 and 2 Spider Families

CONCLUSION

Results gathered from analyzing the composition of Araneae families and counts of individual spiders collected at Hogarth 1 and 2 study sites are as following: when taking into consideration the time aspect to how the family compositions changed, the Hogarth 1 study site stayed constant in regards to number of family present. From the June study date through until the august study day 7 families were observed . The Hogarth 2 study site defied this trend in that the number of families present exponentially grew as the study dates proceeded. In early July 3 families were observed, than 4 in mid July, followed by 11 in mid August. Therefore, it can be concluded that the Hogarth 2 study site had higher diversity than Hogarth 1. Upon assessing the counts for individuals belonging to each family Hogarth 1 has higher sums compared to Hogarth 2. Hogarth 1 had a total of 985 individuals trapped over the course of the study while Hogarth 2 only had 394. Therefore, Hogarth 1 had higher abundance of spiders than Hogarth 2.

The composition of families were relatively stable between the two study sites. Lycosidae dominated the family counts, particularly earlier in the summer when many spiders are known to be courting and mating while on the final study date in August individuals represented by the N/A category was more prevalent due to the influx of juveniles hatching in late summer. This trend carried true through the other dominant families in this study as well such as Thomisidae and Gnaphosidae, who were the next most represented families (still significantly less than Lycosidae), followed by Salticidae and Clubionidae.

In conclusion, there are observable trends associated with spider diversity over time at different study sites within the same ecoregion and applications of this data are plentiful and diverse such as to evaluate different sampling techniques, assessing sustainability of forest management practices through use of spiders as bioindicators, and supporting taxonomic and systematic barcoding research. Recommendations for furthering the research would involve performing more surveys in Hogarth Plantations ecoregion (4W) as well as in other forest ecosites such as 3W which neighbours the latter. This would facilitate the comparison of Aranea assemblages and could provide information on if assemblages of spider families are particular to their ecosite and if that relationship persists over different spatial scales. Araneae identification should be taken to a species level to allow diversity indices to be calculated, generation of accumulation curves, and the use of EstimateS to statistically compare ecosites.

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APPENDICES

APPENDIX A: ECOZONES, ECOREGIONS AND ECODISTRICTS OF ONTARIO (CRINS 2009)