Assessing spider (Araneae) diversity and pitfall trap retention in canola (*Brassica napus* L.) agroecosystems in north-central Alberta, Canada

by

Kirra Kent

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Department of Agricultural, Food and Nutritional Science
University of Alberta

Abstract

Little is understood about the role of spiders (Araneae), their community composition, and predator-prey interactions in canola agroecosystems. Understanding these relationships may inform management decisions to effectively use spiders as biological control agents against insect pests. In 2021-22, a study was conducted to assess spider diversity in canola (*Brassica napus* L.) fields in the aspen parkland region of Alberta. The initial sampling regime installed traps on the edge and within the field interior, with few spiders captured. To overcome this, additional experiments in 2023 tested modified pitfall trap designs, to improve the retention rates of all spiders. Modified trap designs consisted of a combination of three factors: trap size, presence/absence of polytetrafluoroethylene (PTFE), and presence/absence of preservative fluid (propylene glycol). PTFE is a substance used for creating non-stick surfaces, which causes spider silk to fail to adhere effectively. Traps with and without preservative were included to test if PTFE could improve the retention of live spiders. Glass beads were used as they provided hiding spaces without damaging the traps inner walls. Beads were only employed in the 24-hour sampling periods, all 7-day sampling periods employed only preservative filled traps, which were treated or untreated with PTFE. Traps were installed in two habitat types, herbaceous edges, and woody tree edges. Across all years of this study, the spider community in canola was dominated by two species in the family Lycosidae: *Pardosa distincta* (Blackwall, 1846) and *Pardosa moesta* Banks, 1892. Trap diameter, PTFE application and preservation method impacted the abundance, diversity and richness of spiders collected. Large trap sizes treated with PTFE increased the abundance, diversity and richness of spiders captured, but only in tree-edge habitat. Taken collectively, this research will further our understanding of the role of abundant

spider species in the aspen parkland-canola agroecosystem and offer a novel technique for improving the passive-live collection of spiders.

Preface

This thesis represents the original contributions of Kirra Kent. In 2021, samples were collected by Aldo Rios Martinez, jointly by Aldo and myself in 2022, and independently by me in 2023. I identified all the spiders, analysed the data, and wrote first drafts of all chapters. Dr. Boyd Mori, Dr. Jaime Pinzon, and Shawn Abraham reviewed and edited the chapters; after which I incorporated their suggestions in the final version of this thesis. Summer students working in the Mori Laboratory provided support setting up and maintaining field experiments and collecting and sorting samples. Dr. Mori developed the original research concept, and I and Dr. Pinzon added ideas and expertise to incorporate spider diversity analyses and pitfall trap retention experiments.

Dedication

Edwin Hennig, grandfather, for fiercely supporting me in anything I wanted to do and teaching me a wide variety of useful skills.

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List of Abbreviations

Abbreviation	**Definition**
PTFE	Polytetrafluoroethylene
RDA	Redundancy analysis
CCA	Canonical component analysis
AIC	Akaike information criterion
ISA	Indicator species analysis
GAMLSS	Generalized additive model for location, scale and shape
IndVal	Indicator Value
D0	Trap treatment: Dry trap, filled with beads, no PTFE applied
DF	Trap treatment: Dry trap, filled with beads, PTFE applied
PG0	Trap treatment: Propylene-glycol filled trap, no PTFE applied
PGF	Trap treatment: Propylene-glycol filled trap, PTFE applied

Chapter 1. Introduction

1.1 Ecosystem services

Documenting biological diversity is a fundamental component of ecology and is necessary to assess areas of critical concern for community and species conservation. One critical area of interest, and a very active field of study, is the impact of human land use (Foster et al. 2003). This concern is not based solely on the desire to prevent extinctions due to anthropogenic causes, but also on retaining ecosystem services provided by natural biota present. Despite representing a majority of the animal diversity on earth, arthropods are often neglected in conservation planning and consideration compared to larger, conventionally charismatic fauna like birds and mammals (Dunn 2005). Simultaneously, their role as major contributors to ecosystem services are widely recognized (Dangles & Casas 2019; Elizalde et al. 2020). Arthropods provide a multitude of ecosystem services including pollination, pest control, decomposition, and soil aeration among many others, and provide key nutritional resources for other organisms as prey (Schowalter et al. 2018). In agroecosystems, the role of the semi-natural habitats and their contribution to biodiversity and ecosystem services is under renewed interest, particularly for their potential impact on natural pest control and pollination services (Duflot et al. 2015; Holland et al. 2016; Tscharntke et al. 2016). The ecosystem services provided by arthropods are one of the many reasons why effective sampling of these organisms is critical to understanding ecosystem makeup and function (Prather et al. 2013).

1.2 Effect of uncultivated habitats on ecosystem services

The retention of uncultivated, semi-natural, habitats within the broader agroecosystem is vital to maintain ecosystem services as they act as refugia for biodiversity (Bianchi et al. 2006). An agroecosystem refers to both cultivated fields and the larger surrounding region, which includes a variety of uncultivated and semi-natural habitats within the broader habitat matrix

(Moonen & Bàrberi 2008). These habitats support overwintering, offer additional food sources, and generally provide a more stable environment than the adjacent cultivated land (Bartual et al. 2019). They can broadly be categorized as semi-natural grasslands, woodlands, or wetlands, where vegetation resembles the natural habitat but are still impacted by nearby agriculture activity (Duflot et al. 2015).

Natural areas increase the abundance of arthropod predators (e.g., spiders) in cultivated areas, but the impact of increased predator abundance on enhanced pest suppression is variable (Bianchi et al. 2006). This may be due to the quality of 'service' offered by different predator species as certain predators are more effective at controlling pests than others. Thus, simply increasing the abundance of predators may not be an effective management strategy compared to retention of specific predators known for their pest control abilities, on a crop by crop basis (Birkhofer et al. 2018). For example, the invasive spider *Cheiracanthium mildei* L. Koch 1864 has been shown to have a greater pest management potential in California vineyards than comparable native species, which may be due to the combination of the specific preferences of spiders and the management practices in the vineyards (Hogg & Daane 2011; Winter et al. 2018; Nardi et al. 2019). In small systems such as mixed plant gardens, the presence of spiders, of any origin, reduced pest damage up to three times on radishes, broccoli, potatoes and tomatoes (Riechert & Bishop 1990). While in a rice paddy system the presence of small brown plant-hopper nymphs (*Laodelphax striatellus* (Fallén 1826)) declined with a higher abundance of tetragnathids, a group of spiders that construct horizontal orb webs (Baba et al. 2018).

Like other arthropods, spider communities in agroecosystems are stratified by ecosystem boundaries, both laterally (i.e., field edge to interior) and vertically (i.e., soil surface to plant canopy) (Dauber & Wolters 2004; Pompozzi et al. 2021). Lateral stratification can result in an “edge effect”, which is the observed trend of increased species richness at the boundary between habitats (e.g., field edges and semi-natural habitats), as these transitional zones exhibit characteristics of both habitats (Dauber & Wolters 2004). Spiders are highly sensitive to edge effects in both agricultural and forest systems (Larrivée et al. 2008; Baba et al. 2018), but the impact on community composition differs. Edges are generally beneficial to the species found in agricultural fields, while forest edges create disturbances which can limit the distribution of sensitive interior forest species (Larrivée et al. 2008; Galle et al. 2019). In agricultural systems, many field edges are adjacent to semi-natural habitats that can increase ecosystem services, enabling accelerated colonization of field interiors by spider and other arachnids (Galle et al. 2019). The recolonization process occurs as plants reestablish in the field, providing both food for prey items, and structured habitat for foliage dwelling spiders. In addition to lateral stratification, vertical stratification between foliage and ground-dwelling communities is associated with distinct ecological niches and minimal overlap (Culin & Rust 1980). Resource availability determines the pattern of stratification for foliage- and ground-dwelling spiders, and these colonization patterns have been found to be relatively consistent within various agricultural landscapes (Oguri et al. 2014; Samu et al. 2018).

Comprehensive documentation of diversity supports conservation research, especially for taxa with documented preferences for specific microclimates and microstructures in ecosystems. Guild composition and spider species richness vary across major cropping systems, with compositional differences resulting from the combined effects of recolonization from nearby refugia and the structural complexity of the crop itself (Uetz et al. 1999; Nyffeler & Sunderland 2003). Guilds refer to taxonomic groups that use similar strategies to exploit a variety of resources; for spiders, guilds describe various hunting strategies employed (Cardoso et al. 2011).

Many of these hunting strategies are in part dependent on the vegetation, either for web anchoring, camouflage, or as substrate for effective foraging. In annual crop systems, both ground- and foliage-dwelling guilds must recolonize each year, resulting in a transient and vulnerable community that may be dependent on the stable, semi-natural habitat along the crop edge (Gallé et al. 2018). Research across multiple crops and climatic zones suggests guild-level taxonomic differences in how spiders use crop plants compared to weeds and ground cover plants (Balfour & Rypstra 1998; Downie et al. 2000; Birkhofer et al. 2013). For example, orb- (Araneidae) and sheet-weaving spiders (Linyphiidae) built more webs in areas with high weed density, in both soybean and maize, resulting in a higher number of pests captured per growing season than crops with higher weed management intensity (Balfour & Rypstra 1998; Diehl et al. 2013). Understanding the guild composition in agroecosystems can guide both conservation and effective manipulation of the agroecosystem environment to promote the activity of the most effective guilds on relevant pests (Marc & Canard 1997; Tscharntke et al. 2016; Samu et al. 2018).

1.3 Spiders in canola agroecosystems

Spiders are one of the most abundant predators and effective insect pest control agents in agroecosystems (Nyffeler & Benz 1987; Alderweireldt 1994a; Carter & Rypstra 1995; Benamú et al. 2017). In soybean agroecosystems, increased spider density is correlated with reduced insect herbivory damage (Carter & Rypstra 1995) and in continental climates, spiders can aid in spring pest suppression as their population establishment peaks in the early season (Royauté & Buddle 2012; Cuff et al. 2021). An important crop in the continental climate region of North America and Europe is canola (oilseed rape), *Brassica napus* L. 1753 and *Brassica rapa* L. 1753 (Brassicaceae). Canola is a major crop, occupying over 20 million acres of farmland on the Canadian Prairies (Statistics Canada, 2024); however, the role of spiders in insect pest management is understudied (Furlong et al. 2008; Sarwar 2013; Benamú et al. 2017). As not all spiders offer equal pest control potential and their community composition differs widely among agroecosystems, it is important to assess their pest control potential by crop (Marc & Canard 1997; Sunderland & Samu 2000).

Canola hosts several pests, weeds, and diseases that negatively impact productivity. Flea beetles (*Phyllotreta* spp. (Coleoptera: Chrysomelidae)), diamondback moths (*Plutella xylostella* (L. 1758) (Lepidoptera: Plutellidae)), bertha armyworms (*Mamestra configurata* Walker 1856 (Lepidoptera: Noctuidae)), and lygus bugs (*Lygus* spp. (Hemiptera: Lygaeidae)) are the most destructive arthropod pest taxa (Dosdall & Mason 2010). Integrated pest management (IPM) in Canada combines traditional methods such as pest monitoring, resistant crop varieties, crop rotation, early seeding, reduced tillage, and chemical pesticides, with conservation-based practices such as maintaining natural areas near crops that promote the abundance of natural enemies (Öberg et al. 2007; Dosdall & Mason 2010; Gavloski et al. 2011). Some research has been previously conducted on spiders in canola. Spiders have the potential to aid in managing aphid populations, and members of at least one genus of wolf spider (*Pardosa*) were found to consume flea beetles in the early growing season in canola (Ekbom et al. 2014; Amjad et al. 2017; Elliott et al. 2023). Spiders can also consume diamondback moth, with mortality as high as 20%, and in a gut content study, two of three focal spider species were found to have consumed diamondback moths (or larvae), despite low density of both the moths and the spider species (Quan et al. 2011; Farias et al. 2021). However, these studies occurred in non-continental climates; thus, it is important to assess the diversity of and potential impact of spiders in each unique focal crop.

1.4 Sampling ground-dwelling arthropod diversity in agroecosystems

Sampling arthropods can be a complex process filled with many biases. There are two major categories of sampling: active, which involves collecting specimens by hand, with nets, or aspirators, and passive which involves deploying traps and returning at a later time to retrieve captured specimens (Yi et al. 2012). Both active and passive sampling share susceptibility to activity density biases, where larger, more mobile organisms are more frequently sampled (Engel et al. 2017). Across the numerous trap types employed in entomological research there are similar trapping tradeoffs. As a result, biodiversity-based research is, in part, limited by the sampling tools available. For arthropods, appropriate selection, installation, and collection of a sampling method determines how accurately a focal community can be represented (Russo et al. 2011; Boetzl et al. 2018). Selecting or modifying an inappropriate sampling technique, can leave researchers without useful data for assessing their focal questions, and an excess of bycatch that increases processing time (Popic et al. 2013). Furthermore, the composition of diversity collected may not necessarily reflect the composition of the collection area, it would reflect the taxa more likely to be caught by the sampling method employed. For these reasons, a combination of passive and active sampling is often employed to minimize potential systematic biases.

Of the numerous passive sampling methods available, pitfall traps are often used to study ground dwelling taxa. Pitfall traps are containers installed in the ground that passively capture arthropods as they fall in. They are both highly economical and effective sampling tools, which have significantly contributed to their sustained and increasing popularity since their initial conception and early implementations (Brown & Matthews 2016; Hohbein & Conway 2018). There are variations in trap material, size, color, installation style, and compounds used as arthropod retention media (Boetzl et al. 2018; Stašiov et al. 2021). Most frequently they are round plastic containers, but other factors vary extensively across study designs (Brown &

Matthews 2016). Data recovered from pitfall trap sampling is generally focused on actively moving ground-dwelling taxa (e.g., spiders, ground beetles, ants, and rove beetles) (Perner & Schueler 2004; Bergeron et al. 2013).

Pitfall traps are an activity-density biased sampling device and cannot be employed for direct population density estimates, but their use can still generate useful data for describing ground-dwelling arthropod communities (Perner & Schueler 2004; Otoshi et al. 2015). Awareness of biases introduced through the use of pitfall traps, ranging from the impact of the physical properties of the trap itself to the focal taxon's susceptibility to the different biases introduced by pitfall traps (Boetzl et al. 2018; Gardarin & Valantin-Morison 2021; Stašiov et al. 2021), can help mitigate these shortcomings. Generally, when a preservative is employed, these traps have high capture efficiency, work in a wide variety of terrestrial environments and collect sufficient individuals to support statistical analyses (Siewers et al. 2014).

Sampling arthropods without preservatives is often necessary for supporting behavioral and genetic research, but is extremely difficult for certain arthropod groups, because of their propensity for escape, or in-trap predation (Greenslade 1964; Joosse-van Damme & Kapteijn 1968). It also enables passive collection with reduced casualties of bycatch, as they can be released in the field, and specimens caught alive are all but guaranteed to be sufficiently fresh for genetic studies. Live-passive collecting is one area where pitfall traps fall short, when compared to their effectiveness when employed as a kill trap (Weeks Jr. & McIntyre 1997).

1.5 Pitfall trap designs to improve spider retention

Spiders are innately strong climbers and many can use silken drag lines to recover after falling, which confers a significant challenge to pitfall trapping (Topping 1993; Gurdebeke & Maelfait 2002; Work et al. 2002). The construction of a pitfall trap – diameter, depth, placement, and preservative, impact spider retention rate. A larger pitfall diameter increases the number of spiders captured compared to traps of smaller diameters (Lange et al. 2011). While the effect of trap depth alone has not been studied, increasing trap depth and diameter increases the abundance of spiders captured (Work et al. 2002). Placement of pitfall traps below the soil surface, where there are vertical soil walls above the trap walls, reduces spider capture rates, as the soil increases the likelihood of recovery anchor attachment, and spider escape, compared to smooth trap walls (Bergeron et al. 2013). While climbing ability is difficult to quantify, the effectiveness of silk recovery lines is known to be dependent on the ratio of the distance travelled before finding a recovery surface relative to the spider's weight (Grawe et al. 2014). When produced rapidly, the quality of the attachment point is reduced, but often still sufficiently strong to save the spider from a fall (Luff 1975; Grawe et al. 2014; Chen et al. 2021; Weissbach et al. 2021). The spider silk-quality to weight supported relationship has evolved differentially across families without the pressures exerted by man-made materials, which may be an exploitable characteristic for improving trap efficiency and capture. Under this model, web-builders with high strength silk and low mass, such as species in the family Linyphiidae, are theoretically the most difficult to accurately sample, as activity density bias is working in tandem with higher escape rates (Topping 1993; Swanson et al. 2007; Grawe et al. 2014).

Another factor that can lead to differences in the retention of captured spiders is the choice of preservative. Diluted glycol is the most effective preservative, with the addition of a detergent greatly increasing the number of Linyphiidae captured, compared to all other preservatives tested (Topping & Luff 1995; Schmidt et al. 2006). Consequently, trapping spiders without preservative is even more difficult than for most other taxa, which may constrain our knowledge of spider behaviour to those species captured more readily and limit knowledge of other more cryptic species (Watson 1990; Vaccaro et al. 2010).

1.6 Objectives

***Objective 1**: Describe the diversity of spiders in canola fields in central Alberta, Canada.*

A baseline inventory of the spider diversity in canola systems is valuable for both conservation and pest management considerations. Spider diversity can be lower in crops, but can be enhanced through semi-natural areas, supporting continued benefits from spider-provided ecosystem services (Plath et al. 2021). By sampling within canola fields and adjacent semi-natural areas, I aim to provide an initial description of the diversity of spiders in the canola agroecosystem. This baseline information will be useful to identify species that may offer pest control services (Hogg & Daane 2011). I expect to see a broader diversity of spiders in the edge habitats, as the vegetation complexity and habitat suitability are higher, and disturbance is lower (Samu et al. 1999). Previous research suggests that increased numbers of spiders in the edge does not always correlate with an increase within the field (Samu et al. 1999); however, by sampling both environments, I aim to identify which species find canola a suitable habitat (Samu et al. 1999; Prieto-Benítez & Méndez 2011). Recent research in canola indicates a low abundance of mid-sized spiders (e.g., wolf spiders in the genus *Pardosa*) and suggests that much of the pest control is accomplished by the extremely abundant and introduced ground beetle *Pterostichus melanarius* (Illiger, 1798) (Robinson et al. 2021). However, the large jaws of *P. melanarius* may reduce their ability to eat smaller prey items, subsequently limiting their diet to pests with larger body sizes (Seric Jelaska et al. 2014). This morphological limitation may be ecologically compensated by the predatory contributions of smaller spiders such as linyphiids, which may have higher susceptibility to the biases pitfall traps exert on data generated (Topping 1993; Alderweireldt 1994b).

Objective 2: Determine pitfall trap characteristics that can improve the retention of spiders.

Improving passive collection of spiders may reduce bias due to trap design and differing the propensity to escape of some spider species, which will enhance data collection (e.g., retain more species) for taxonomic and ecological studies. The inner walls of pitfall traps are still climbable by some spiders, so even if a spider is 'captured' it may not be retained due to the physical properties of the trap. With an improved passive collection method, it would be possible to investigate the pest control potential of small species (e.g., linyphiids) not easily sampled by hand, but known to be abundant in agricultural systems (Downie et al. 2000). Therefore, improving the retention potential of pitfall traps is an important component of contemporary study design if more complete diversity data is a priority.

In tandem with the improvement of diversity data, improving the retention of live spiders would allow for a wider breadth of studies on the ecology and behavior of many spiders. Spider ecology and behavior is a niche field with few entries relative to their taxonomic diversity, with the family Linyphiidae being particularly understudied (Hormiga 2000). Much of the sparse existing work focuses on the larger members of the family (mostly those in the subfamily Linyphiinae), which are easier to collect by hand (Suter 1981; Benjamin & Zschokke 2004; Deng et al. 2007). This leaves the very morphologically diverse subfamily Erigoninae mostly understudied, even compared to other members of the family (Harwood & Obrycki 2005; Heuts & Brunt 2008). In agroecosystems, this is particularly relevant because some research suggests that erigonines are only caught in large numbers due to activity differences, while others suggest they are an important source of potential pest control (Topping 1993; Downie et al. 2000). Better pitfall trap retention theoretically mitigates some of the sampling biases that come from taxon-specific differential ability to escape from traps, which will result in a better baseline understanding of the spider diversity in canola.

Here, I test several different pitfall trap designs which vary by diameter and the application of polytetrafluoroethylene (PTFE) to the inner surface walls. By coating the upper portion of the inner walls of the pitfall trap with PTFE, I expect to increase the retention rate of erigonines and other taxa, reducing biases relative to “standard” sampling regimes. PTFE is a lubricating polymer used globally to reduce surface friction and create non-stick surfaces (Li et al. 2019). I expect this outcome due to reduced effectiveness of attachment disks because of the combined effect of the PTFE and the element of surprise resulting in lower quality recovery lines when encountering pitfall traps. I expect larger trap sizes to capture a wider diversity of species, and overall, a higher abundance of spiders, as this has been previously found by other studies (Work et al. 2002).

Chapter 2. Materials and Methods

2.1 Study area

All studies were conducted in rain-fed, commercial spring-planted canola (*Brassica napus* L.) fields in the aspen parkland ecoregion north of Edmonton, Alberta, Canada (Figure 1) (Albert et al. 2006). The aspen parkland is a transitional zone between the southern prairies and the northern boreal forest (Young et al. 2006). This region is characterized by a mix of aspen and spruce stands and grasslands, much of which has been transformed for ranching of cattle, and the cultivation of canola (*Brassica napus* L. and *B. rapa* L.), wheat (*Triticum aestivum* L. 1753), and barley (*Hordeum vulgare* L. 1753) (Bailey et al. 1990; Chapagain & Good 2015). Soils in the study area are predominately black and dark grey chernozems (AGRASID 2024). Canola fields varied in area from 26 to 120 ha and were ≥ 10 km apart.

2.2 Spider diversity and composition in canola fields (Study 1)

A pitfall trap study was conducted to assess the diversity and activity density of spiders in canola fields. In each canola field, spiders were sampled with pitfall traps throughout the summer (June-August) in 2021 (n = 8 sites) and 2022 (n = 6 sites) (Table 1). Pitfall traps (Solo Cups, No Name Brand and Wholesale Club), diameter = 8.5 cm, depth = 12.4 cm) consisted of a 473-ml (16 oz) cup installed with the rim flush to the soil surface. An additional cup, with drainage holes, was placed as an insert into the first cup for ease of trap servicing (Spence & Niemelä 1994; St Onge et al. 2018). Five pitfall traps were installed 25 m apart along a 100 m transect. Two transects were installed parallel to the field edge, 0.5 m and 100 m into the field (Figure 2).

Field edges adjacent to semi-natural habitat that consisted mainly of herbaceous plants (i.e., grasses [Poaceae] and legumes [Fabacaeae]) were selected to avoid the potential influence of different plant species and architecture (e.g., heights) on spider diversity. To reduce disturbance and the potential of trap flooding due to rainfall, a corrugated plastic cover (15 x 15 cm) was installed ~5 cm above the trap and secured at the four corners using wooden dowls (Spence & Niemelä 1994; St Onge et al. 2018). Traps were filled with ~150 ml of propylene glycol (Plumbing Antifreeze, Certified, Canadian Tire, Edmonton, AB) and all samples retrieved after 1 week. Samples from all pitfalls within a transect were pooled by pouring the contents of the traps into a single 532-ml (19 oz) plastic bag (Whirl-Pak®, Uline Canada, Milton, ON) at each field. After collection, samples were stored on ice in a cooler for transportation to the laboratory where they were stored in a refrigerator at 4 °C prior to processing.

Spiders (and other arthropods) were collected over three collection periods each year (Table 1). In the laboratory, spiders were separated from other arthropods collected in each sample and stored in 70 % ethanol. Spiders were identified to the species level using relevant taxonomic literature using a dissection stereoscope (Nikon SMZ-U) (Dondale & Redner 1978, 1982, 1990; Dondale et al. 2003; Platnick & Dondale 1992; Paquin & Dupérré 2003). Spider taxonomy followed the World Spider Catalog V 25.0 (World Spider Catalog 2024). Juveniles were identified to family whenever possible but excluded from most analyses. Specimens that could not be identified to species were excluded from species level analysis but were included in analysis at family level (see *Statistical analyses*).

Five additional traps were installed in 2021-2022 following the same methodology as above, in between the previously installed traps (Figure 2), these traps were closed during week-long sampling efforts, and only activated for 24-hour collections. The traps for the 24-hour collections contained no propylene glycol, and instead soil and vegetation in a volume approximately equivalent to the glycol volume during week-long sampling periods. Spiders were only retained from the 2022 live collection. There were three 24-hour sampling periods in 2022. These samples were retrieved live and transported in one large plastic bag per transect. Transect bags were stored on ice in coolers and immediately processed upon return to lab, where specimens were placed in Eppendorf tubes and frozen at -80 °C. The 2022 24-hour samples were intended to support molecular gut content analysis; however, there were insufficient specimens captured to warrant further analyses.

2.3 Effect of trap size and PTFE application on spider sampling (Study 2)

Due to the low abundance and diversity of spiders documented from the 2021-2022 collections (see *Results*), an experiment was designed in 2023 to assess whether trap diameter, interior finish (i.e., plastic or PTFE), preservation substrate, and length of collection period influences spider sampling. Grawe et al. (2014) found a reduction in the effectiveness of spider silk attachment disks when spiders attempt to affix to PTFE-coated surfaces. Specifically, the effectiveness of silk attachment disks was dependent on the distance travelled before finding a recovery surface. Thus, various trap sizes (i.e., different diameter) were tested to manipulate the distance spiders could travel before finding a recovery surface and the inner trap surface was treated with PTFE to determine if size and finish would influence the capture rate and retention of spiders.

Spiders have become a focal point to explore their ecological networks through molecular gut content analysis (Eitzinger et al. 2019; Saqib et al. 2021). For these and other studies, spiders need to be captured alive and preserved generally within 24 hours; however, intraguild predation and spiders escaping the traps are known issues with live trapping (Weeks Jr. & McIntyre 1997; Gurdebeke & Maelfait 2002). Therefore, PTFE-coated and uncoated traps, with propylene glycol or 6 mm glass beads, were compared. Traps with propylene glycol were included as a control, as research suggests propylene glycol is the best substance to retain captured spiders (Schmidt et al. 2006).

2.3.1 Pitfall traps

Three types of plastic containers were selected as pitfall traps, based on commonly used sizes in other studies (Brown & Matthews 2016; Hohbein & Conway 2018): large (14.5 cm diameter, 16.5 cm depth, 86.5° wall slope, 2.25-l pail, Bee Maid Supplies, Spruce Grove, AB); medium (11.5 cm diameter, 7.6 cm depth, 80.7° wall slope, 16 oz deli container, 81.7° wall slope ULINE); and, small (8.5 cm diameter, 12.4 cm depth, 16 oz Solo® cup, ULINE) The small trap size was included to support descriptive comparisons of estimated spider activity with the two previous sampling years (2021-2022). The differences in trap wall slope were assumed to be inconsequential, as studies comparing funnels (shallower slope) to straight walled (steep slope) traps found no significant difference in capture rate for spiders (Lange et al. 2011; Csaszar et al. 2018).

PTFE (byFormica Fluon, Canada Ant Colony, Keswick, ON) was applied to the interior surface including the rim of each trap. A 1-cm foam swab on a wand was used to evenly apply non-overlapping PTFE bands parallel to the trap opening, while the trap was rotated for 45 s. Rotation prevented pooling of PTFE, which can reduce the effectiveness of the compound (byFormica 2024). Diffuse lighting was used to increase visualization of the PTFE bands during application as plastic coated with PTFE has a different reflectance than uncoated plastic. Due to differences in trap depths, the area coated with PTFE differed between traps (small: 94 cm^2, medium: 72 cm^2, large: 233 cm^2). All PTFE application was conducted in a fume hood, after which traps were left to dry under the fume hood for 15 min. Lids were placed on all PTFE treated traps when transported to the field to ensure PTFE was not disturbed in transit. Traps were filled in-field to different volumes with beads and propylene glycol, to accommodate the differences in depth, with the aim of maintaining a similar trap depth-diameter ratio, where approximately 25-30% of the trap height is filled with fluid (Table 3, Figure 3). A large, graduated syringe was used to fill traps in the field to ensure a consistent volume of propylene glycol was used in each trap. Beads volume was weighed, and bagged by trap size in the lab, bead volume was measured to match the fill volume of propylene glycol.

2.3.2 Experimental design

The study was conducted in ten canola fields during the summer of 2023 (June-August) (Figure 1, Table 2). Five canola fields with treed edges and five fields with uncultivated weedy-grass edges were selected to sample a broad diversity of spiders with the novel trap designs. The grass edges were dominated primarily by a mixture of fescue (*Festuca*), dandelions and their relatives (*Taraxacum* spp.) and sporadic horsetail (*Equisetum* spp.). Tree edges were dominated by cereal grasses (*Elymus* spp.) and trembling aspen (*Populus tremuloides* Michx. 1803*)*. Vegetation was identified using several field guides to the region (Farrar 1995; Wheatland County 2017; LaForge et al. 2018). Treed edges were on average 12 meters wide, while grass edges were on average 5 meters wide. Measurements were taken from the edge of the canola field to the roadside for grass edges and from the canola field to the outer edge of the tree patch for treed edges.

At each field site, 12 pitfall traps were installed at 25 m intervals along a 250 m transect within the field edge parallel to and approximately 2.5 m from the first seed row. At sites with treed edges, transects started at least 20 m away from the beginning of the tree line, where the tree line was either bisected by a road or met by a grass edge (Figure 3). This was to avoid setting up traps in corner areas where the density of trees was much higher or lower than the density found running between fields. At sites with grassy edges, transects started at least 20 m from the corners of neighboring fields.

Traps were setup following a randomized complete block design (field site = block) with all possible substrate and trap wall coating combinations represented in each size class (Table 3).

Traps utilized two plastic containers, and were functionally similar to the trap installation style in experiment 1 (Spence & Niemelä 1994; St Onge et al. 2018). Covers were 4 cm larger than the trap diameter. Identification codes were assigned to each trap to ensure the same trap was reinstalled at the same location in each collection period.

Two collection period lengths, either 24 hours (n = 5) or 7 days (n =3), were run multiple times over the growing season (Table 2). During 24-hour collections, two trap substrates were employed, propylene glycol (Certified) or 6 mm glass beads. Propylene glycol traps (n = 6) ran concurrently with live traps (glass beads) (n = 6) to compare spider activity density and retention in the dry, live traps (Table 3). A proportional volume of glass beads was used for each trap size class. A large syringe was used to avoid spilling propylene glycol on trap walls, and to ensure similar fill levels across all trap types within a size class. Premeasured glass beads were poured from bags into the traps to prevent the loss of beads and abrasion to trap walls. During each 24-hour collection period, 120 traps were active (12 traps at 10 sites), and five 24-hour collections occurred over the growing season.

In addition to the 24-hour collection periods, three 7-day collection periods occurred over the growing season (Table 2). For 7-day periods, only 6 propylene glycol filled traps (1 trap of each size class with and without PTFE-coating) were active, equating to 60 traps (6 traps at 10 sites) during each collection period. Collections were timed such that each 7-day collection had an associated 24-hour collection; the paired sampling method supported assessment of what species could potentially be captured in the 24-hour period. Between collections, exterior pitfall containers were closed using lids and plastic covers were lowered to be flush with the ground.

At the end of each collection period, samples were retrieved from each trap separately. Fine mesh bags were used to sieve samples in the traps containing propylene glycol in both the

24-hour and 7-day collection periods; the remaining propylene glycol was removed from the trap and disposed. For traps containing glass beads and live spiders from the 24-hour collection period, trap contents were carefully emptied into large plastic bags (1 liter) to reduce damage of live specimens. Samples were transported to the laboratory following the same procedures as in Study 1 (above). Live samples were processed immediately by pouring the contents of the plastic bags into water filled wash-bins, and the spiders were separated out by hand. To separate spiders out of propylene glycol traps, the contents of the mesh bags were emptied into well-lit sample trays filled with water and spiders separated out by hand. All sorted spiders were preserved in 70% ethanol and identified as in Study 1 (above). Voucher specimens are deposited in the Northern Forestry Center Arthropod Collection (Natural Resources Canada, Canadian Forest Service, Edmonton, Alberta).

After each collection period, PTFE-treated containers were retrieved and cleaned with ethanol and water, then PTFE was reapplied to maintain efficacy. Non-PTFE (untreated) traps were also retrieved and cleaned between collections. Throughout the summer two sets of containers were used, one set for the 24-hour collection, and one set for the 7-day collection.

2.4 Statistical analyses

All statistical analyses were performed in R v.4.3.1 (R Core Team 2023) using relevant packages. Figures were generated using the R package *Esquisse* v. 1.1.2 (Meyer & Perrier 2024), and readability adjustments in the image editing software, Serif’s Affinity Designer 2 v. 2.4 (Serif (Europe) 2024).

2.4.1 Diversity & habitat association

To estimate spider diversity over the sampling periods within the edge (0.5 m transect) and interior (100 m transect) of the crop (Study 1), and among trap designs in each habitat (Study 2), coverage-base rarefaction was used (Chao & Jost 2012). In contrast to individual-based rarefaction, in which estimations are compared under a minimum sample size (sample with the lowest number of individuals), coverage-based rarefaction uses a minimum sampling coverage level (sample with the lowest coverage) for comparisons, which make a more robust approach (Jost 2006, 2007). Within each year, transect data (interior or edge) was pooled across sites and sampling periods. Hill numbers (q0 = richness, q1 = exponential of Shannon's index, and q2 = inverse of Simpson's index) and coverage scores were obtained using iNext v.3.0 (Hsieh et al. 2022). For 2021-2022 (Study 1), all habitats were rarefied to a sample coverage of 94%. For 2023 (Study 2), data from the 24-hour and 7-day sampling periods were rarefied to a sample coverage of 83% and 98%, respectively. Indicator species analysis (ISA) was performed allowing site combinations using *Indicspecies* v.1.7.14 (de Cáceres & Legendre 2009), to assess if any species were significantly associated to either the interior or edge habitats. Species that were captured with a higher abundance in the interior transect are reported as a percent of total captured for that species. As pest abundance has been found to increase in the absence of natural areas, and potential pest controllers decline further from natural areas, the species with higher interior crop abundance are likely to have a higher chance of offering within-crop pest control than those found in higher abundance in edge habitats (Veres et al. 2013).

For 2023 experiments (Study 2), a similar approach as above was taken to estimate diversity and identify indicator species as a function of trap types and habitats (grass vs. tree edges) over time for both 24-hour and 7-day collection periods. Additionally, for Study 2, a Redundancy Analysis (RDA; constrained ordination) was performed on Hellinger transformed abundances to improve the model and account for the double absences in Euclidean space (Legendre & Gallagher 2001) using *vegan* v 2.6-4 (Oksanen et al. 2022). Thus, the model tested whether the variation in species composition could be explained by the different treatment variables. RDA was chosen over Canonical Correspondence Analysis (CCA) due to the short gradient nature of the data after inspection using Detrended Correspondence Analysis (DCA), which is a regression-based rescaling of beta diversity across experimental variables (Hill & Gauch Jr 1980). Singleton and doubleton (species represented by 1 or 2 individuals, respectively) were excluded prior to transformation to improve model R^2 by removing species that contribute little to the result. Model selection for RDA was performed using *vegan'*s v 2.6-4 built in *ordistep* function. Habitat, trap size and PTFE treatment were the selected variables in the final mode, no interaction effects were included as they lead to a lower R^2 and proportion of variance explained. The adjusted-R^2 was compared manually to ensure overfitting did not occur.

2.4.2 Pitfall trap characteristics influencing spider retention

To test if pitfall trap size, PTFE treatment and/or trap substrate influence the retention rate of spiders, the number of spiders captured in the various pitfall traps (Study 2) were assessed by fitting a Generalized Additive Model for Location, Scale and Shape (GAMLSS v.5.4-20) (Ziel 2022). A global model was constructed using pitfall catch-data from all families to serve as test data for the initial model structure, it included edge type (i.e., grass or treed), PTFE treatment, trap substrate (i.e., propylene glycol or glass beads), and trap size as fixed variables, and transect and trap-location within transect as random variables. Collection date was not included as a variable as it did not improve the accuracy of the model, and thus, data were pooled across collections. The following steps were employed for the creation of the global model, and subsequent models used for assessing retained abundance of specific families. After initial model selection in *Glmulti* v1.08 (Calcagno 2020), the model was secondarily assessed using *GAMLSS*, which supported treating trap-location as a potential source of autocorrelation, and a wider breadth of distribution families not supported by other generalized linear models, which ensured finding the best possible distribution family for assessing the data. Due to low abundance of most families, targeted models were fit on two of the 17 families represented in this study (Lycosidae and Linyphiidae). The global model is not reported in results as it was used for testing model structure.

In the 24-hour collection experiment, *Glmulti* was used to initially select a model for assessing the impact of different trap variables. Trap treatment variables (size, substrate, PTFE) were treated as fixed as the generic screening algorithm found that the inclusion of interaction effects negatively impacted the model fit. After initial Akaike Information Criterion (AIC) based model selection in *Glmulti*, *GAMLSS* was used for a more extensive assessment and final build of all models. *GAMLSS* was used to ensure the best distribution family was selected, using the *chooseDist* function and examination of the randomized quantile residuals. Both models used the Delaporte distribution family. Delaporte is a mathematical hybrid of the Negative Binomial and Poisson distributions, which are both appropriate for assessing count data, but the Delaporte provided the best fit (Adler 2013). The *GAMLSS* modelling package was designed to be effective with small data sets, supported best-fitting distribution family and supported the inclusion of correlation structures (Ziel 2022). *GAMLSS* provides model-assessment metrics that are suggested to be more accurate than AIC. The metrics are: quantile residuals of mean (0), variance (1), coefficient of skewness (-0.5 - 0.5), coefficient of kurtosis (3) and filiben correlation coefficient (1) (Groeneveld & Meeden 1984; Dunn & Smyth 1997; Hohberg et al. 2020). Following the scoring principles of Hohberg et al. (2020) the final *GAMLSS* model-assessment for the Linyphiidae model was based on the following metrics: mean= -0.056, variance= 0.98, coef. of skewness= 0.204, coef. of kurtosis= 3.07, filliben correlation coefficient= 0.998; and for the Lycosidae model: mean= 0.06, variance = 0.86, coef. of skewness = 0.054, coef. of kurtosis = 3.37, Filliben correlation coefficient = 0.998.

Parameters v.0.21.3 was used to test post-hoc multiple comparisons for significant main effects using Bonferroni correction to adjust *p*-values (Lüdecke et al. 2020). The *parameters* package also provides standard error and confidence intervals. A forest box plot of the response coefficients was created using *sjPlot* v. 2.8.15 (Lüdecke 2023).

Chapter 3. Results

3.1 Species diversity and composition in canola crops (Study 1)

In Study 1, during the 7-day long sampling periods (2021-2022), 669 (78 juveniles) and 495 (49 juveniles) spiders, respectively, were captured from all sites, represented by 77 spider species across 14 families (Table 4; Table S1). In contrast, only 46 live spiders were captured over the three 24-hour collection periods, which motivated the 2023 pitfall design (Study 2). In 2021 and 2022, the number of spiders captured peaked during the first collection period in June (Table 4). Spider abundance was lowest in the field interior, particularly during mid-July each year (Table 4). The most abundant families across both years were Linyphiidae and Lycosidae (Table S1). A majority of linyphiids were captured in the field interior (137), while they were half as abundant along the field edge (72). The opposite trend was observed for lycosids, with 160 captured in the field interior and 489 captured at the field edge. Similar trends were observed for crab spiders (Thomisidae: interior = 31, edge = 72), ground spiders (Gnaphosidae: interior = 5, edge = 62) and cobweb spiders (Theridiidae: interior = 22, edge = 5) (Table S1). Eight of the remaining 10 families (Tetragnathidae, Phrurolithidae, Philodromidae, Hanhniidae, Clubionidae, Titanoecidae, Agelenidae, and Liocranidae) were represented by less than 20 individuals each, with most of their capture occurring at the edge. The two remaining families (Amaurobiidae and Araneidae) were represented by a single individual each in the field interior.

There were 17 species shared across both habitats and years. There were 25 species caught in the edge both years, and 18 caught in the interior both years, including those shared across all habitats. In 2022, there were 11 species caught only in the edge and five species caught only in the interior. In 2021 there were 13 species caught only in the edge and eight in the interior. Two species were caught in the edge of 2021 and 2022, one species was shared between the edge and interior of 2022, one species was caught in the edge of 2022 and the interior of

2021. There were 10 species caught in the edge and interior of 2021, but not found in the 2022 samples. One species was caught in the edge of 2021, 2022, and interior of 2022. Another single species was caught in the edge and interior of 2022, and the interior of 2021. Four species were caught in the edge and interior of 2021, and the edge of 2022. (Table S1).

In both 2021 and 2022 there were no significant differences in estimated spider richness (q0) between the edge and interior transect. However, there were marginal differences in Shannon's equivalent (q1) and Simpson's equivalent (q2) measures in both years; in 2021 the interior habitat had higher values for both metrics (interior: q1 = 24.2, CI = 3.49 & q2 = 16.6, CI = 3.37; edge: q1 = 18.7, CI = 2.14 & q2 = 10.3, CI = 2.45). In 2022, the opposite was observed, were the edge was slightly more diverse for0 both Shannon's (q1) and Simpson's (q2) equivalent measures (interior: q1 = 14.8, CI = 2.9 & q2 = 8.02, CI = 1.96; edge: q1 = 20.7, CI = 2.63 & q2 = 14.7, CI = 1.83) while Simpson's equivalent (q2) values were slightly higher in the field interior in 2021, they were higher in the field edge in 2022 (Figure 4).

Seven species were found to be significant indicators of the edge habitat in canola: *P. distincta* (Indicator value (IndVal) = 0.80, p = 0.001)*, P. moesta* (IndVal = 0.75, p = 0.001), *Trochosa terricola* Thorell, 1856 (IndVal = 0.71, p = 0.001), *Micaria pulicaria* (Sundevall, 1831) (IndVal = 0.64, p = 0.001), *Pardosa ontariensis* Gertsch, 1933 (IndVal = 0.55, p = 0.014), *Micaria rossica* Thorell, 1875 (IndVal = 0.50, p = 0.01), *Pardosa modica* (Blackwall, 1846) (IndVal = 0.49, p = 0.037) (Table 5). No significant indicator species were detected for the field interior habitat, but there were eight species that were collected in greater proportion in the interior when compared to the edge, proportion collected in edge presented as a percent value, number found in habitats listed with associated habitat: *Grammonota gentilis* Banks, 1898 (89%, interior 16, edge 2), *Enoplognatha marmorata* Simon, 1894 (86%, interior 19, edge 3), *Agyneta* *fabra* (Keyserling, 1886) (81%, interior 13, edge 3), *Xysticus emertoni* Keyserling, 1880 (74%, interior 17, edge 6)*, Diplostyla concolor* (Wider, 1834) (67%, interior 12, edge 6)*, Erigone blaesa* Crosby & Bishop, 1928 (67%, interior 18, edge 9)*, Erigone aletris* Crosby & Bishop, 1928 (66%, 37 interior, 18 edge)*,* and *Pardosa groenlandica* (Thorell, 1872) (63%, interior 39, edge 23).

3.2 Effect of trap size and PTFE application on diversity and abundance of spider sampling (Study 2)

3.2.1 Pitfall trap efficacy – 24-hour collection periods

Across the five 24-hour collection periods in 2023, 1,071 spiders were collected represented by 62 species in 12 families (Table 6). There were 42 species collected in treed habitats, 16 of these species were only captured in the treed habitats. In the grass habitats there were 37 species captured, 13 of these species were exclusive to the grass habitats. There were 17 species shared between the two habitats. With respect to trap treatments, 12 species were collected only in PTFE-treated traps and six only in untreated traps from treed edges. In contrast, unique species in treated and untreated traps in grassy edges totaled six and five, respectively (Table S2). As there are 24 possible combinations of habitat-trap size-treatment-habitat for the 24-h collection period, the size-habitat-treatment combinations are not addressed here but are included in the supplementary table.

The GAMLSS model assessment of the combined significant effects of habitat, trap size, PTFE-treatment, and substrate were detected for both Linyphiidae (adjusted intercept coefficient = 0.28, t(272) = -5.22, SE = 0.07, p = < 0.001) and Lycosidae (adjusted intercept coefficient = 3.00, t(272) = 7.08, SE = 0.47, p = < 0.001)). The abundance of linyphiids increased in response to treed field edges (response coefficient = 2.37, SE = 0.44, t(272) = 4.66, p < 0.001) and with the application of PTFE (response coefficient = 1.73, SE = 0.33, t(272) = 2.89, p = 0.004)

(Figure 5). However, no significant effects were detected in relation to trap size (averaged response coefficient and SE for small and medium traps: response coefficient = 0.835, SE = 0.185) or trap substrate (response coefficient = 0.89, SE = 0.89). The abundance of lycosids was not affected by the application of PTFE or substrate, but there was a significant effect with respect to habitat, with lower abundances in treed edges (response coefficient = 0.60, SE = 0.09, t(272) = -3.51, $p < 0.001$). Similarly, a significant effect with respect to trap size was detected, with lower abundances in small (response coefficient = 0.62, SE = 0.10, t(272)= -3.00, p = 0.003) and medium traps (response coefficient = 0.52, SE = 0 .09, t(272) = -3.92, $p < .001$) (Figure 6).

The application of PTFE combined with glass beads (trap substrate) significantly increased the diversity of spiders captured in the large traps in treed environments (q0: qD = 28.2, CI = 8.1, q1: qD = 26.9, CI = 8.6, qD = 24.8, CI = 8.6) , compared to untreated large dry traps (q0: qD = 10.25, CI = 5.70, q1: qD = 8.27, CI = 3.99) (Figure 7). No significant effects, however, were observed in the grass habitat or the smaller trap sizes (Figure 7).

3.2.2 Pitfall trap efficacy – 7 day collection periods

In the 7-day collection period experiment, a total of 2,278 spiders were collected representing 72 species in 16 families (Table 7; Table S3). There were 56 species captured in the tree habitat, 26 of these species were captured only in the treed habitat. Twenty-five species were captured in the grass habitats 15 of these species were captured only in the grass habitat, the remaining 25 species were captured in both habitats. One species (*P. moesta*) was caught in all habitats, trap treatments and trap sizes. Nine species were captured in most habitats, trap treatments and trap sizes, where they were only absent from 1-2 trap treatment-size-habitat combinations. Fourteen species were captured in at least half of the trap treatment-size-habitat combination types (6-9 of the possible 12 treatment-size-habitat combinations (6-9/12)). Most species (49) were captured in less than half of the trap treatment combinations (1-5/12). There were 27 species captured by only one trap type, across both habitats. Four species were captured only in the untreated traps in the grass habitats. Five species were captured in only the treated traps in the grass habitats. Seven species were captured in only the untreated traps in the tree habitats, and 13 species were captured only in the treated traps in the treed habitats (Table S3).

PTFE application significantly increased the estimated diversity (q0, q1 and q2 diversity orders) of spiders captured in the large traps in the treed environments (PTFE traps: q0: qD = 44.1, CI = 7.5, q1: qD = 15.4, CI = 3.3, q2: qD = 6.2, CI = 2, non-PTFE traps: q0: qD = 24.93, CI = 4.2, q1: qD = 5.6, CI = 1.1, q2: qD = 2.6, CI = 0.43) (Figure 8). PTFE application significantly reduced q2 diversity in the large traps in the grass environment (q2 = 4.1, CI= 1.1) (Figure 8). In the medium traps, PTFE had a marginally significant positive effect on the Simpson's (q2) diversity score in tree habitats (medium PTFE: q2 = 9.5 , CI = 3.20, medium Non-PTFE 2 = 5.8, CI = 1.85), and a marginally negative effect in grass habitats (medium PTFE: q2 = 6.5, CI = 2.58, medium Non-PTFE: q2 = 11.01, CI = 2.31) (Figure 8). In the small traps, there was a marginal negative effect from PTFE application in grass habitats on Simpson's (q2) diversity scores (small PTFE: q2 = 5.5, CI = 2.02, small Non-PTFE: q2 = 10.3, CI = 3.43) (Figure 8).

3.2.3 Community structure of grass and tree habitats – 7-day collection periods

In the 7-day collection period experiment, eight species were significant indicators of both treed and grassy habitats (Tables 8). These 16 species accounted for 77.97% of the total spiders in the 7-day collection period experiment, with 29.48% of them represented by *P. moesta* and 14.08% of them represented by *P. distincta* (Table S3). Habitat was the only variable detected to have a significant impact (F = 15.37, df = 1, p – = 0.001) on species level variation after RDA model selection (F = 4.7, df = 4, p = 0.002). PTFE application (F = 1.13, df = 1, p = 0.328) and trap size

(F = 1.16, df = 2, p = 0.241) were both included, but were not found to have a significant effect on species level variation. Collectively these three variables explained 73% of the constrained variance, with an adjusted R^2 of 0.57. Axis 1 (mostly explaining a habitat gradient) and 2 (mostly explaining a PTFE gradient) of the RDA model explained 60.17% and 5.99% of the constrained variance, respectively (Figure 9). Most species clustered around the center node, with species previously identified as indicators located more distant from the central node, towards the same previously suggested habitats. Habitat explained the greatest portion of variance in the species collected.

3.3 Comparisons of spiders across all years (2021-2023)

A total of 4,514 spiders were collected across all three years of sampling, represented by 119 (7 unidentified) species in 17 families. Six spiders could not be identified beyond family, but were morphological distinct, these were treated as “unidentified Linyphiidae 1-6”. One spider could not be identified past genus and was treated as ‘unidentified *Walckenaeria*”. Damage to spiders left a proportion of unidentifiable specimens in each year: 2021: 10.84% (n = 49); 2022: 8.78% (n = 28); and, 2023: 0.9% (n = 30). Using estimation of sample completeness (Chao & Jost 2012), the observed sample coverage in 2021 and 2022 was 96% and 97% at the edge and 92% and 90% at the interior, respectively. In 2023, the observed sample coverage was 99%.

Over the three sampling years, two species were the most abundant: *P. distincta*, and *P. moesta* (Table S1, S2). The same four families contributed the most to total capture in all years: Lycosidae (2021: n = 355, 2022: n = 294, 2023: n = 2259), Linyphiidae (2021: n = 172, 2022: n = 37, 2023: n = 343), Gnaphosidae (2021: n = 31, 2022: n = 36, 2023: n = 328) and Thomisidae (2021: n = 72, 2022: n =31, 2023: n = 234) (Table S1-S3). Spider abundance was highest at the start of summer and decreased by more than half by August in all habitat types. Twelve species were only captured in 2021, 11 were only captured in 2022, and 40 species were only captured in 2023.

Chapter 4. Discussion

Documenting the diversity in highly modified environments is an important step in creating both integrated pest management regimes and assessing the feasibility of conservation efforts within small natural area patches near cultivated lands. Here, we found few species contributed to the overall abundance of spiders collected in canola fields in central Alberta. Similar results have been demonstrated repeatedly in agricultural research (Samu et al. 1999; Robinson et al. 2021). Our study further supports the paradigm that nearby semi-natural areas host a variety of spider species, but not all natural areas are equal in habitability. More complex vegetation (e.g., a greater variation in plant height, trees, bushes, and weeds) in field margins supported a wider variety of species but had lower populations of the species collected within canola fields. Secondly, we found that spider retention rates in traps with either wet (i.e., propylene glycol) or dry (i.e., glass beads) substrates can be improved with the application of PTFE to the inner trap surface and with larger traps. In tree habitats, PTFE application on large traps also resulted in significantly higher diversity captured, relative to non-PTFE traps, but this was not observed with the small traps (Figure 8). Increased capture rates, and better retention of the diversity of spiders in a given habitat can support future studies that require live collected spiders. With live specimens, studies of behavior can be conducted to unravel the specific needs of these organisms, thereby enabling future enhancements to the ecosystem services provided by spiders.

4.1 Species diversity and composition in canola crops (Study 1)

Across all study years, the ground-dwelling spider assemblage in canola was dominated by species in the families Lycosidae and Linyphiidae (Table S1-S3). These findings are consistent with a number of other agroecosystem studies, as well as forest systems, that sampled spiders via pitfall traps and observed similar patterns, with dominance of wolf spiders (e.g., *Pardosa*) complemented by linyphiids, in smaller, but still notable numbers (Huhta 1965; Doane & Dondale 1979; Ferguson et al. 1984; Djoudi et al. 2018). Further, higher proportion of lycosids were found at canola field edges compared to the interior, while higher proportions of linyphiids were found in field interiors (Table S1-S3). This similar trend was also found in northern-European cropping systems, which are similar climatically to Alberta (Nyffeler & Sunderland 2003; Öberg et al. 2007). Climatic similarities are likely not the only cause for this trend, as linyphiids are known to dominate areas with greater vegetative canopy cover while lycosids are more abundant in open areas (Larrivée et al. 2008; Pinzon et al. 2012). Excessive competition for medium-large food items in crop interiors could lead to reduced abundance of lycosids, while smaller bodied arthropods may sustain the linyphiid population more readily (Uetz 1977; Rusch et al. 2015). In all three years, spider abundances steeply declined towards the end of summer, which is consistent with most systems in northern latitudes (Table 4, Table 7) (Oxbrough et al. 2005; Bowden et al. 2018). Early season is characterized by high spider activity and reproduction, especially for lycosids, whose abundance declines steeply as questing males, and early season species die with the progress of summer (Niemelä et al. 1994; Król et al. 2018). Decreased abundances across most families were observed in 2022, relative to 2021, which may be attributed to increased precipitation in 2022, as lower spider activity with increased precipitation has been observed in other studies (Lensing et al. 2005). In 2023, precipitation was similar to 2022, but activity cannot be directly compared as the sampling regime was different. Comparison between the 2021-2022 and 2023 sampling regimes is limited to broad trends as the two sampling regimes were different. All sampling occurred near canola, but trap size, location and trap type differed significantly; thus, only extremely general trends can be reported responsibly. Additionally, 2021-2022 selected fields with no treed edges specifically, which may have impacted the species composition due to landscape level effects.

There were no indicator species detected for interior habitats, and spider abundance was comparatively low, which indicates there may be limited potential for control of crop-interior pests. In contrast, spiders were in high abundance at the edge of canola fields adjacent to semi-natural habitat and several species were indicators of field edges (Table 5), which may reduce the number of pests entering the field as field edges act as a refuge for both predators and crop pests (Samaranayake & Costamagna 2018; Maino et al. 2019). It also suggests the crop interior is a more hostile environment for ground dwelling spiders, as there is less dense ground cover in the interior in comparison to the field edge, resulting in fewer available hiding places (Rypstra et al. 1999). While raw richness was relatively consistent in each habitat in both 2021-2022, estimated diversity differed marginally between habitats, in 2021 the interior was more diverse, and in 2022 the edge was more diverse. It impossible to attribute this difference to a single factor, but it is likely that the previously mentioned precipitation differences between the two years contribute to this year-to-year difference. Excessive rainfall in 2022 may have inhibited the colonization of the crop interior by members of Linyphiidae (Schmidt & Tscharntke 2005), who previously represented a large portion of the interior crop diversity.

The ground-dwelling spider assemblage in and around canola fields was dominated largely by wolf spiders, particularly *Pardosa* spp. (mainly *P. distincta* and *P. moesta*). Other studies have also documented the dominance of *Pardosa* spp. in crops, including *Pardosa agrestis* in Hungarian agricultural fields (Samu & Szinetár 2002). The apparent role of *Pardosa* species in crops is somewhat limited: they are restricted to field edges, and they are eating aphids, but often not enough to make a meaningful difference in pest levels (Glück & Ingrisch

1990; Birkhofer et al. 2008; Kuusk & Ekbom 2012). Despite their dominance over the spider assemblage, their potential as biological control is likely limited due to low abundances relative to the pest species, still, the spiders that are present have been documented eating pests (Nyffeler & Sunderland 2003; Kuusk & Ekbom 2012; Robinson et al. 2021).

Others suggests that the dominance of some species is not due to truly high abundances, but a marked absence of other species, because the arable field habitat is inadequate for consistently supporting species-rich communities (Schmidt & Tscharntke 2005). This leaves arable fields dependent on the recolonization effect to support diversity, which can be hampered by lack of nearby sources for spider diversity, and poor weather patterns for migration by ballooning species (Bishop & Riechert 1990; Öberg & Ekbom 2006). Subsequently, only species capable of overwintering near the field, or in relatively open areas, will sustain populations in these challenging environments (Mestre et al. 2018). As landscape level effects (e.g., presence of wooded areas) can impact in-crop diversity (Djoudi et al. 2018), the sampling regime in 2021-2022, which selected fields with only grassy-weedy areas and no nearby complex vegetation (e.g., trees, bushes, etc.), may have contributed to a lower diversity of species captured in these two years compared to the observed diversity in 2023. This low diversity may be also a result of the small size of traps employed in these years. Studies comparing trap sizes have demonstrated that smaller traps tend to be less effective, influencing diversity assessments from these data (Brennan et al. 1999; Work et al. 2002; Lange et al. 2011). Additionally, ridges on the interior walls of the cups can collect soil and other debris, potentially increasing the chance of spiders escaping. As the sampling regime was originally designed for carabids as the focal taxa, this issue only became a concern when spider diversity was an added facet of the study. These challenges lead to the development of the PTFE experiment, with the aim of increasing retention of captured spiders in relation to non-PTFE traps.

4.2 Effect of trap size and PTFE application on spider sampling (Study 2)

Modifying pitfall trap design including the application of PTFE, trap diameter, and spider retention substrate, had significant effects when examined in two different semi-natural habitats along the edge of canola fields and over two different collection period lengths. While sparse, prior studies have explicitly tested the ability of PTFE to improve capture and retention of arboreal beetles, where it was highly successful (Graham et al. 2010; Graham & Poland 2012; Allison et al. 2014). Several other studies employed traps treated with PTFE but did not include untreated traps, and, thus could not determine if PTFE influenced the abundance and diversity of species captured (Koponen et al. 1997; Lucey & Hill 2012).

During the 24-hour collection periods, large diameter pitfall traps captured a higher abundance of spiders, regardless of PTFE treatment or retention substrate (total large capture = 554, medium = 263, small = 258). Surprisingly, in grass edges, the large, dry (i.e., glass beads) traps captured a higher abundance of spiders compared to the wet (i.e., propylene glycol) traps, results that are contrasting to those of other studies that documented the opposite effect (Weeks Jr. & McIntyre 1997; Winder et al. 2001; Schmidt et al. 2006). Overall, the application of PTFE increased the abundance of spiders, regardless of family, retained in dry traps in both edge types. The only exception was in the grass edge, where large PTFE-treated and untreated traps performed similarly. Estimated diversity (i.e., q1 and q2) was significantly higher in the large dry traps in the treed edges when compared to all other trap-treatment combinations (Figure 7). Richness (q0) was only significantly higher in the large, dry, treed edge traps. The difference in estimated diversity between the grass and tree edges is the most apparent in the large traps in the true diversity (q1) and common species weighted (q2) metrics, where the diversity is nearly doubled in some trap types. Overall, these results suggest that live sampling can be improved with the use of PTFE and large trap sizes, but only in treed environments.

Linyphiid abundance increased in the treed edges and to response to PTFE application, whereas lycosid abundance was lower in the treed edge and there was no response to PTFE (Figures 5 and 6). Linyphiids prefer more humid environments (Pearce et al. 2004; Pluess et al. 2010), such as those in treed edges, which may explain their higher abundance in this habitat compared to the more open and drier grass edge. The lower abundance of lycosids in treed edges supports the paradigm that wolf spiders are more abundant in open habitats, such as grass edges (Moring & Stewart 1994).

Despite the overall neutral effect of PTFE on Lycosidae during the 24-hour collection periods, one highly abundant species was collected in lower abundances in treated traps compared to untreated traps. Fewer *P. moesta* were captured in PTFE treated traps in both edge types (Table S2, S3). A possible mechanism for this may be changes in trap reflectance where PTFE was applied, leading to alterations in navigation behavior by *P. moesta*, (Dacke et al. 2001; Qinghe Li et al. 2008). However, given inconsistent response to PTFE across the family or even the genus *Pardosa*, the reduced capture of this species may have a more complex mechanism than strict visual acuity. Despite the possibility of some frequently sampled spider species potentially avoiding the PTFE-treated traps, a few infrequently sampled species were captured in the PTFE traps, so utilizing only treated traps may provide a slightly better diversity estimate in an ecosystem, as common species were still regularly captured in treated traps. Including both treated and untreated traps may provide more complete diversity estimates of spiders in an ecosystem.

Our results support our initial hypothesis that PTFE will improve the diversity of live trapping; however, it was unexpected that this hypothesis was only supported in the large traps. This outcome may be due to the interaction of trap size and the reduction in the thread safety factor and ability to support the spiders' weight due to PTFE and the need to rapidly create recovery lines (Grawe et al. 2014). Recovery lines have a lower weight capacity than standard drag lines, as spiders must rapidly spin additional silk to maintain thread integrity, and if the spider moves above the attachment point, the forces exerted exceed the safety factor, leading to a fall (Ortlepp & Gosline 2008). Presumably, large traps were of a sufficiently wide diameter for failure of the recovery line or attachment disk. Our study design did not include investigation into the mechanism of thread failure caused by PTFE, but evidence of a measurable effect on spider retention in field studies is still exciting. It is unclear what proportion of increased spider capture can be attributed to a failure to climb out versus silk thread failure upon entry, but a small number of field observations of spiders resting directly below the PTFE on the walls of both the large and small traps points to inability to climb as a significant contributor. However, in a "climbing inhibition-only" scenario, this should have been observable in smaller trap sizes as well, but samples from large traps resulted in significantly greater diversity sampled. This suggests that recovery line silk failure interactions were important to the functional improvement to the traps. The large size traps being the only ones to demonstrate a significant increase in sampled diversity does suggest that silk interactions are important.

While it was not explicitly tested, the glass beads in dry traps were used over plant material and soil. Beads create more consistent and uniform gaps for small spiders to hide from larger predators. It also abrades the walls of traps less, increasing reusability and ease of cleaning, as well as providing ease of visibility for researchers retrieving specimens. We were unable to assess to what extent the glass beads improved in-trap survival due to time constraints, but because the glass beads sink and spiders float when, retrieval of intact specimens by flooding traps was simple. The objective of improving capture and retention rates of live spiders was broadly successful.

Increased retention provided by this study design reaffirms work concluding that treed and grass edges provide habitats for different species assemblages (Rodrigues et al. 2014; Pompozzi et al. 2019; Hamřík et al. 2023). In our sampling, 14 specimens of Titanoecidae*,* a relatively infrequently sampled family with only 396 GBIF records for North America (GBIF 2024), were collected primarily in PTFE coated traps in canola-adjacent treed edges (11 in PTFE traps, 3 in untreated traps, Table S2, S3). Although it was not the core focus of the study, our results affirm that semi-natural habitat adjacent to crops may act as refugia for multiple species (Mestre et al. 2018).

During the 7-day collection periods, PTFE application decreased abundance of lycosids in large traps in the treed edge, a decrease in abundance of most families, in medium and small traps in the grass edge, and an increase in abundance in large traps for most non-lycosid families (Table S3). Small traps treated with PTFE captured a slightly higher abundance of spiders in treed edges when compared to untreated traps (Table S3). In 7-day collection periods, PTFE increased the catch rate, resulting in more accurate estimates of diversity of species captured in only the large traps in treed edges (Figure 8). There was a higher species richness in treed edges overall (55 species in treed-habitats versus 39 species in grass-habitats). In the grass edge, PTFE had no effect on richness (q0) and true diversity (q1), and a negative effect on the estimated diversity of common species (q2), which may have resulted from low diversity in the habitat overall. Much of the variation seen in abundance throughout the 7-day collection periods can likely be attributed to the response of lycosids. When capture abundances exclude lycosids, PTFE increased the overall abundance of spiders captured in all trap sizes in treed edges. This suggests that if the aim of a 7-day sampling project is high retention of Lycosidae, PTFE should not be employed, but it may increase retention of other families in both habitats with trees and in grasslands if large traps are used. The overall effect of PTFE improving the rate of capture resulting in a more accurate estimate of the diversity of spiders captured in treed edges may be because the higher vegetation complexity led to higher diversity of web-building spiders available for capture (Greenstone 1984) .

The consistent success of large PTFE treated traps during the 7-day collection periods was surprising because each sampling week had on average 4 mm of precipitation, with most weeks including at least one day with up to 10 mm, and an overall average of 315 mm of accumulated rain over the season. It is assumed that the correct installation of rain guards maintained the PTFE's effectiveness, but increased ambient moisture has been suggested to degrade PTFE by PTFE-lined ant colony keepers (byFormica 2024). The continued effectiveness may be due to a wide trap opening allowing sufficient evaporation, and for water that breached the rain guard, the surface area of the larger traps was big enough for there to still be enough PTFE to impede spider escape.

Our work in parallel with Robinson et al. (2021) suggests that fields with treed edges may have more effective spider-based pest control available in the early season because of elevated abundances of *P. moesta*. These authors found that *P. moesta* has slightly better pest control potential than *P. distincta*, with the latter being found more abundantly in grass edged fields, and both assessed to have lower pest control potential than carabid ground beetles. Our canola spider diversity study (2021-2022) did not include the early season sampling timeframe (May), which likely contributed to the low number of *P. moesta* collected in the field interior. When *P. moesta* is compared to *P. distincta*, which had higher activity numbers throughout the season overall, it may suggest a higher chance of encountering pests simply due to abundance differences. However, both species were represented by fewer than 20 individuals in the field interior, with both years pooled, implying a potentially spatially limited range of control offered by these species, specifically only in portions of the crop that border an edge. We did find species from groups known to associate with agriculture (Erigoninae) consistent with studies in Europe (Downie et al. 2000), but our collected abundance in both studies was comparatively low. However, there were twice the number of *Erigone* collected in the field interior compared to the edges in 2021-2022. Interestingly, more *Erigone* were found in the grass edges in 2023, and they were species shared with the field interior in the 2021-2022 study (*E. aletris, E. blaesa*). These observations are promising, but it is unclear if the potential impact on pests in Canadian agriculture are relevant. Erigonines were also previously recorded to be one of the groups more susceptible to pitfall collection, so their abundance may reflect trapping methodology more than pest control potential (Topping & Sunderland 1992).

The proposal of the PTFE enhanced trap adds another trap design to the already problematically variable nature of pitfall designs. This novel approach is not being put forward as the optimal design that all future studies should endeavor to employ, but it is apparent that live collecting spiders should be treated as a specialized case (Brown & Matthews 2016). In these cases, and in studies looking to establish baseline diversity in a system or ensure maximal representation of ground-dwelling spider diversity, we recommend the use of both PTFE coating and sufficiently large sized traps.

This study was limited by not considering the effects of pitfall traps on other taxa, but current literature supports PTFE increasing retention of other arthropod taxa (Jackson 1984; Lucey & Hill 2012). Low sampling effort was another limitation: taxa with brief adult lifespans may not be collected due to collection date paucity (Heuts & Brunt 2010). Thirdly, due to supply limitations for medium-sized traps, we were unable to fully account for the potential differences in effectiveness of white versus clear plastic traps (Buchholz et al. 2010). However, because PTFE effectiveness was compared across trap sizes, the impact of PTFE is still supported for large traps. Finally, there is evidence that PTFE can shift trap reflectance, which may deter or attract individuals in families known to display high visual acuity, such as Lycosidae and Thomisidae (Qinghe Li et al. 2008; Francese et al. 2013; Allison et al. 2016). Both families are known to be highly visual, with lycosids documented orienting differently in response to polarized light. PTFE differentially scatters incident light and could lead to reduced trap encounters due to avoidance (Dacke et al. 2001).

Differential PTFE degradation in humid climates is not fully resolved. Despite research showing retained effectiveness when diluted, manufacturers suggest PTFE rapidly degrades in high humidity, so an explicit test of this would be valuable (Allison et al. 2016; ByFormica 2024). Since it was apparent that some species differentially responded to PTFE, it would be useful to assess if it was visual or olfactory mediated response to clarify the possible sampling biases introduced using PTFE. Considering the accumulated abrasion from substrate falling in and trap content retrieval degrading the smooth plastic traps, it would be highly practical to assess the effective lifespan of pitfall traps, and if PTFE can extend it (Woodcock 2005).

Our findings on PTFE can best be described as adding another tool to the arachnology toolbox. The potential to live sample with successful retention compared to prior efforts, supports more precise investigations of how select species interact with their environment. Researchers can improve traps using PTFEs in aqueous solution, which are categorized as a "green" formulations of PTFE due to natural degradation and limited release of volatile organic compounds (Hintzer & Schwertfeger 2014; Li et al. 2019). The resulting increase in retention of live spiders supports many research avenues such as genetic, ontogenetic, behavioral, and conservation work. For example, after the establishment of sufficient abundance for pest control, diet analysis via gut content DNA metabarcoding can be performed (Macfadyen et al. 2019; Saqib et al. 2021; Ghosh et al. 2023). Molecular techniques have provided additional lines of evidence for pest-control potential and effectiveness of spiders in Europe and can be broadly applied to abundant spider taxa in North American agroecosystems (Eitzinger et al. 2019; Cuff et al. 2021). Applications of our findings can support a wider variety of controlled laboratory experiments on wild populations and can reveal answers to gaps in the bigger picture of agroecosystem ecology.

When considered in the context of agroecosystems, spiders are chiefly thought of as contributing to environmentally friendly pest control. There are a handful of spider species that live in and around canola crops, some of which are likely to offer more relevant services than others. As this work focused on active hunting spiders which are better at controlling sedentary pests, there may be some potential for control of sedentary pest species within canola(Kersch-Becker et al. 2018). Retention of semi-natural areas near crops is likely important in maintaining a wider diversity of species for their ecosystem services, as several within crop species were also found in the nearby edges. This work has generated a baseline inventory of the spiders present in canola agroecosystems and provides a modified method for improved retention of spider diversity in traps, which supports future spider-related works.

Tables

Table 1. Collection periods to assess spider diversity and composition in canola fields in central Alberta, Canada in 2021 and 2022 (Study 1).

Collection period	2021	2022
1	16-23 June	24 June-1 July
2	21-28 July	15-22 July
3	11-18 August	19-26 August

Table 2. Collection periods (24-hour and 7-day) to assess the effect of pitfall trap characteristics on spider diversity and composition in canola fields in central Alberta, Canada in 2023 (Study 2).

Collection period	24-hour	7-day
1	31 May-1 June	24-31 May
2	21-22 June	--
3	5-6 July	--
4	19-20 July	12-19 July
5	10-11 August	3-10 August

-- No 7-day collection period.

Table 3. Pitfall trap characteristics tested to determine the impact on spider diversity and retention in 2023 (Study 2; PTFE:).

Size	Preservative substrate	Approximate Substrate volume	PTFE application
Large	Propylene glycol	590 ml	Untreated
			PTFE
	Glass beads	225 g	Untreated
			PTFE
Medium	Propylene glycol	175 ml	Untreated
			PTFE
	Glass beads	175 g	Untreated
			PTFE
Small	Propylene glycol	150 ml	Untreated
			PTFE
	Glass beads	65 g	Untreated
			PTFE

Note: Large traps: 14.5 cm diameter, 16.5 cm depth; medium traps: 11.5 cm diameter, 7.6 cm depth; small traps: 8.5 cm diameter, 12.4 cm depth.

Table 4. Total number of spiders captured in edge and interior transects in canola fields (n = 8 and 6, 2021 and 2022, respectively) in central Alberta, Canada.

		Number of spiders		
Year	**Week**	**Edge (0.5 m)**	**Interior (100 m)**	**Total**
2021	16-23 June	278	152	430
	21-28 July	121	23	144
	11-18 August	42	53	95
2022	24 June-1 July	97	90	187
	16-22 July	160	31	191
	19-26 August	56	15	71

Table 5. List of indicator species for edge habitat types (2021-2022 study). Species listed are all indicator for edge habitats only as no species were identified as indicators for the field interior. Indicator value is the square root of the product of specificity and fidelity (De Cáceres et al. 2010). Specificity scores how infrequently a species occurs outside of edge habitats, a specificity of 1 means species did not occur outside of edge habitats. Fidelity measures the frequency of samples the species was found in the edge habitat. A fidelity score of 1 is equivalent to occurrence in all samples in the edge habitat. Significance ($\alpha = 0.05$) was obtained after 999 permutations.

Family	**Species**	**Specificity**	**Fidelity**	**Indicator value**	***p*-value**
Lycosidae	*Pardosa distincta*	0.8786	0.7273	0.80	0.001
Lycosidae	*Pardosa moesta*	0.8111	0.697	0.75	0.001
Lycosidae	*Trochosa terricola*	0.7851	0.6364	0.71	0.001
Gnaphosidae	*Micaria pulicaria*	0.9093	0.4545	0.64	0.001
Lycosidae	*Pardosa ontariensis*	0.8968	0.3333	0.55	0.014
Gnaphosidae	*Micaria rossica*	0.9293	0.2727	0.50	0.01
Lycosidae	*Pardosa modica*	0.8799	0.2727	0.49	0.037

Table 6. Total spiders captured combined across all experimental pitfall designs in the 24-hour collection period in 2023. Pitfall traps were placed adjacent to canola fields next to grass or treed edges.

	Number of spiders		
Week	**Grass edge**	**Tree edge**	**Total**
31 May- 1 June	123	64	183
21-22 June	252	94	346
5-6 July	208	59	267
19-20 July	112	61	173
10-11 August	45	57	102

Table 7. Total number of spiders captured during each 7-day collection period in 2023. Spider abundances included adults and juveniles. Spider abundances declined steeply after the May collection.

	Number of spiders		
Week	**Grass edge**	**Tree edge**	**Total**
24-31 May	722	836	1558
12-19 July	288	243	531
3-10 August	76	110	186

Table 8. Indicator values for seven-day collection in grass habitats, ordered by indicator value score. Indicator value is the relationship between specificity and fidelity, numerically describing how accurately a species can indicate a habitat condition. Specificity of 1 suggests a species occurred only in the grass habitat. Fidelity scores how many of the total samples the species was found in. Significance (α = 0.05) was obtained after 999 permutations.

Habitat	**Family**	**Species**	**Specificity**	**Fidelity**	**Indicator value**	***p*-value**
Tree	Lycosidae	*Pardosa moesta*	0.85	0.93	0.89	0.001
Tree	Thomisidae	*Ozyptila sincera canadensis*	0.98	0.63	0.79	0.001
Tree	Thomisidae	*Xysticus emertoni*	0.87	0.6	0.72	0.001
Tree	Gnaphosidae	*Zelotes fratris*	0.83	0.63	0.72	0.004
Tree	Lycosidae	*Trochosa terricola*	0.78	0.57	0.67	0.008
Tree	Lycosidae	*Alopecosa aculeata*	0.74	0.57	0.65	0.015
Tree	Agelenidae	*Agelenopsis utahana*	1	0.37	0.61	0.002
Tree	Linyphiidae	*Diplostyla concolour*	0.83	0.4	0.58	0.024
Tree	Lycosidae	*Pardosa mackenziana*	0.94	0.3	0.53	0.011
Tree	Titanoecidae	*Titanoeca nigrella*	1	0.17	0.41	0.044
Grass	Lycosidae	*Pardosa distincta*	0.98	0.8	0.87	0.001
Grass	Thomisidae	*Xysticus ferox*	0.91	0.67	0.78	0.001
Grass	Lycosidae	*Pardosa modica*	0.97	0.43	0.65	0.001
Grass	Lycosidae	*Pardosa ontariensis*	0.96	0.4	0.62	0.002
Grass	Lycosidae	*Pardosa tesqourum*	0.86	0.43	0.61	0.022
Grass	Lycosidae	*Pardosa groenlandica*	1	0.3	0.55	0.004
Grass	Linyphiidae	*Grammonota gentilis*	1	0.27	0.52	0.002

Figures

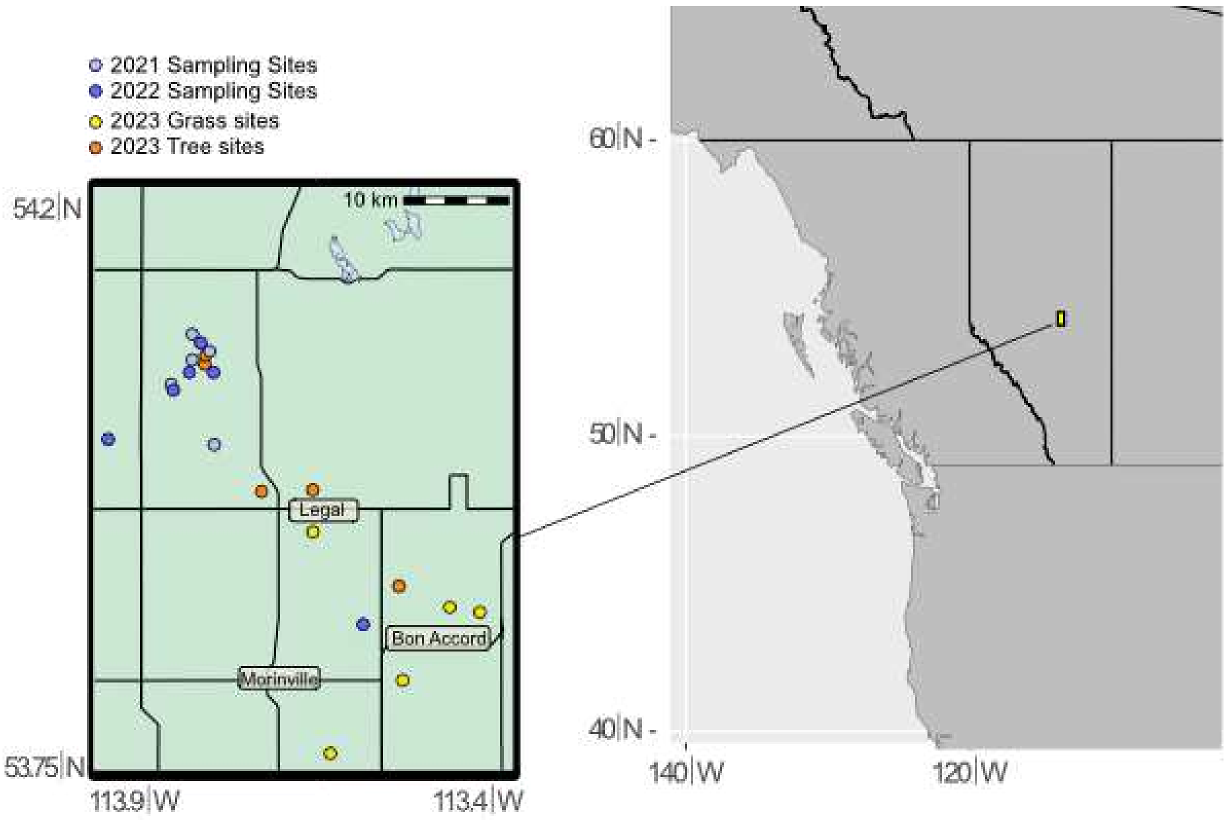

Figure 1. Locations of canola fields in central Alberta (Canada) used for sampling for spiders in 2021-2023. Light blue: 2021; dark blue: 2022. Yellow circles represent grass sites and orange circles represent treed sites in 2023. Black lines represent highways, township, and range roads.

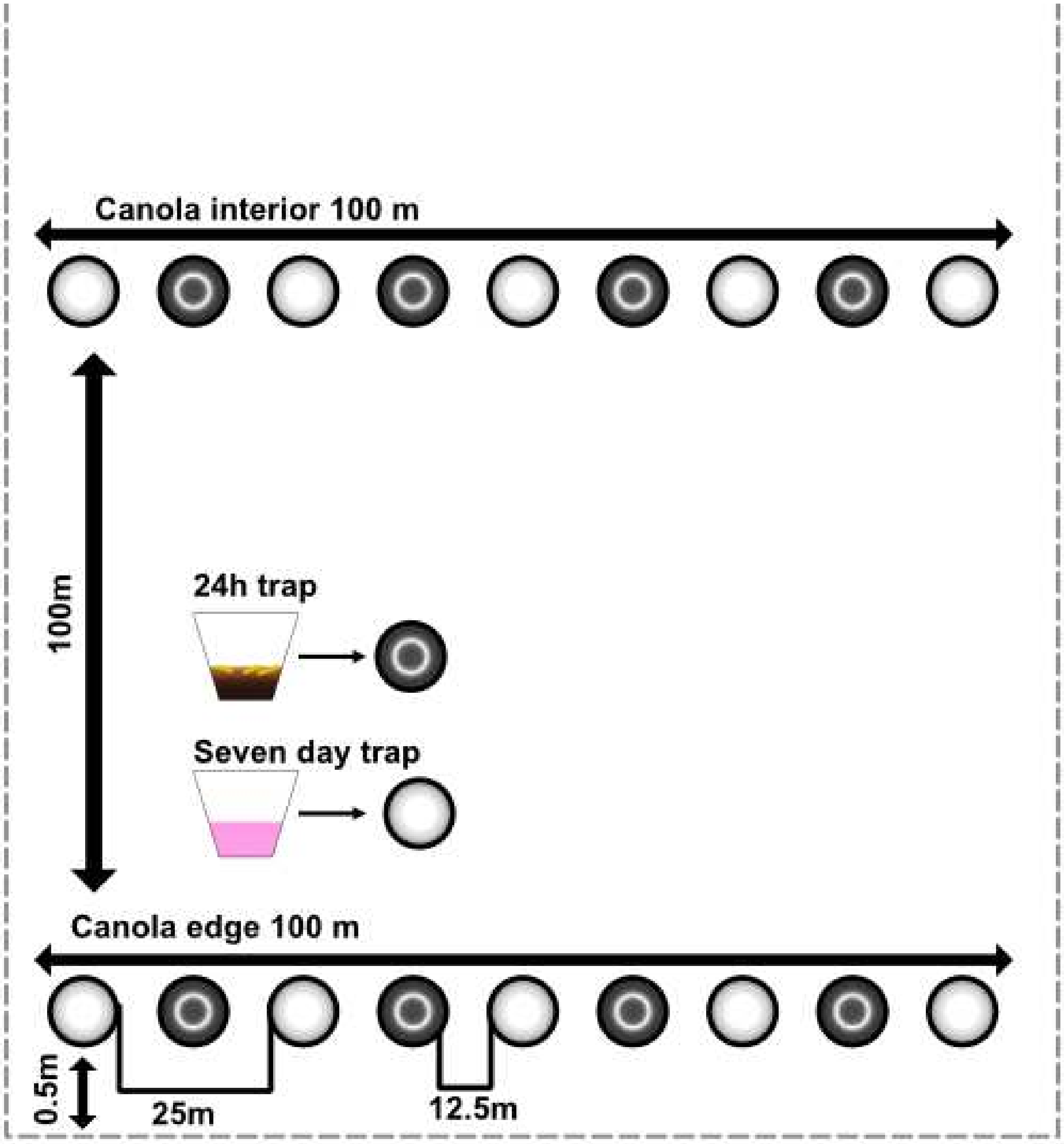

Figure 2. Experimental design for the 2021-2022 diversity study. Light circles represent pitfall traps that were opened seven days per month. Canola field edge represented by dashed grey line. Grey filled pitfall trap circles were active bi-weekly, filled with a layer of soil and used for 24-hour live collection sample periods only. All traps were 8.5cm in diameter, 12.4cm deep.

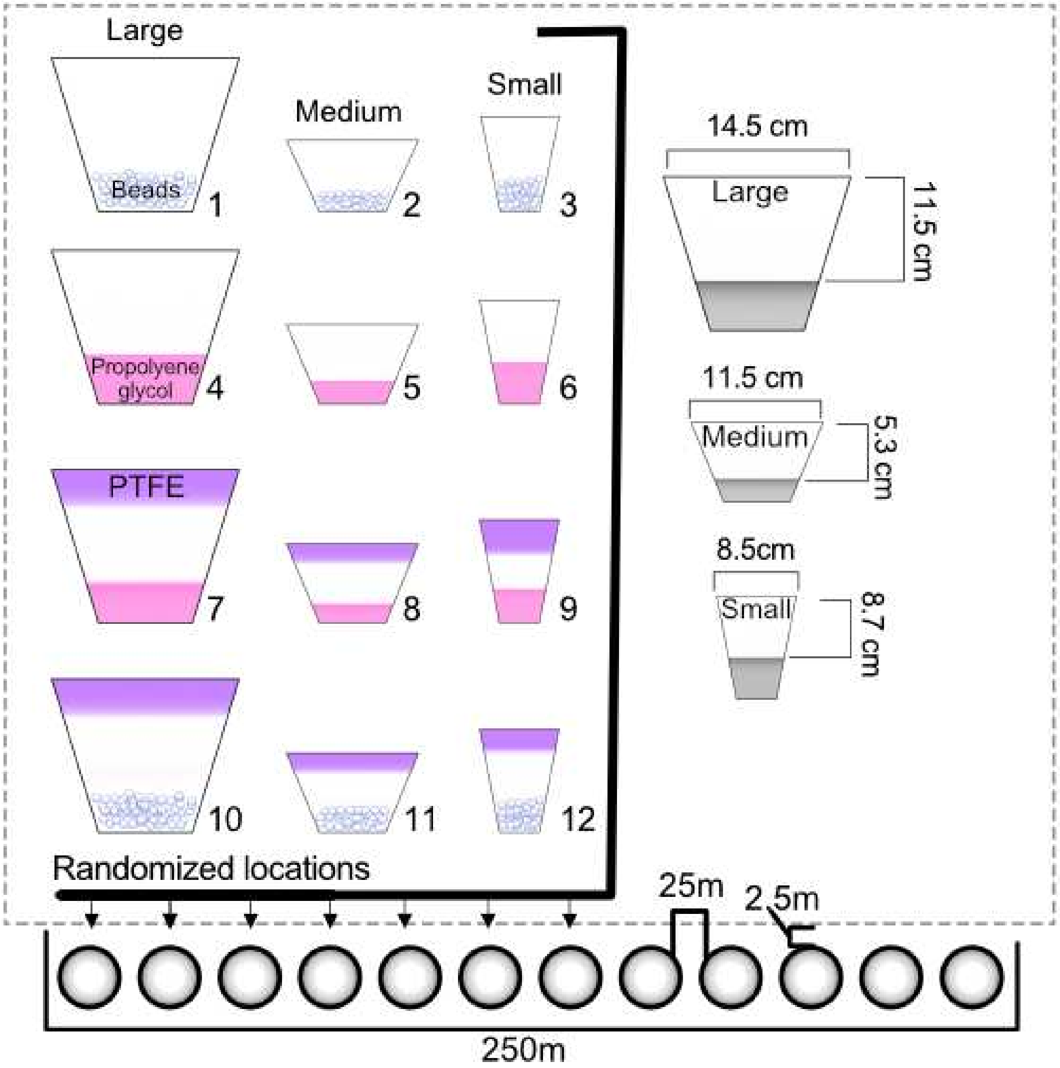

Figure 3. Experimental design for the 2023 trapping methods study. Canola field edge represented by a dashed line. Depth to substrate show for all trap sizes, fill volume of both substrates was between 25-30% for all traps.

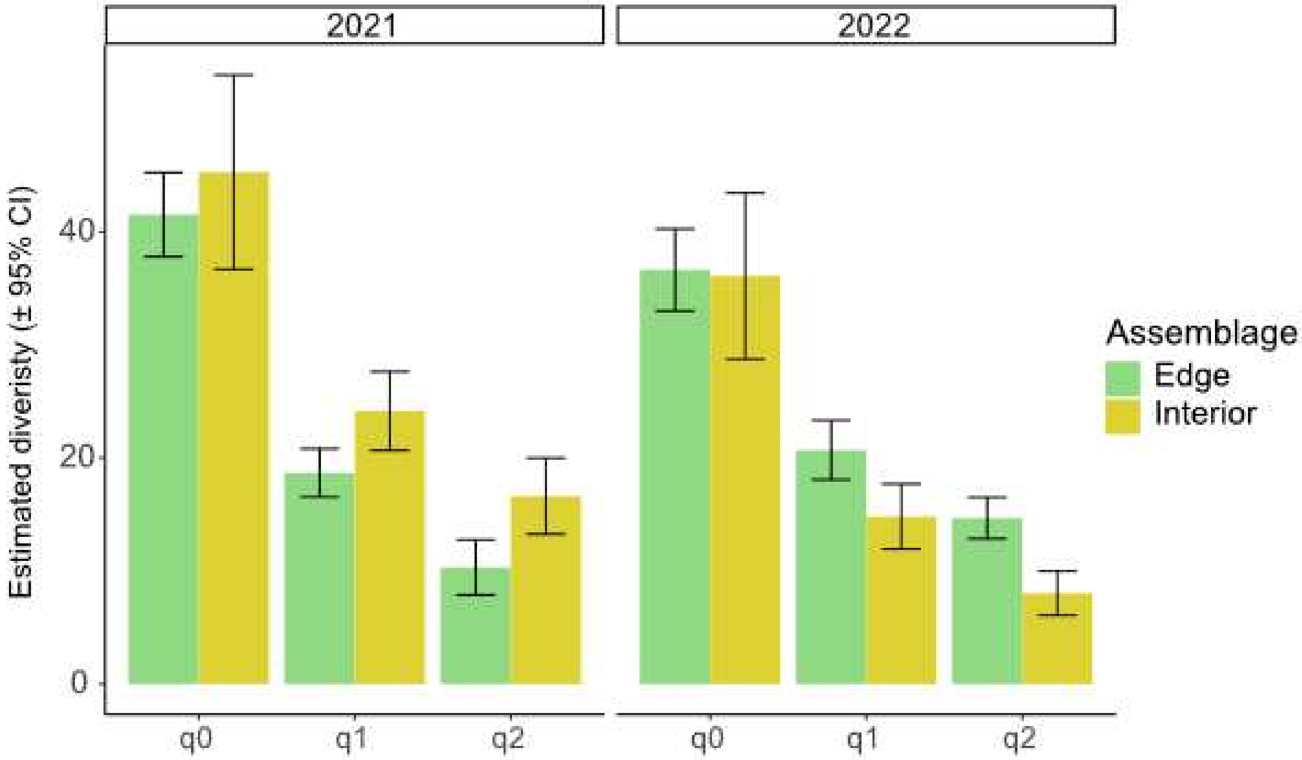

Figure 4. Estimated spider diversity in canola habitats in 2021 and 2022 (Study 1). Values were obtained using coverage-based rarefaction (Chao & Jost 2012) with a sample coverage of 94%.

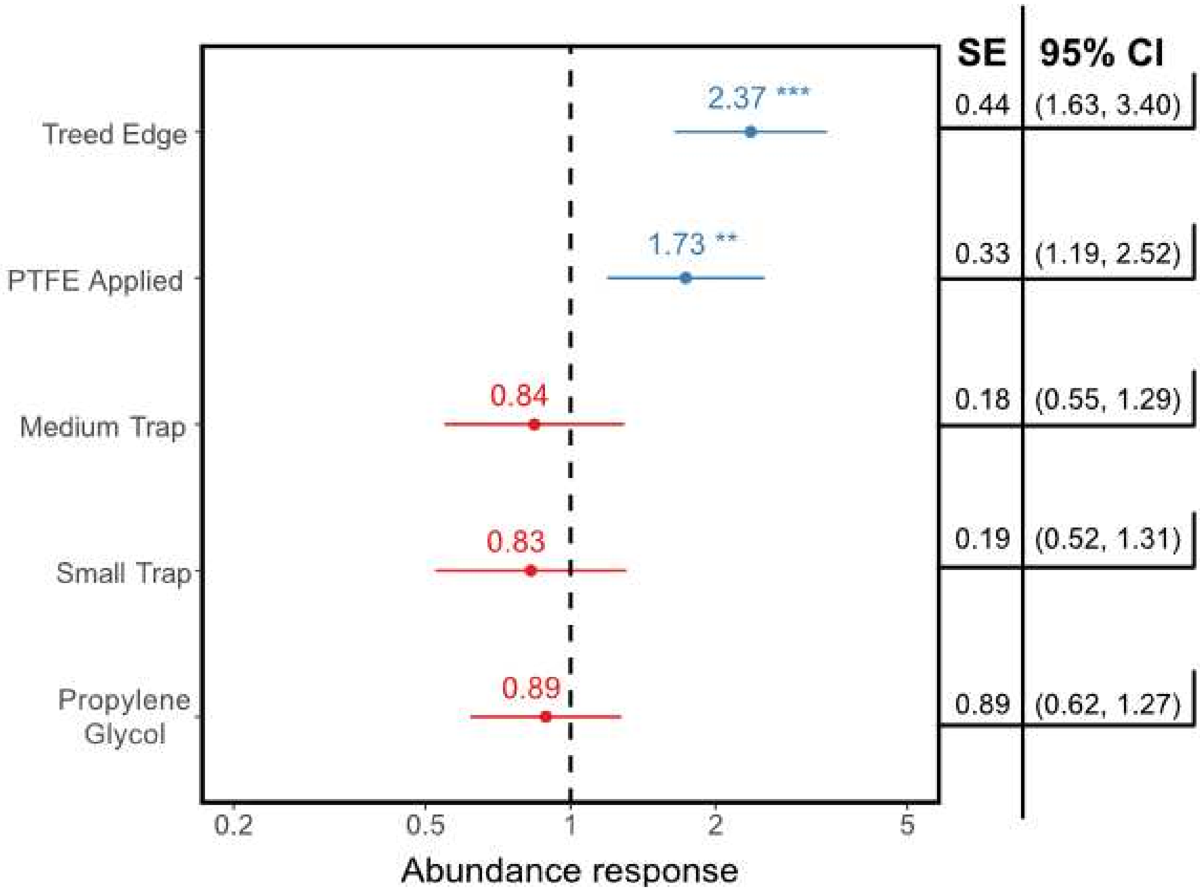

Figure 5. Abundance responses in Linyphiidae to trap treatments in 24-hour collection periods. Dots are the mean abundance by treatment type and whiskers the 95% confidence interval (red indicates negative response; blue indicates positive response; ** $p < 0.01$; *** $p < 0.001$). Treatment levels overlapping with the dashed vertical line denote no response with respect to the alternative (i.e., Propylene Glycol is compared against glass beads; small and medium trap sizes compared against large traps; PTFE applied is compared against no PTFE; treed edge compared against Grass edge).

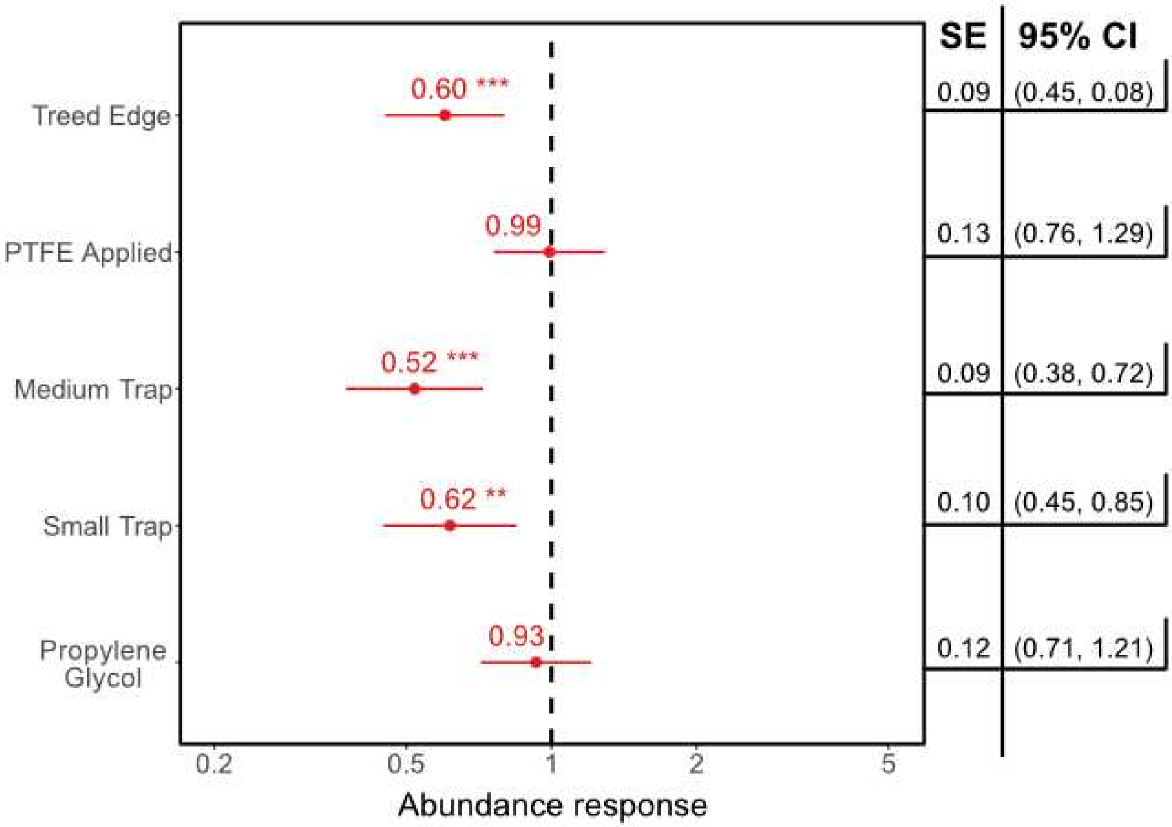

Figure 6. Forest plot of Lycosidae response to trap treatments in 24-hour collection periods. Dashed median is line of no effect, dots represent mean for treatment type, and whiskers represent 95% confidence interval. Red indicates a negative response; ** p <0.01; *** p <0.001. Three stars indicate highly significant response, two stars indicate marginally significant response.

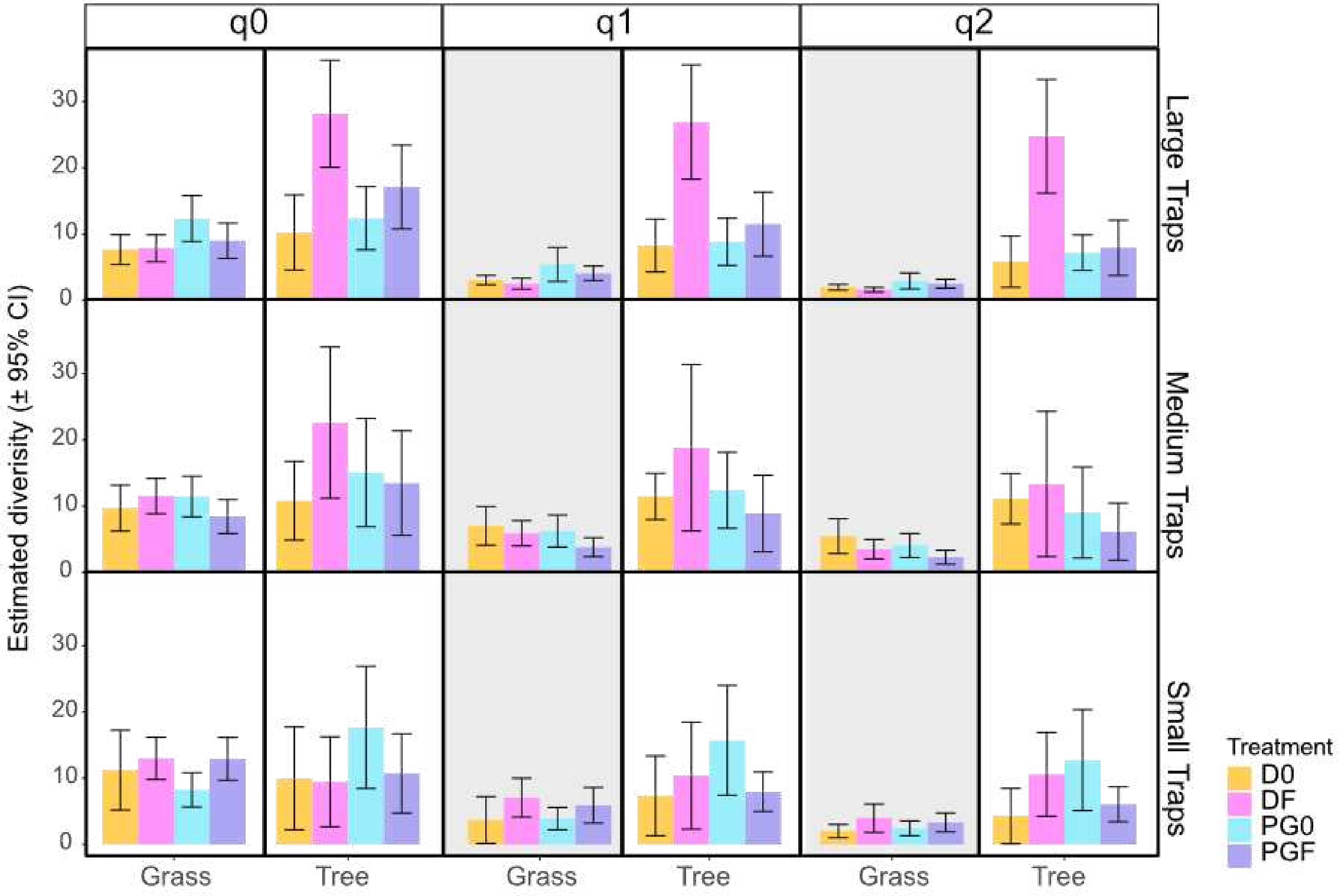

Figure 7. Estimated diversity in 24-hour collection period by trap size, PTFE and substrate treatment, and habitat type. All samples were rarefied to a sample coverage estimated to be 82% (D0 = Dry trap, No PTFE. DF = Dry trap, PTFE, PG0 = Propylene glycol, No PTFE, PGF= Propylene glycol, PTFE).

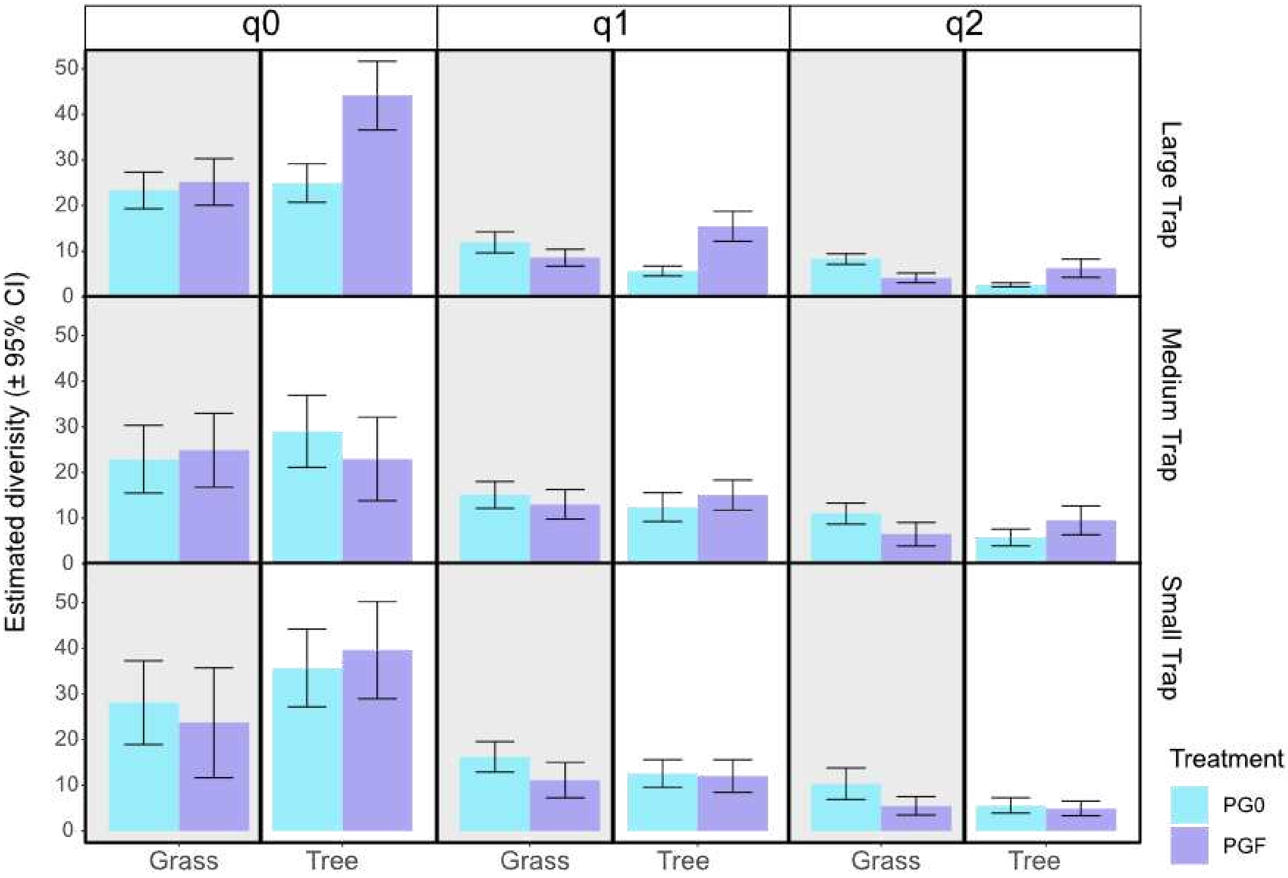

Figure 8. Estimated diversity in 7-day collection period by trap size, type, and location. All treatment combinations were rarefied to a sample coverage that was estimated to be 98%. Acronyms are as follows: PG0 = Propylene glycol, No PTFE, PGF= Propylene glycol, PTFE. Grey background represents the grass collection sites; white backgrounds are treed collection sites.

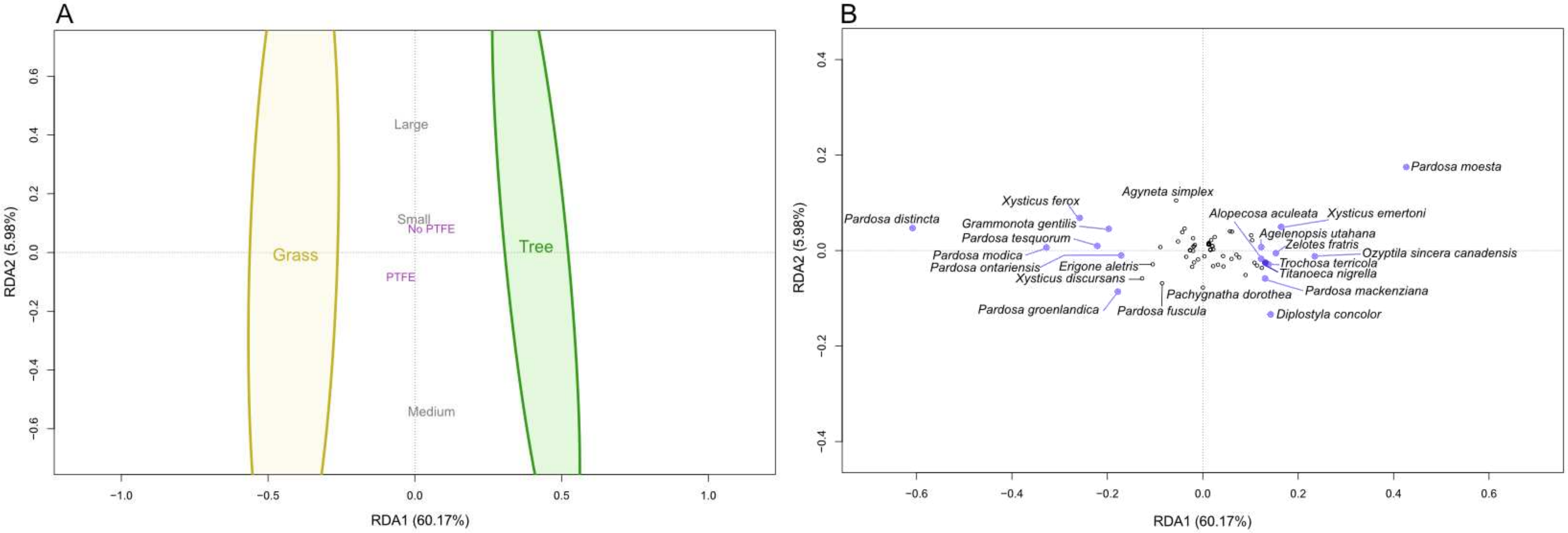

Figure 9. Species composition (RDA ordination) as a function of habitat (tree vs. grass edge), and trap treatment (PTFE-treated vs. untreated) & size in the 7-day collection periods in 2023. The adjusted R^2 for the above ordination is 0.57. PTFE & size were not plotted as ellipsis because they encompassed the entire plotting region. Both plots are unscaled. Plot B shows species relative to ordination variables. Species with purple circles were found to be indicators of a habitat type by indicator species analysis. Species names clustered on central axis were hidden for readability. Open circles represent non-indicator species, most are left unlabeled due to tight clustering.

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Appendix

Table S1. Species abundance in the edge and interior habitats during 2021-2022. Edge refers to the samples from the transect 0.5m into field interior refers to the samples from the transect 100 m into the field.

			2021		**2022**	
Family	**Species**	**Author/Date**	**Edge**	**Interior**	**Edge**	**Interior**
Agelenidae	*Agelenopsis actuosa*	(Gertsch & Ivie, 1936)	1	-	-	-
Agelenidae	*Agelenopsis utahana*	(Chamberlin & Ivie, 1933)	2	-	-	-
Agelenidae Total			**3**	**-**	**-**	**-**
Amaurobiidae	*Cybaeopsis euopla*	(Bishop & Crosby, 1935)	-	1	-	-
Amaurobiidae Total			**-**	**1**	**-**	**-**
Clubionidae	*Clubiona bryantae*	Gertsch, 1941	1	-	-	-
Clubionidae	*Clubiona gertschi*	Edwards, 1958	1	1	-	-
Clubionidae	*Clubiona johnsoni*	Gertsch, 1941	-	-	2	-
Clubionidae Total			**2**	**1**	**2**	**-**
Gnaphosidae	*Gnaphosa parvula*	Banks, 1896	4	-	2	-
Gnaphosidae	*Micaria pulicaria*	(Sundevall, 1831)	8	1	24	2
Gnaphosidae	*Micaria rossica*	Thorell, 1875	9	1	5	-
Gnaphosidae	*Zelotes fratris*	Chamberlin, 1920	3	1	-	-
Gnaphosidae Total			**24**	**3**	**31**	**2**
Hahniidae	*Neoantistea magna*	(Keyserling, 1887)	4	1	5	-
Hahniidae Total			**4**	**1**	**5**	**-**
Linyphiidae	*Agyneta fabra*	(Keyserling, 1886)	3	13	-	-
Linyphiidae	*Agyneta perspicua*	Dupérré, 2013	-	5	-	-
Linyphiidae	*Agyneta simplex*	(Emerton, 1926)	2	7	-	-
Linyphiidae	*Allomengea dentisetis*	(Grube, 1861)	2	1	1	1
Linyphiidae	*Bathyphantes pallidus*	(Banks, 1892)	2	1	2	3
Linyphiidae	*Centromerus sylvaticus*	(Blackwall, 1841)	-	-	5	-
Linyphiidae	*Ceratinops inflatus*	(Emerton, 1923)	-	1	-	-
Linyphiidae	*Diplostyla concolor*	(Wider, 1834)	5	11	1	1
Linyphiidae	*Erigone aletris*	Crosby & Bishop, 1928	16	32	2	5
Linyphiidae	*Erigone alsaida*	Crosby & Bishop, 1928	1	1	3	2
Linyphiidae	*Erigone blaesa*	Crosby & Bishop, 1928	5	16	4	2
Linyphiidae	*Erigone dentigera*	O.Pickard-Cambridge, 1874	1	3	-	-
Linyphiidae	*Grammonota gentilis*	Banks, 1898	2	16	-	-
Linyphiidae	*Islandiana princeps*	Braendegaard, 1932	2	4	-	-
Linyphiidae	Linyphiidae Sp3		1	-	-	-
Linyphiidae	Linyphiidae Sp1		-	-	1	-

Linyphiidae	Linyphiidae Sp4		-	1	-	-
Linyphiidae	Linyphiidae Sp5		1	-	-	-
Linyphiidae	Linyphiidae Sp6		2	-	-	-
Linyphiidae	*Mermessus trilobatus*	(Emerton, 1882)	1	4	-	-
Linyphiidae	*Microlinyphia mandibulata*	(Emerton, 1882)	4	-	-	2
Linyphiidae	*Microneta viaria*	(Blackwall, 1841)	-	2	-	-
Linyphiidae	*Oreonetides rectangulatus*	(Emerton, 1913)	-	2	2	-
Linyphiidae Total			**50**	**120**	**21**	**16**
Liocranidae	*Agroeca ornata*	Banks, 1892	1	-	-	-
Liocranidae Total			**1**	**-**	**-**	**-**
Lycosidae	*Alopecosa aculeata*	(Clerck, 1757)	1	-	2	1
Lycosidae	*Alopecosa kochii*	(Keyserling, 1877)	-	-	1	-
Lycosidae	*Arctosa rubicunda*	(Keyserling, 1877)	1	-	-	-
Lycosidae	*Hogna frondicola*	(Emerton, 1885)	1	-	-	-
Lycosidae	*Pardosa albomaculata*	Emerton, 1885	-	-	1	-
Lycosidae	*Pardosa distincta*	(Blackwall, 1846)	92	7	39	10
Lycosidae	*Pardosa fuscula*	(Thorell, 1875)	19	4	9	14
Lycosidae	*Pardosa groenlandica*	(Thorell, 1872)	13	2	10	37
Lycosidae	*Pardosa mackenziana*	(Keyserling, 1877)	-	-	-	1
Lycosidae	*Pardosa milivina*	(Hentz, 1844)	-	1	-	-
Lycosidae	*Pardosa modica*	(Blackwall, 1846)	26	4	13	1
Lycosidae	*Pardosa moesta*	Banks, 1892	38	11	26	3
Lycosidae	*Pardosa mulaiki*	Gertsch, 1934	10	3	4	3
Lycosidae	*Pardosa ontariensis*	Gertsch, 1933	14	1	23	3
Lycosidae	*Pardosa tesquorum*	(Odenwall, 1901)	28	18	22	12
Lycosidae	*Pardosa uintana*	Gertsch, 1933	-	-	11	-
Lycosidae	*Pardosa xerampelina*	(Keyserling, 1877)	2	-	-	1
Lycosidae	*Pirata piraticus*	(Clerck, 1757)	2	1	-	-
Lycosidae	*Trochosa terricola*	Thorell, 1856	15	6	20	3
Lycosidae Total			**262**	**58**	**181**	**89**
Philodromidae	*Philodromus rufus quartus*	Dondale & Redner, 1968	-	-	-	1
Philodromidae	*Thanatus formicinus*	(Clerck, 1757)	-	-	2	-
Philodromidae	*Thanatus rubicellus*	Mello-Leitão, 1929	-	-	3	-
Philodromidae	*Thanatus striatus*	C.L.Koch, 1845	1	-	-	-
Philodromidae	*Tibellus asiaticus*	Kulczyński, 1908	3	-	2	-
Philodromidae	*Tibellus maritimus*	(Menge, 1875)	1	-	-	-
Philodromidae Total			**5**	**-**	**7**	**1**
Phrurolithidae	*Scotinella pugnata*	(Emerton, 1890)	1	1	2	-

Phrurolithidae Total			**1**	**1**	**2**	**-**
Tetragnathidae	*Pachygnatha dorothea*	McCook, 1894	2	1	-	-
Tetragnathidae	*Tetragnatha labiosa*	Hentz, 1850	-	2	-	-
Tetragnathidae Total			**2**	**3**	**-**	**-**
Theridiidae	*Emblyna borealis*	(O.Pickard-Cambridge, 1877)	-	-	-	1
Theridiidae	*Enoplognatha caricis*	(Fickert, 1876)	-	-	-	1
Theridiidae	*Enoplognatha marmorata*	(Hentz, 1850)	-	5	3	14
Theridiidae	*Neottiura bimaculata*	(Linnaeus, 1767)	1	-	-	-
Theridiidae	*Thymoites minnesota*	Levi, 1964	-	-	1	-
Theridiidae Total			**1**	**5**	**4**	**16**
Thomisidae	*Ozyptila gertschi*	Kurata, 1944	-	1	-	-
Thomisidae	*Ozyptila sincera canadensis*	Dondale and Redner, 1975	-	-	1	-
Thomisidae	*Xysticus canadensis*	Gertsch, 1934	-	-	2	1
Thomisidae	*Xysticus discursans*	Keyserling, 1880	7	1	4	-
Thomisidae	*Xysticus emertoni*	Keyserling, 1880	2	17	4	-
Thomisidae	*Xysticus ferox*	(Hentz, 1847)	8	4	7	2
Thomisidae	*Xysticus luctuosus*	(Blackwall, 1836)	-	-	1	-
Thomisidae	*Xysticus punctatus*	Keyserling, 1880	-	-	-	1
Thomisidae Total			**17**	**23**	**19**	**4**
Titanoecidae	*Titanoeca nigrella*	(Chamberlin, 1919)	2	-	-	-
Titanoecidae Total			**2**	**-**	**-**	**-**

Table S2. Species abundance by location, trap size, and treatment 24H data for 2023. (D0 = Dry traps with no PTFE applied, DF= Dry traps with PTFE applied, PG0 = Propylene glycol traps with no PTFE applied, PGF = Propylene glycol traps, with PTFE applied).

			Grass Edge												Tree Edge											
			Small				Medium				Large				Small				Medium				Large			
Family	**Species**	**Author/Date**	**D0**	**DF**	**PG0**	**PGF**	**D0**	**DF**	**PG0**	**PGF**	**D0**	**DF**	**PG0**	**PGF**	**D0**	**DF**	**PG0**	**PGF**	**D0**	**DF**	**PG0**	**PGF**	**D0**	**DF**	**PG0**	**PGF**
Agelenidae	*Agelenopsis utahana*	(Chamberlin & Ivie, 1933)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	1	-	-	1	-	-
Agelenidae Total			**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**2**	**-**	**-**	**1**	**-**	**-**	**1**	**-**	**-**
Amaurobiidae	*Amaurobius borealis*	Emerton, 1909	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
Amaurobiidae Total			**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**1**	**-**	**-**
Clubionidae	*Clubiona abbotii*	L.Koch, 1866	-	-	-	1	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	2
Clubionidae	*Clubiona gertschi*	Edwards, 1958	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Clubionidae	*Clubiona kastoni*	Gertsch, 1941	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
Clubionidae	*Clubiona riparia*	L.Koch, 1866	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Clubionidae Total			**-**	**-**	**-**	**1**	**-**	**-**	**-**	**-**	**1**	**-**	**1**	**-**	**-**	**-**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**3**
Corinnidae	*Castianeira alteranda*	Gertsch, 1942	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Corinnidae Total			**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Gnaphosidae	*Micaria pulicaria*	(Sundevall, 1831)	-	2	1	-	-	1	-	-	-	2	-	-	-	-	-	-	1	-	-	-	-	1	-	-
Gnaphosidae	*Micaria rossica*	Thorell, 1875	-	1	-	-	-	-	1	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Gnaphosidae	*Zelotes fratris*	Chamberlin, 1920	1	-	2	1	1	-	3	1	1	1	2	1	1	-	-	2	-	-	-	5	-	2	6	4
Gnaphosidae	*Zelotes puritanus*	Chamberlin, 1922	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Gnaphosidae Total			**1**	**3**	**3**	**1**	**1**	**1**	**4**	**1**	**1**	**3**	**2**	**2**	**1**	**-**	**-**	**2**	**1**	**-**	**-**	**5**	**-**	**3**	**6**	**5**
Hahniidae	*Neoantistea magna*	(Keyserling, 1887)	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hahniidae Total			**-**	**-**	**-**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Linyphiidae	*Agyneta fabra*	(Keyserling, 1886)	-	1	-	-	-	1	-	-	1	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-
Linyphiidae	*Agyneta simplex*	(Emerton, 1926)	1	3	1	2	4	6	-	1	-	-	1	-	-	-	-	-	-	1	-	-	-	-	-	-
Linyphiidae	*Allomengea dentisetis*	(Grube, 1861)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	2	-	2	1	-	-
Linyphiidae	*Bathyphantes eumenis*	(L.Koch, 1879)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-

Linyphiidae	*Bathyphantes pallidus*	(Banks, 1892)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	-	-
Linyphiidae	*Ceratinella buna*	Chamberlin, 1949	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-
Linyphiidae	*Diplocentria bidentata*	(Emerton, 1882)	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	1	-	1	-	1	1	-
Linyphiidae	*Diplocephalus subrostratus*	(O.Pickard-Cambridge, 1873)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	1	2	-	-
Linyphiidae	*Diplostyla concolor*	(Wider, 1834)	-	1	-	-	-	2	-	-	-	1	-	-	-	1	2	5	2	3	4	4	2	-	1	4
Linyphiidae	*Erigone aletris*	Crosby & Bishop, 1928	-	3	-	1	-	2	1	2	1	2	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Linyphiidae	*Erigone blaesa*	Crosby & Bishop, 1928	-	-	-	-	-	-	1	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Linyphiidae	*Grammonota gentilis*	Banks, 1898	-	2	4	4	-	2	-	2	5	3	3	10	-	-	1	-	-	-	-	-	-	-	-	-
Linyphiidae	*Grammonota gigas*	(Banks, 1896)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
Linyphiidae	*Islandiana princeps*	Braendegaard, 1932	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Linyphiidae	*Lepthyphantes turbatrix*	(O.Pickard-Cambridge, 1877)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	1	-	-	-
Linyphiidae	*Linyphiidae Sp5*		-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Linyphiidae	*Linyphiidae UIND*		-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Linyphiidae	*Maso sundevalli*	(Westring, 1851)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1	-	-
Linyphiidae	*Mermessus trilobatus*	(Emerton, 1882)	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-
Linyphiidae	*Microneta viaria*	(Blackwall, 1841)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1	-	1
Linyphiidae	*Pelecopsis mengei*	(Simon, 1884)	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
Linyphiidae	*Pelecopsis moesta*	(Banks, 1892)	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
Linyphiidae	*Pocadicnemis pumila*	(Blackwall, 1841)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
Linyphiidae	*Styloctetor compar*	(Westring, 1861)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1	-	-
Linyphiidae	*Tunagyna debilis*	(Banks, 1892)	1	2	-	-	-	-	-	-	1	-	1	2	-	-	-	-	-	-	-	-	-	-	-	-
Linyphiidae	*Walckenaeria atrotibialis*	(O.Pickard-Cambridge, 1878)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Linyphiidae	*Walckenaeria exigua*	Millidge, 1983	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
Linyphiidae Total			**2**	**13**	**5**	**7**	**4**	**13**	**2**	**7**	**9**	**8**	**5**	**15**	**-**	**2**	**5**	**7**	**6**	**8**	**8**	**6**	**8**	**9**	**4**	**8**
Liocranidae	*Agroeca ornata*	Banks, 1892	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
Liocranidae Total			**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**1**	**-**
Lycosidae	*Alopecosa aculeata*	(Clerck, 1757)	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1	-	1	-	-	-	-	-	-	-
Lycosidae	*Hogna frondicola*	(Emerton, 1885)	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lycosidae	*Pardosa distincta*	(Blackwall, 1846)	21	19	23	26	8	22	19	22	66	90	25	60	1	-	-	-	-	-	-	-	-	-	4	-

Lycosidae	*Pardosa dromaea*	(Thorell, 1878)	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lycosidae	*Pardosa fuscula*	(Thorell, 1875)	-	1	1	-	-	1	1	1	1	1	-	3	-	-	-	-	-	-	-	-	-	-	-	-
Lycosidae	*Pardosa groenlandica*	(Thorell, 1872)	-	-	-	-	1	-	2	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Lycosidae	*Pardosa mackenziana*	(Keyserling, 1877)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	1	-	-
Lycosidae	*Pardosa modica*	(Blackwall, 1846)	-	2	-	1	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Lycosidae	*Pardosa moesta*	Banks, 1892	1	2	3	6	3	1	3	-	10	6	2	6	1	2	3	1	2	1	1	2	1	1	4	8
Lycosidae	*Pardosa mulaiki*	Gertsch, 1934	1	-	-	1	-	1	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Lycosidae	*Pardosa ontariensis*	Gertsch, 1933	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lycosidae	*Pardosa tesquorum*	(Odenwall, 1901)	2	-	2	1	3	3	9	-	1	1	2	8	-	-	-	-	-	-	1	1	-	-	-	-
Lycosidae	*Trochosa terricola*	Thorell, 1856	1	-	-	1	2	-	1	-	5	1	3	3	4	1	2	5	2	1	-	1	6	2	5	1
Lycosidae Total			**27**	**24**	**29**	**37**	**18**	**28**	**35**	**23**	**83**	**101**	**35**	**81**	**6**	**3**	**6**	**6**	**5**	**4**	**2**	**4**	**7**	**4**	**13**	**9**
Phrurolithidae	*Scotinella pugnata*	(Emerton, 1890)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
Phrurolithidae Total			**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**1**	**-**
Theridiidae	*Enoplognatha marmorata*	(Hentz, 1850)	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Theridiidae	*Robertus pumila*	(Emerton, 1909)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Theridiidae	*Robertus riparius*	(Keyserling, 1886)	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1	-	1
Theridiidae	*Theridion petraeum*	L.Koch, 1872	-	-	-	2	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Theridiidae Total			**-**	**-**	**-**	**2**	**-**	**-**	**1**	**-**	**-**	**-**	**-**	**1**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**1**	**-**	**2**
Thomisidae	*Ozyptila sincera canadensis*	Dondale and Redner, 1975	-	-	-	-	-	-	-	-	-	1	-	-	-	2	-	-	3	1	1	1	1	1	-	1
Thomisidae	*Xysticus discursans*	Keyserling, 1880	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thomisidae	*Xysticus emertoni*	Keyserling, 1880	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	2	-	-	-	-	1
Thomisidae	*Xysticus ferox*	(Hentz, 1847)	-	-	-	1	-	2	2	3	1	2	-	1	-	1	1	-	-	-	-	-	-	-	1	-
Thomisidae Total			**-**	**-**	**-**	**1**	**-**	**2**	**2**	**3**	**1**	**4**	**-**	**1**	**-**	**3**	**2**	**1**	**3**	**1**	**3**	**1**	**1**	**1**	**1**	**2**

Table S3. Species abundance by location, trap size, and treatment 7-day data for 2023. (PG0 = Propylene glycol traps with no PTFE applied, PGF = Propylene glycol traps, with PTFE applied).

			Grass Edge						**Tree Edge**					
			Small		**Medium**		**Large**		**Small**		**Medium**		**Large**	
Family	**Species**	**Author/Date**	**PG0**	**PGF**	**PG0**	**PGF**	**PG0**	**PGF**	**PG0**	**PGF**	**PG0**	**PGF**	**PG0**	**PGF**
Agelenidae	*Agelenopsis potteri*	(Blackwall, 1846)	-	-	-	-	2	-	-	-	-	-	-	-
Agelenidae	*Agelenopsis utahana*	(Chamberlin & Ivie, 1933)	-	-	-	-	-	-	2	-	-	4	7	2
Agelenidae Total			**-**	**-**	**-**	**-**	**2**	**-**	**2**	**-**	**-**	**4**	**7**	**2**
Amaurobiidae	*Amaurobius borealis*	Emerton, 1909	-	-	-	-	-	-	2	1	1	-	1	3
Amaurobiidae Total			**-**	**-**	**-**	**-**	**-**	**-**	**2**	**1**	**1**	**-**	**1**	**3**
Clubionidae	*Clubiona abbotii*	L.Koch, 1866	-	-	-	-	1	3	-	-	-	-	-	-
Clubionidae	*Clubiona canadensis*	Emerton, 1890	-	-	-	-	-	-	-	-	-	-	1	-
Clubionidae	*Clubiona kastoni*	Gertsch, 1941	-	-	-	-	-	-	-	2	-	-	1	3
Clubionidae	*Clubiona kulczynskii*	Lessert, 1905	-	-	-	-	-	-	-	-	-	-	-	1
Clubionidae Total			**-**	**-**	**-**	**-**	**1**	**3**	**-**	**2**	**-**	**-**	**2**	**4**
Dictynidae	*Dictyna minuta*	Emerton, 1888	-	-	-	-	-	-	1	-	-	-	-	-
Dictynidae Total			**-**	**-**	**-**	**-**	**-**	**-**	**1**	**-**	**-**	**-**	**-**	**-**
Gnaphosidae	*Haplodrassus eunis*	Chamberlin, 1922	-	-	-	-	-	-	2	1	2	-	-	-
Gnaphosidae	*Micaria pulicaria*	(Sundevall, 1831)	4	-	2	1	-	6	3	2	1	4	8	5
Gnaphosidae	*Micaria rossica*	Thorell, 1875	4	-	2	-	1	7	-	2	-	1	2	3
Gnaphosidae	*Zelotes fratris*	Chamberlin, 1920	2	3	-	2	3	2	6	6	5	11	17	12
Gnaphosidae	*Zelotes puritanus*	Chamberlin, 1922	-	-	-	-	-	-	1	1	-	-	1	1
Gnaphosidae Total			**1-**	**3**	**4**	**3**	**4**	**15**	**12**	**12**	**8**	**16**	**28**	**21**
Hahniidae	*Neoantistea magna*	(Keyserling, 1887)	-	-	-	1	-	-	-	-	-	-	1	-
Hahniidae Total			**-**	**-**	**-**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	**1**	**-**
Linyphiidae	*Agyneta fabra*	(Keyserling, 1886)	-	-	-	1	2	-	1	-	1	-	-	3
Linyphiidae	*Agyneta simplex*	(Emerton, 1926)	4	1	-	-	6	1	1	2	-	-	-	2
Linyphiidae	*Allomengea dentisetis*	(Grube, 1861)	-	-	-	-	-	-	1	1	-	1	-	1
Linyphiidae	*Bathyphantes pallidus*	(L.Koch, 1879)	-	-	-	-	-	-	1	1	2	2	1	1
Linyphiidae	*Diplocentria bidentata*	(Emerton, 1882)	-	-	-	-	-	-	1	-	1	-	-	-
Linyphiidae	*Diplocephalus subrostratus*	(O.Pickard-Cambridge, 1873)	-	-	-	-	-	-	-	-	-	2	-	1
Linyphiidae	*Diplostyla concolor*	(Wider, 1834)	1	-	1	3	-	1	2	7	7	7	4	3

Linyphiidae	*Erigone aletris*	Crosby & Bishop, 1928	3	4	-	4	2	1	-	1	2	-	-	1
Linyphiidae	*Erigone blaesa*	Crosby & Bishop, 1928	1	-	-	-	-	-	-	-	-	-	-	-
Linyphiidae	*Grammonota gentilis*	Banks, 1898	2	2	1	1	1-	8	-	-	-	-	-	-
Linyphiidae	*Hypselistes florens*	(O.Pickard-Cambridge, 1875)	-	-	-	-	-	-	-	-	-	-	-	1
Linyphiidae	*Islandiana princeps*	Braendegaard, 1932	-	-	-	1	-	-	-	-	-	-	-	-
Linyphiidae	*Lepthyphantes alpinus*	(Emerton, 1882)	-	-	-	-	-	-	-	-	-	-	-	1
Linyphiidae	*Lepthyphantes turbatrix*	(O.Pickard-Cambridge, 1877)	-	-	-	-	-	-	-	-	-	-	1	1
Linyphiidae	Linyphiidae Sp4		-	-	-	-	-	-	-	-	-	-	1	-
Linyphiidae	Linyphiidae Sp1		1	-	-	-	-	-	-	-	-	-	-	-
Linyphiidae	*Mermessus trilobatus*	(Emerton, 1882)	-	-	-	-	-	-	-	-	-	-	-	1
Linyphiidae	*Microlinyphia mandibulata*	(Emerton, 1882)	-	-	-	-	-	-	-	-	2	-	-	-
Linyphiidae	*Microneta viaria*	(Blackwall, 1841)	-	-	-	-	1	-	2	1	1	4	2	-
Linyphiidae	*Neriene clathrata*	(Sundevall, 1830)	-	-	-	-	-	-	-	3	1	3	3	3
Linyphiidae	*Styloctetor compar*	(Westring, 1861)	-	-	-	-	-	-	-	1	-	-	-	-
Linyphiidae	*Tunagyna debilis*	(Banks, 1892)	-	2	-	-	1	-	-	-	-	-	-	-
Linyphiidae	*Walckenaeria exigua*	Millidge, 1983	-	-	-	-	-	-	1	1	2	1	-	-
Linyphiidae	*Walckenaeria* Sp1		-	-	-	-	-	-	-	-	-	1	-	-
Linyphiidae Total			**12**	**9**	**2**	**1-**	**22**	**11**	**1-**	**18**	**19**	**21**	**12**	**19**
Liocranidae	*Agroeca ornata*	Banks, 1892	-	-	-	-	-	-	1	1	2	-	2	2
Liocranidae	*Agroeca pratensis*	Emerton, 1890	-	-	-	-	-	-	-	-	-	-	-	1
Liocranidae Total			**-**	**-**	**-**	**-**	**-**	**-**	**1**	**1**	**2**	**-**	**2**	**3**
Lycosidae	*Alopecosa aculeata*	(Clerck, 1757)	7	-	4	2	2	2	1-	7	7	3	11	1-
Lycosidae	*Hogna frondicola*	(Emerton, 1885)	-	-	1	-	-	1	-	-	-	-	-	-
Lycosidae	*Pardosa distincta*	(Blackwall, 1846)	23	28	9	3-	4-	89	-	1	-	-	1	2
Lycosidae	*Pardosa fuscula*	(Thorell, 1875)	3	3	2	5	2	5	9	-	1	2	-	1
Lycosidae	*Pardosa groenlandica*	(Thorell, 1872)	1	1	5	6	3	1	-	-	-	-	-	-
Lycosidae	*Pardosa hyperborea*		-	-	-	-	-	-	-	1	-	-	-	-
Lycosidae	*Pardosa mackenziana*	(Keyserling, 1877)	-	-	-	1	-	-	2	7	3	1	3	-
Lycosidae	*Pardosa modica*	(Blackwall, 1846)	5	7	1-	7	22	15	1	-	-	-	-	1
Lycosidae	*Pardosa moesta*	Banks, 1892	9	5	5	2	34	14	44	53	41	21	17-	69
Lycosidae	*Pardosa mulaiki*	Gertsch, 1934	1	-	-	-	-	-	-	-	1	-	-	-
Lycosidae	*Pardosa ontariensis*	Gertsch, 1933	1	2	15	-	5	3	-	-	-	-	-	1
Lycosidae	*Pardosa tesquorum*	(Odenwall, 1901)	5	2	13	6	14	8	1	1	-	-	3	3
Lycosidae	*Pardosa xerampelina*	(Keyserling, 1877)	-	-	-	-	-	-	-	-	-	-	-	1

Lycosidae	*Pirata piraticus*	(Clerck, 1757)	-	-	-	-	-	-	1	-	-	-	-	-
Lycosidae	*Trochosa terricola*	Thorell, 1856	-	1	2	2	6	-	1-	4	4	4	1-	7
Lycosidae Total			**55**	**49**	**66**	**61**	**128**	**138**	**78**	**74**	**57**	**31**	**198**	**95**
Philodromidae	*Thanatus rubicellus*	Mello-Leitão, 1929	4	-	1	1	7	5	-	1	-	2	-	2
Philodromidae Total			**4**	**-**	**1**	**1**	**7**	**5**	**-**	**1**	**-**	**2**	**-**	**2**
Phrurolithidae	*Scotinella pugnata*	(Emerton, 1890)	-	-	2	-	-	1	-	-	-	-	-	3
Phrurolithidae Total			**-**	**-**	**2**	**-**	**-**	**1**	**-**	**-**	**-**	**-**	**-**	**3**
Salticidae	*Habronattus captiosus*	(Gertsch, 1934)	-	-	-	-	-	1	-	-	-	-	-	-
Salticidae Total			**-**	**-**	**-**	**-**	**-**	**1**	**-**	**-**	**-**	**-**	**-**	**-**
Tetragnathidae	*Pachygnatha dorothea*	McCook, 1894	-	-	-	2	-	-	-	-	2	-	-	-
Tetragnathidae Total			**-**	**-**	**-**	**2**	**-**	**-**	**-**	**-**	**2**	**-**	**-**	**-**
Theridiidae	*Neottiura bimaculata*	(Linnaeus, 1767)	-	-	1	-	-	-	-	-	-	-	-	-
Theridiidae	*Robertus fuscus*	(Emerton, 1894)	-	-	-	-	-	-	-	1	-	-	-	-
Theridiidae Total			**-**	**-**	**1**	**-**	**-**	**-**	**-**	**1**	**-**	**-**	**-**	**-**
Thomisidae	*Misumena vatia*	(Clerck, 1757)	-	-	-	-	-	-	-	-	-	-	2	-
Thomisidae	*Ozyptila sincera canadensis*	Dondale and Redner, 1975	1	-	-	-	-	-	2	5	9	4	12	8
Thomisidae	*Xysticus canadensis*	Gertsch, 1934	-	1	-	-	-	-	-	-	-	-	-	-
Thomisidae	*Xysticus chippewa*	Gertsch, 1953	-	1	-	-	-	-	-	-	-	-	-	-
Thomisidae	*Xysticus discursans*	Keyserling, 1880	2	1	2	2	-	1	-	-	-	-	-	-
Thomisidae	*Xysticus ellipticus*	Dondale & Redner, 1965	-	-	-	-	-	-	-	-	-	-	-	1
Thomisidae	*Xysticus emertoni*	Keyserling, 1880	1	-	1	-	1	3	3	8	7	1	1-	12
Thomisidae	*Xysticus ferox*	(Hentz, 1847)	1-	5	6	3	14	12	1	-	-	-	2	2
Thomisidae	*Xysticus luctuosus*	(Blackwall, 1836)	-	-	-	-	-	-	-	-	-	-	-	1
Thomisidae	*Xysticus triguttatus*	Keyserling, 1880	-	1	-	-	-	-	-	-	-	-	-	-
Thomisidae Total			**14**	**9**	**9**	**5**	**15**	**16**	**6**	**13**	**16**	**5**	**26**	**24**
Titanoecidae	*Titanoeca nigrella*	(Chamberlin, 1919)	-	-	-	-	-	-	-	-	1	3	1	8
Titanoecidae Total			**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**1**	**3**	**1**	**8**