Potential for cascading interactions among of wolves, deer, and arthropods: prospective top predator effects on the diversity of insects and spiders

BIOS 35502: Practicum in Field Biology

Cinzia Ballantyne

Advisor: David Flagel

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Abstract:

Over browsing of white-tailed deer has substantially reduced understory growth and diversity. This has possible implications for the arthropods that inhabit this understory. However, gray wolves have recently recolonized portions of this region. I examined whether wolves indirectly affected insect and spider diversity and abundance. Insect and spider populations in both high and low wolf use areas were counted, and abundance, species richness, and Shannon diversity were all calculated for each transect. There was no significant difference for any aspect of insect diversity or abundance, but spider diversity approached significance. This may be due to legacy effects of deer, as well as insect migratory abilities. There also may be more factors at play, including intra-guild predation by spiders, as well as bird predation. Spider diversity should be reinvestigated in future years to affirm possible significance.

Introduction:

Gray wolves *(Canis lupus)* were considered extirpated from most of the Great Lakes region by 1960 (Wydeven et al. 2009). However, with classification as an endangered species, wolves began to move back into this region (MacFarland and Wiedenhoeft 2013). The removal of wolves was a removal of the top predator, and without their presence, the populations of other species, particularly the white-tailed deer (*Odocoileus virginianus)* increased. This may have effects beyond the prey: these expanded populations can have severe impacts on regeneration of both trees and herbaceous plants and flowers. The latter is particularly harmed because of their inability to grow tall enough to escape risk of browsing (Rooney and Waller 2002). When only plants that are tolerant to browsing can regenerate, this can reduce the diversity of understory plants.

These direct effects of overabundant deer browsing are troubling enough, but there are even further implications of this problematic population. It has been suggested that insect diversity could also be impacted (Bressette et al. 2012). Insect diversity is shown to have a positive correlation with plant diversity in the understory (Murdoch et al. 1972). The recolonization of wolves may restore plant communities as part of trophic cascades.

Deer browsing may not just affect insects, however. One of the primary predators of insects, spiders, may also be affected by deer browsing cascades. Spiders are generally web weavers, although some are active ground hunters. Spiders compete for location to build these webs, and are even known to take over each other's webs in an effort to find prime locale (Greenstone 1984). When lack of wolves allow for deer to deplete understory diversity, there follows that there could be less opportunities for spiders to spin different types of webs in different types of plants.

I hypothesized that deer browsing, in causing a decrease in understory plant diversity, would also cause a decrease in both insect and spider diversity. Insects were counted in both high and low wolf areas (Flagel et al., *in review*). Shannon diversity, abundance, and species richness were calculated for each transect.

Methods:

Location:

The University of Notre Dame Research Center is located on the border between Wisconsin and Michigan's Upper Peninsula near Land O' Lakes, Wisconsin. The habitat is a mosaic of northern mesic forests and wetlands (Curtis 1959). The understory is dominated by maple trees *(Acer spp.)*, ferns, Canadian mayflower *(Maianthemum canadense)*, and Canadian bunchberry *(Cornus canadensis).* There exist about 900 species of spiders in the Great Lakes Region, primarily from five different families (Sierwald et al. 2005). There does not seem to be a comprehensive study of the diversity of insect species in this region, being a poorly studied and non-charismatic group of animals.

Experimental Procedure:

Eighteen sugar maple (*Acer saccharum)* dominated forest spreads were haphazardly selected within the property, with an even number being low-wolf and high-wolf use. Wolf use was previously determined by Flagel et al. (*in review*). A single 20 meters by 1 meter transect was surveyed in each stand. Transects were measured at least 20 meters from the road to avoid road effects. I also avoided areas that possessed canopy gaps or large wet patches. Each plant that touched the transect was examined, and insects (or spiders) on this plant were either recorded, or placed into a kill jar for further observation. Insects were counted at a height of 1.5 meters and below. Insects were differentiated by species. Any larval stages of insects, including caterpillars, were not counted due to difficulty of identification. All transects were measured in similar weather conditions, 18° C and sunny.

Statistics:

Shannon-Wiener diversity indices were calculated for insect and spider diversity, using the following formula:

$$-\sum_{i}\left(\frac{n_i}{N}\cdot ln\left(\frac{n_i}{N}\right)\right)$$

Shapiro-Wilks tests were conducted for normality. Square-root transformations were used when necessary to correct for normality. Student's t-tests were conducted for insect and spider species richness, spider diversity, insect abundance, and spider abundance. Insect diversity was found to have a non-normal distribution that could not be corrected by taking a logarithmic transformation, so a Mann-Whitney U test was conducted. All statistical tests were calculated using SPSS Statistics 21.

Results:

There was no significant difference in insect species richness between high and low wolf use areas (t=-1.383, df=16, p=0.186, Figure 1). There was also no significant difference in spider species richness between high and low wolf use areas (t=0.912, df=16, p=0.375, Figure 2), or insect diversity (u=34, p=0.605, Figure 3). However, a Student's t-test found that spider diversity approached significance. (t=2.001, df=13, p=0.067, Figure 4). No significant difference between high and low wolf areas was found for either insect abundance (t=0.787, df=16, p=0443, Figure 5) or spider abundance (t=0.787, df=16, p=0.443, Figure 6).

Discussion:

Insect richness, abundance, and actual diversity did not seem to be impacted by wolf use. One reason for this is may be the "legacy effect," in which an ecological disturbance affects an area for at least 10 years afterwards (Nuttle et al. 2011). As previously stated, wolves have only been on UNDERC property for about 12 years (D. Flagel, personal communication). The removal of the wolves and henceforth over browsing by deer may have affected the structure of the forests so substantially that the understory is still recovering. There have been changes in the understory composition between the wolf use zones (Flagel et al., *in review*), but these may not be different enough to see a marked change in insect diversity between the two areas. These effects may therefore need to be reexamined in the future to see if these legacy effects will continue to persist in this area.

Another possibility as to why insect diversity may not vary significantly across types of wolf use is that many insects possess the ability to fly. This makes their migration between wolf use areas potentially very easy. While there may be more diverse plants in high wolf areas, insects may be able to access different areas of forest just by taking a quick flight.

As with the insects, spider species richness or abundance did not vary with type of wolf use. However, spider diversity approached a significant difference. Rather than just change the alpha level of significance, this may necessitate further investigation into the differences in spider communities. Spiders generally prey upon insects by weaving a web, or alternately, hunting them on the ground. As the structure of the understory diversifies and changes, more areas for spiders to build webs come to be (Greenstone 1984). This may attract more functional groups of spiders that spin different types of webs. However, with deer browsing reducing understory complexity (Rooney 2001), these differences amongst predation techniques may be accountable for the difference in spider diversity between wolf types. Additionally, because of their tendency to stay in one place to collect food, and inability to fly, they may be slower at migrating between areas of forests. However, some spiders show great speed in migration by using a technique known as “ballooning” (Greenstone 1982). It would be interesting to investigate potential differences in hunting and migration strategies of spiders that are found in each type of wolf use.

There may be more than wolf trophic cascades indirectly affecting the populations and diversity of insects and spiders in this instance. Spiders are known to prey on each other, and this intra-guild predation may result in a weaker impact of the cascade on insect diversity (Finke and Denno 2004). This may be another factor in the lack of association between wolf use type and diversity of insects.

Predation by birds may also be significantly impacting the diversity of both insects and spiders. With a more diverse understory, there are more places for birds to place nests, as well as more locations to hide from predators (Nuttle et al. 2011). A more welcoming habitat for birds would also include greater prey populations, including both insects and spiders. This may have more impact on larger spiders that more likely to be preyed upon by birds. However, many of these are active hunters, and are more likely to require a developed understory to survive (Oxbrough et al. 2005). Having more diverse plant life could provide the necessary environment for various types of hunters, spiders and birds alike.

Spiders may also have their own cascading effects, as their removal may cause increases in phytophagous insect populations (Carter and Rypstra 1995). Having a less developed understory, which could allow for greater predation on spiders by birds, could therefore be advantageous to smaller insects. With less spider predators, more insects that would not as easily be preyed upon by birds could thrive and take full advantage of resources. This could be investigated as another possible hypothesis as to reasoning for the low difference in diversity between wolf use areas.

As of now on the UNDERC property, there is no significant difference in arthropod communities across wolf use types. Whether it is due to legacy effects, or insect migration, or predation between spiders or by birds, necessitates further investigation. However, the approaching significance in spider diversity certainly encourages further investigation.

This study has implications for management in regards to biodiversity. Biodiversity is a critical aspect of our ecosystems to maintain. By allowing wolves to recolonize our forests, we can prevent over browsing by deer, and in turn, potentially allow for greater diversity of spiders within our forests. Additionally, in studying the trophic cascades of our forest ecosystems, we can further understand the effects that humans have indirectly caused. In the removal of wolves, white-tailed deer have caused a structural change of the forest understory and reduction in diversity. How these changes have affected insect and spider communities has not been examined thoroughly. With further experimentation, we can learn about additional implications of deer browsing and

Figures:

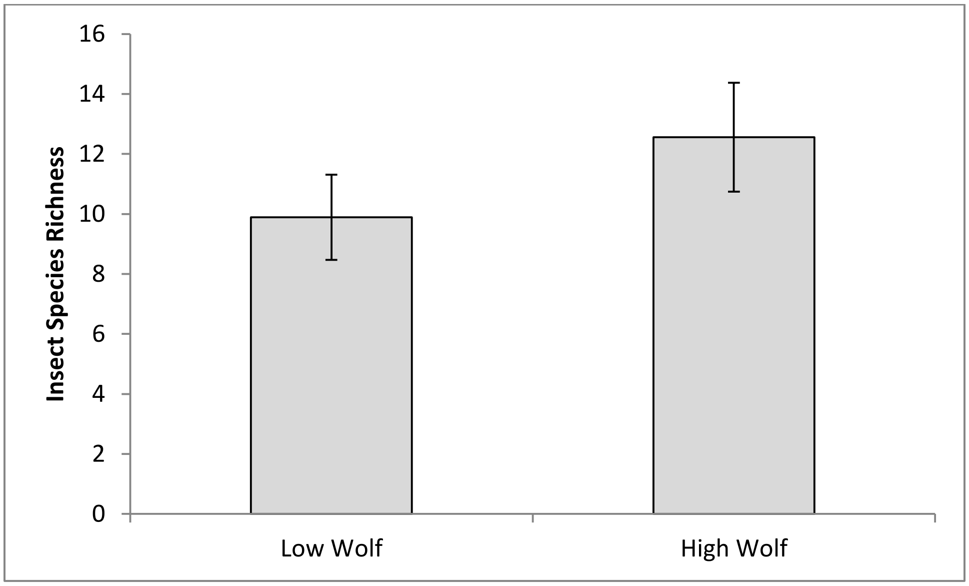

Figure 1: Difference in insect species richness between low and high wolf areas (mean ± 1 SE). There is no significant difference (p=0.186, t=-1.383, df=16). Insect species along transects were counted for each type of wolf use.

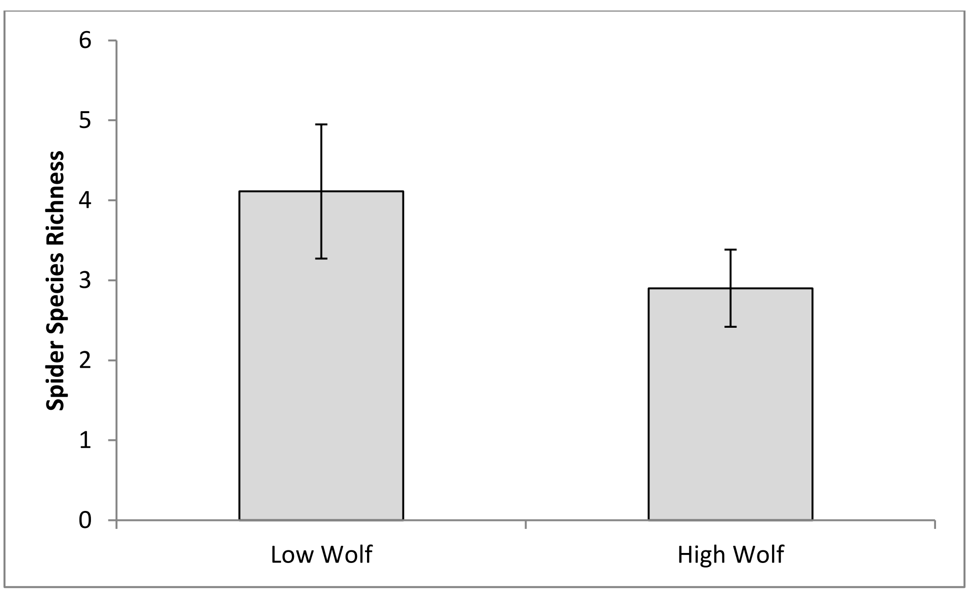

Figure 2: Difference in spider species richness between low and high wolf areas (mean ± 1 se). There is no significant difference between the two areas. (p=0.375, t=0.912, df=16). Spider species along transects were counted for each type of wolf use.

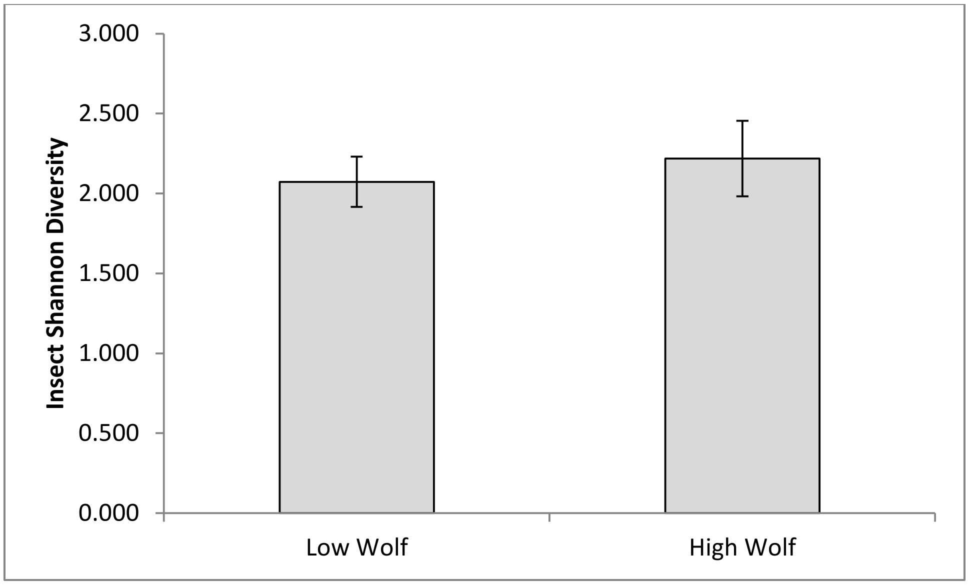

Figure 3: Difference in insect diversity calculated using the Shannon-Wiener diversity index (mean ± 1 se). There is no significant difference in insect diversity across wolf type (p=0.605, u=34). Diversity was calculated using number of species as well as abundance of each species of insect.

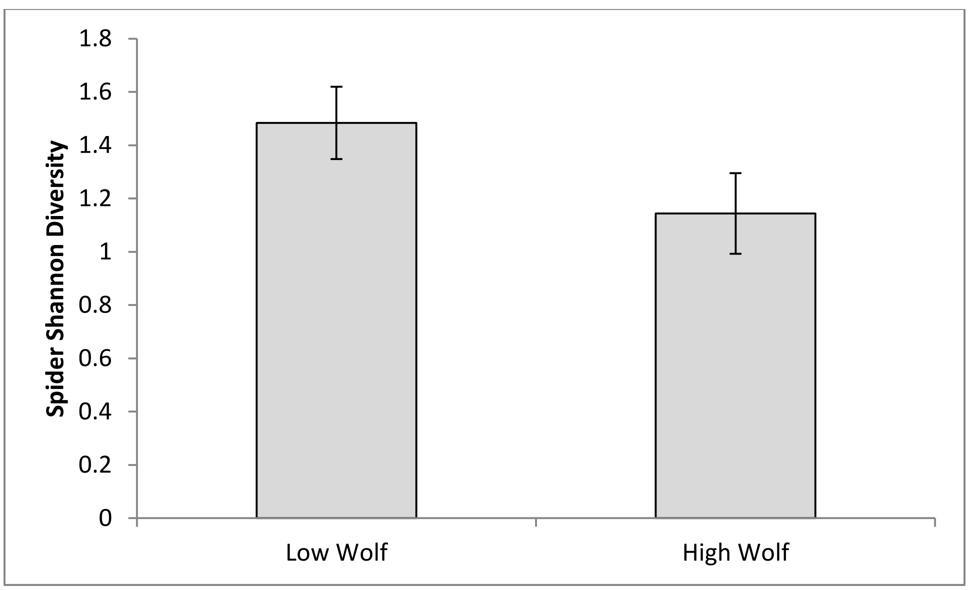

Figure 4: Difference in spider diversity calculated using the Shannon-Wiener diversity index (mean ± 1 se). The data is trending towards significance, but cannot be declared significant at the 5% level (p=0.067, t=2.001, df=13). Diversity was calculated using number of species as well as abundance of each species of spider.

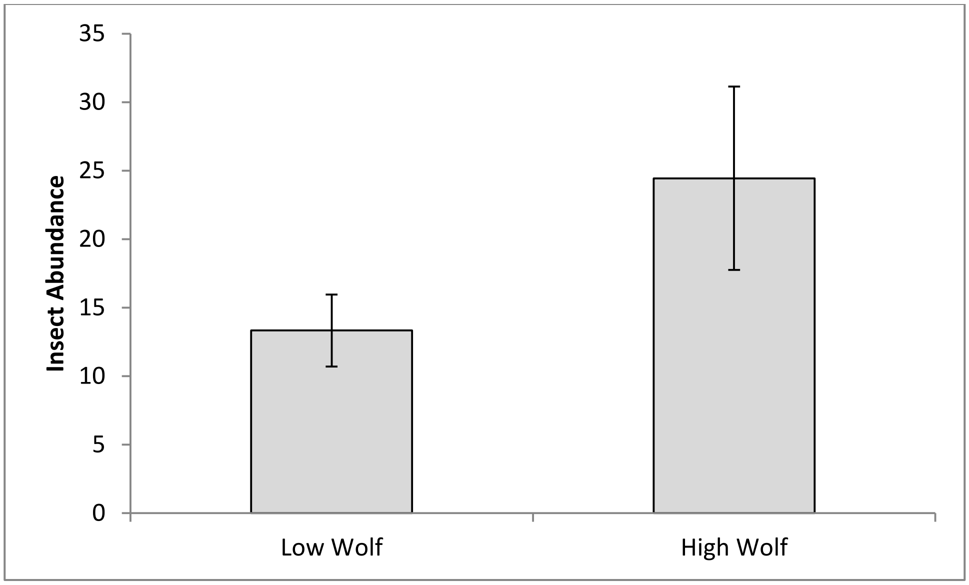

Figure 5: Difference in insect abundance between high and low wolf area (mean ± 1 se). There is no significant difference between the two areas (p=0443, t=0.787, df=16). Abundance of insects along transects were counted for each type of wolf use.

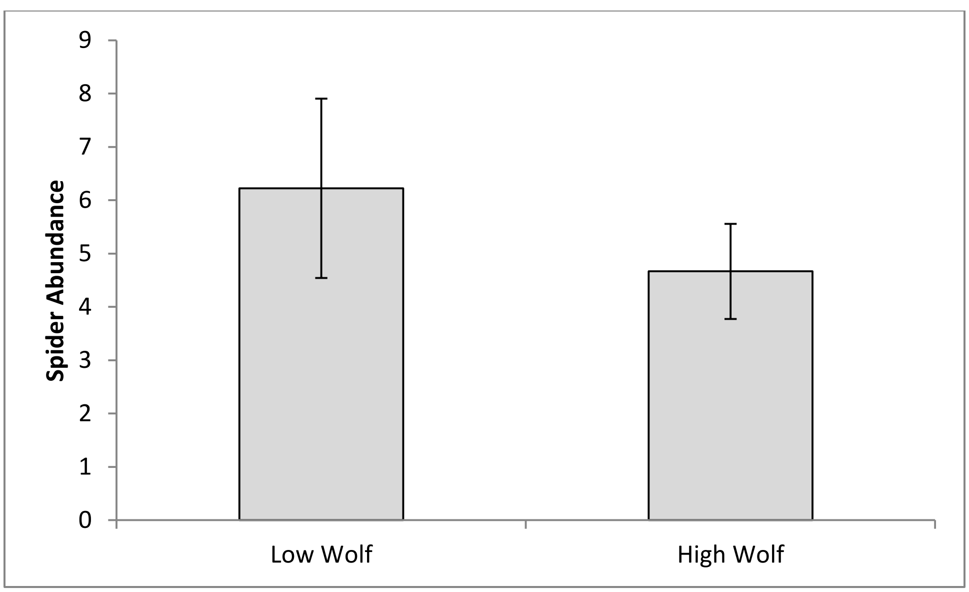

Figure 6: Difference in spider abundance between high and low wolf areas (mean ± 1 se). There is no significant difference between the two areas (p=0.443, t=0.787, df=16). Abundance of spiders along transects were counted for each type of wolf use.

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