The Impact of Sheep Grazing on Spider Diversity and Abundance

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ABSTRACT

Rotational grazing is a livestock management technique known to benefit plant health, soil health (Smith et al. 2011), and pollinator diversity (Enri et al 2017). However, there is a gap in research concerning rotational grazing's benefit or detriment on spider communities. In this study, I investigated the impact of rotational sheep grazing compared to long-term sheep grazing on spider diversity and abundance in Hopland, California. I set pitfall and ramp traps to collect specimens in a long-term grazed pasture, a rotationally grazed pasture, and in an ungrazed control pasture. I collected data between late October and early November, with two cycles of sample collection. The long-term grazed pasture was found to have the highest spider population with 113 individuals in the first collection, and the highest family diversity with a Shannon Diversity Index value of 1.516. In the second round of data collection, the ungrazed area had the highest spider population with 73 individuals, slightly higher than the long-term area population of 69 individuals, while the rotationally grazed pasture had the highest family diversity with a Shannon Diversity Index value of 1.416. Despite aims to control stocking, the sheep stocking densities of the two treated pastures had not been controlled, which impacted the data. The rotationally grazed pasture had a much larger sheep population than the long-term grazed pasture, and it had lower spider abundance than the long-term grazed pasture in both rounds of data, with 83 individuals in the first round and 47 individuals in the second. If the rotationally grazed pasture had the same stocking density as the long-term pasture then it would likely have higher spider abundance. However, this study still provides evidence that some amount of grazing enhances spider communities compared to no grazing.

KEYWORDS

Specimen collection, biodiversity, Hopland Research and Extension Center, functional groups, Shannon Diversity Index, Sorenson's Coefficient

INTRODUCTION

In conventional agriculture, many land managers employ continuous grazing: animals graze a pasture for an extended period of time, and vegetation is not allowed a recovery period to regrow. Continuous grazing can lead to overgrazed areas, in which plants are unable to withstand grazing pressure and plant stands (number of living plants per acre) and vegetative diversity decreases (Longland, 2011). Grazing methods that place less strain on plant stands include lowering the stock density (amount of grazing animals per acre), seasonal grazing, and rotational grazing. Rotational grazing allows farmers to graze their animals throughout the year without lowering their stock density, while allowing plants to recuperate Smith, 2011).

Rotational grazing has been shown to be a more sustainable method than continuous grazing. Animals are rotated between "cells" of the pasture, allowing the plant stands to grow between grazing episodes. There is evidence that rotational grazing can enhance bumblebee and butterfly biodiversity as compared to continuous grazing (Erni et al. 2017), but there is limited evidence on how grazing regimes may impact spider biodiversity. Stjenberg (2011) investigated the effect of twice-over rotational grazing compared to no grazing on ground beetle and spider diversity, but did not examine the impact of rotational grazing. Szamtona-Turi et al. (2019) measured how low stock grazing (0.5 animals/hectare) affected spider diversity compared to high stock grazing (1 animal/hectare). These studies demonstrate that there is an impact of grazing on spider diversity, however, no studies specifically examine the impact of rotational grazing as compared to continuous grazing on spider diversity and abundance.

Spiders were selected to be the subject of this study over pollinators or other arthropods like beetles, because spiders are studied less extensively and are an ecosystem indicator organism. At both the population level and the community level they measure the habitat quality and the impact of human activity on the ecosystem (Marc et al. 1999). Spider community assemblages reflect changes in ecosystem functions and changes in the microclimate caused by factors such as soil disturbance and soil pH (Pearce and Venier, 2006) which are affected by grazing (Hao and He, 2019). The diversity and abundance of spiders at each site can be used as an indicator of the relative state of the overall biodiversity of each site, and thus the resilience of the local ecosystem (Bellamy et al. 2018).

Spider populations have been studied to indicate the impact of different forest management practices on the ecosystem (Pearce and Venier, 2006) and the effect of varying grazing heights (Freiberg et al. 2020). But their response to varying grazing schedules - rotational grazing compared to long-term - has not been studied, which is the impetus for my study. Spiders varying grazing heights (Freiberg et al. 2020). But their response to varying grazing schedules - rotational grazing compared to long-term - has not been studied, which is the impetus for my study. Spiders also play a large role in agriculture, so the impacts of different agricultural techniques on their populations needs to be studied. They are generalist predators with a huge diversity of species, so they eat a wide variety of prey. This makes spiders important agents of biological pest control (Michalko et al. 2019), and it is in farmers' best interest to enhance their populations. The purpose of my study was to provide evidence that rotational grazing supports more diverse and abundant spider populations, which in turn would aid in pest control by enhancing the generalist predator population.

The central question guiding my research is: "How is spider diversity and abundance impacted by rotational grazing compared to continuous grazing?". The sub-questions that I will use to fully answer my central question include "How does the functional group composition differ between sites? ", "What other factors besides grazing affect the spider population?", and "How does community overlap affect the significance of the data?". My working hypothesis is that the rotationally grazed pasture will have higher spider species diversity and abundance compared to the long-term grazed pasture. The goal of my data collection is to determine if there is a differential impact of three grazing treatments - no grazing, long-term grazing, or short-term rotational grazing - on spider abundance and diversity.

METHODS

Study Site

I conducted the study at the Hopland Research and Extension Center (HREC) in Hopland, California, in Mendocino County. The HREC is located at 39°00'04.5" North 123°04'47.3" West, and has hot, dry summers which last through October, and mild, rainy winters. The HREC has a total of 5358 acres and is owned and operated by the University of California Division of Agriculture and Natural Resources. It is used for field research on the North Coast region, including rangeland ecology, animal science, and viticulture.

For my study, I placed traps in a pasture where sheep graze for extended periods of time, one where sheep are rotated out more frequently allowing for plant recovery, and in an ungrazed pasture which served as the control. The rotationally grazed area is called the Huntley Pasture, and the long-term grazed pasture is the Joeys Pasture (Figure 1). The ungrazed area is a patch of pasture that has not been grazed for at least the past six years. When I first set the traps, the weather was sunny and about 90 degrees. I placed the traps in the direct sun, away from trees, creek beds, and hillsides that may have affected the community composition at each site. Each site is at approximately the same elevation, 800' above sea level.

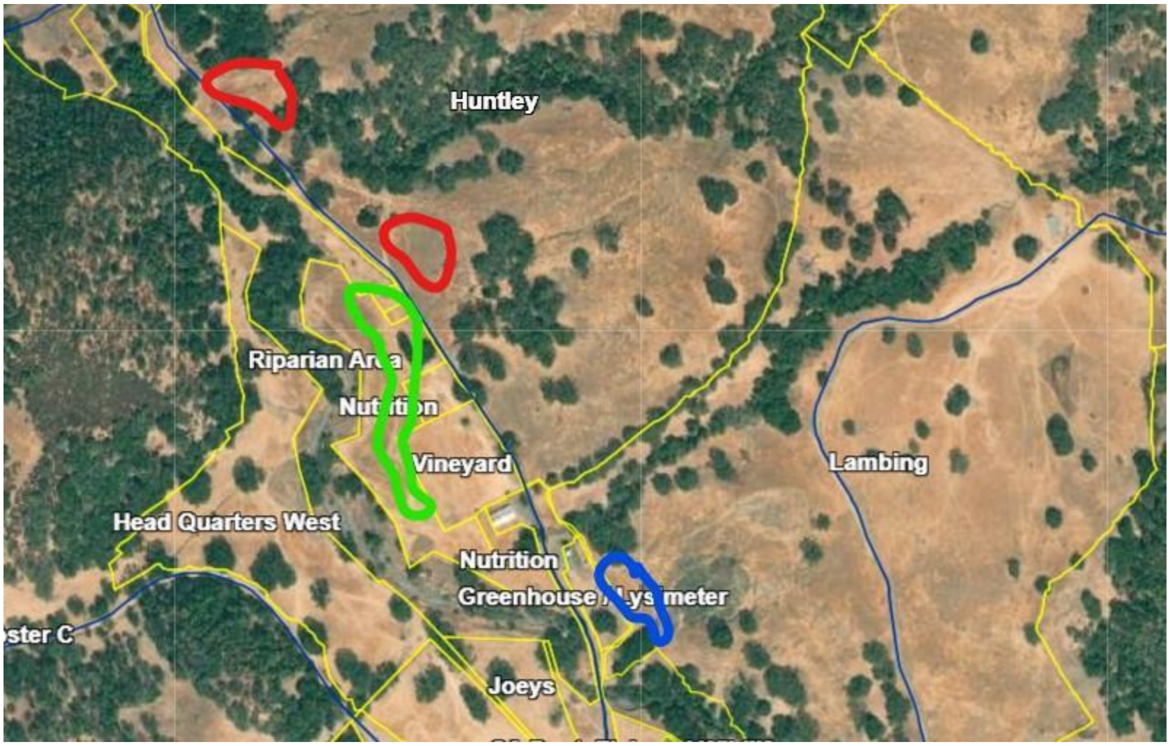


Figure 1. Map of study pastures at HREC drawn by Alison Smith, Staff Research Associate. The blue circle is the rotationally grazed area, the green circle is the long-term grazed area, and the red circle at the top of the map is the ungrazed area.

Data Collection

I chose pitfall and ramp traps to collect specimens, and they are the design used by Weary et al. (2019) (Figures 2 and 3). A pitfall trap consists of a red party cup placed in a hole so that the rim of the cup is flush with the surface, with a hard rain cover about 3 cm above the cup. This allows ground-dwelling organisms to walk in, and the cup is protected from small mammals or sheep hooves. The cup contains a shallow level of propylene glycol to both kill and preserve the specimens once they fall in the trap. A ramp trap consists of two ramps leading into a 120 × 82 × 50 mm box with a cover about 2 cm above the box. The box is also filled with a shallow layer of propylene glycol.

I laid 60 traps total, with 10 ramp traps and 10 pitfall traps in each of the three pastures. I placed the traps in two linear transects, with each trap 5 meters apart, alternating pitfall and ramp, and spanning the length of about 100 meters. The second line was staggered 2.5 meters ahead of the first so as to create more opportunities for spiders to find the traps. A wire electric fence (not live) was strung near the trap lines to deter disturbance by the sheep and sheepdogs in the actively grazed pastures. I placed the traps on October 8th, collected on October 24th, and collected again and removed on November 6th. The contents of each trap were emptied into its own Whirl-Pak,which was labeled with the type of pasture, type of trap, and trap number. I sorted the contents of each trap into spiders and bycatch in the Will Lab at the University of California, Berkeley. Following the completion of this study, voucher specimens will be deposited in the Essig Museum of Entomology, UC Berkeley (EMEC) and will be a part of previous collecting efforts that are developing a picture of arthropod diversity at HREC. The samples will be maintained in the Will lab and will be available for future projects.

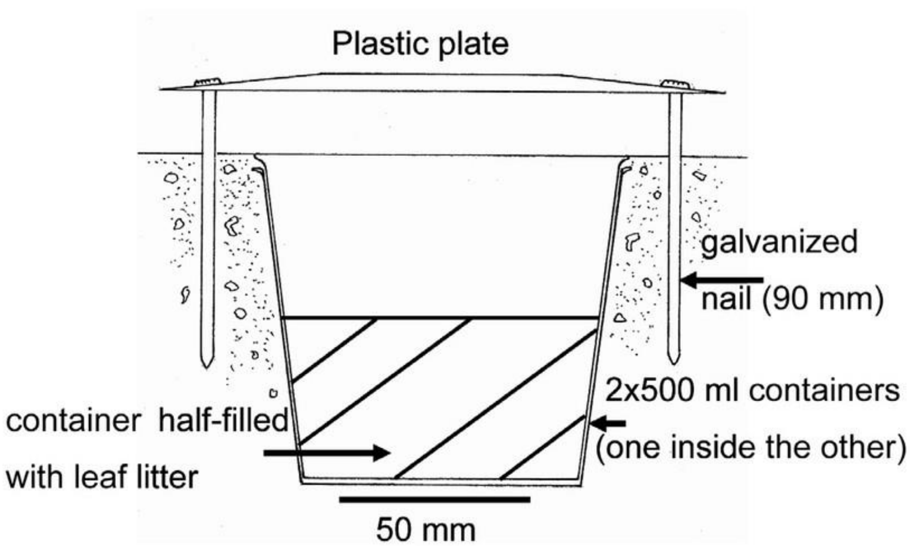


Figure 2. Diagram of a pitfall trap. (Breggs, University of Auckland)

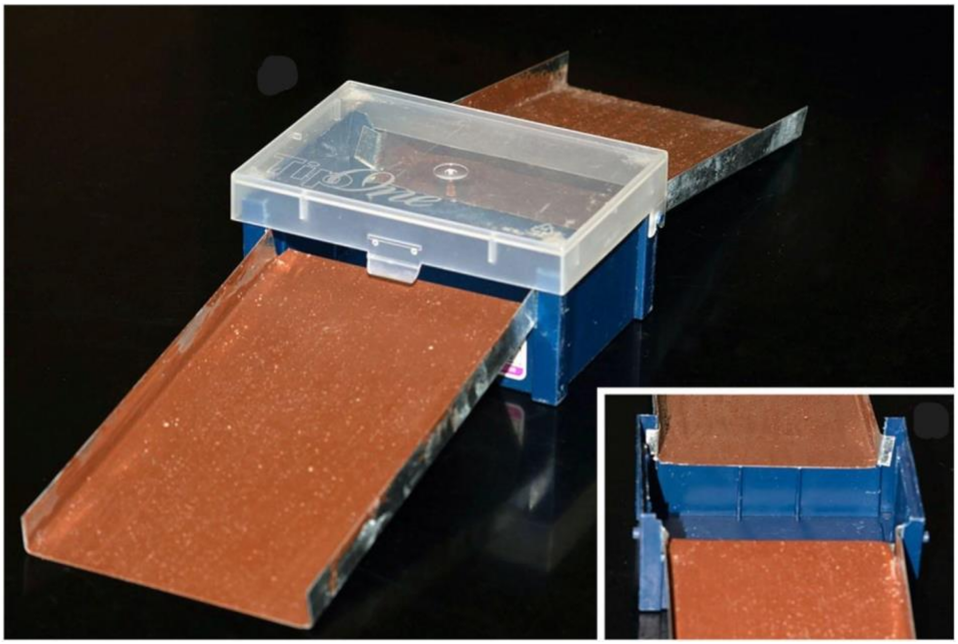


Figure 3. Ramp traps used in study. (Weary et al. University of California, Berkeley)

Data Analysis

I identified spiders to their family level, and sorted them into two functional groups: web-builders and ground-dwellers. I identified the spiders with the North American Spider Identifcation Manual (Ubick et al. 2009), using the number of tarsal claws, eye shape and arrangement, spinneret length, other distinctive morphological characteristics, and geographical distribution. I used Excel spreadsheets to keep track of the data.

After identification and sorting, I calculated the Shannon Diversity Index (Shannon and Weaver, 1949), denoted as H, at each site, which measures the family diversity of each community in terms of richness and evenness. The higher the H value, the higher the level of family diversity is in each site, and the more evenly the population is distributed across families. I calculated this value once for each pasture during both rounds of data collection.

I also calculated Sorenson's Coefficient, which describes how similar two communities are to each other. Sorenson's Coefficient is a calculation that measures how many species, and in the case of my study families, two sites have in common with each other. The calculation gives a value between 0 and 1, where 1 is complete overlap and 0 is complete dissimilarity. I calculated the overlap between eachc ombination of communities for both collection periods. If the communities overlap completely, it may mean that they are not isolated enough for the grazing treatment to have a significant impact, while if they have a low amount of overlap, then they are independent from each other.

RESULTS

The first round of trap collection (Collection A) yielded 276 spiders from 7 different families (Tables 1-3). The second round (Collection B) yielded 189 spiders from 9 families (Tables 1-3). In total, the traps captured 465 spiders. In the first round of data collection, the long-term grazed pasture had the highest spider abundance with 113 individuals (Table 3). The rotationally grazed pasture had the second highest abundance with 83 individuals (Table 2), and the ungrazed pasture had the lowest abundance with 68 individuals (Table 1). In the second round of data collection, the ungrazed pasture had the highest abundance with 73 individuals (Table 1), closely followed by the long-term grazed pasture with 69 individuals (Table 3). The rotationally grazed pasture had the lowest abundance with 47 individuals (Table 2).

In both collections, Clubionidae (sac spiders) and Lycosidae (wolf spiders) were the most commonly collected families. Both belong to the ground-dwellers functional group, which was the dominant group in each of the pastures across both collections. Salticidae, Corinnidae-Trachelidae, and Philodromidae were among the families that had an intermediate occurence in the collection. The most infrequent families included Oecobeidae, of which there was only one individual in the entire collection, and Pholcidae, of which only one individual was found per grazed pasture. Pholcidae, Zoridae, and Thomisdae were only found in grazed pastures.

Spider Abundance by Family

Table 1. Spider abundance by family in the ungrazed pasture across both collection periods.

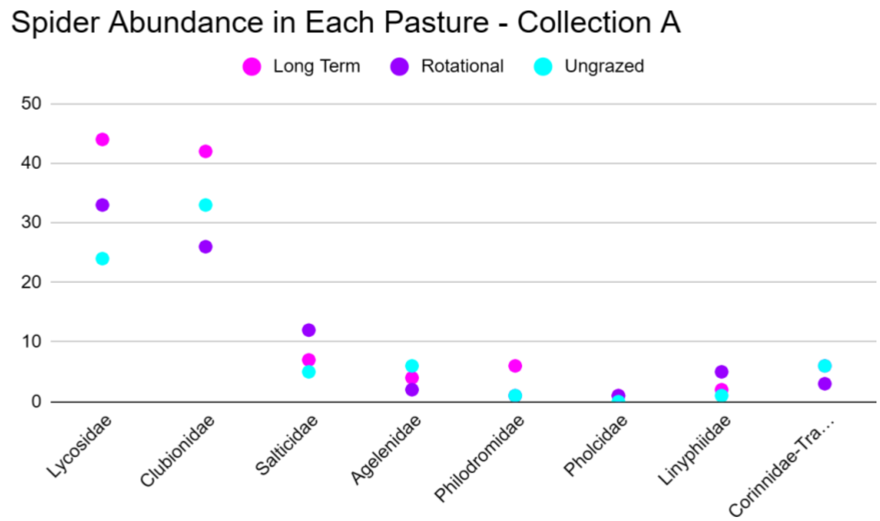
Spider Family	Ungrazed Pit A	Ungrazed Ramp A	Ungrazed Pit B	Ungrazed Ramp B
Lycosidae	10	14	9	12
Clubionidae	11	22	24	22
Salticidae	0	5	0	1
Agelenidae	5	1	0	0
Philodromidae	0	1	0	2
Pholcidae	0	0	0	0
Linyphiidae	1	0	2	1
Corinnidae-Trachelidae	6	0	0	2
Oecobeidae	0	0	0	1
			Ungrazed A Total: 68	Ungrazed B Total: 73

Table 2: Spider abundance by family in the rotationally grazed pasture across both collection periods.

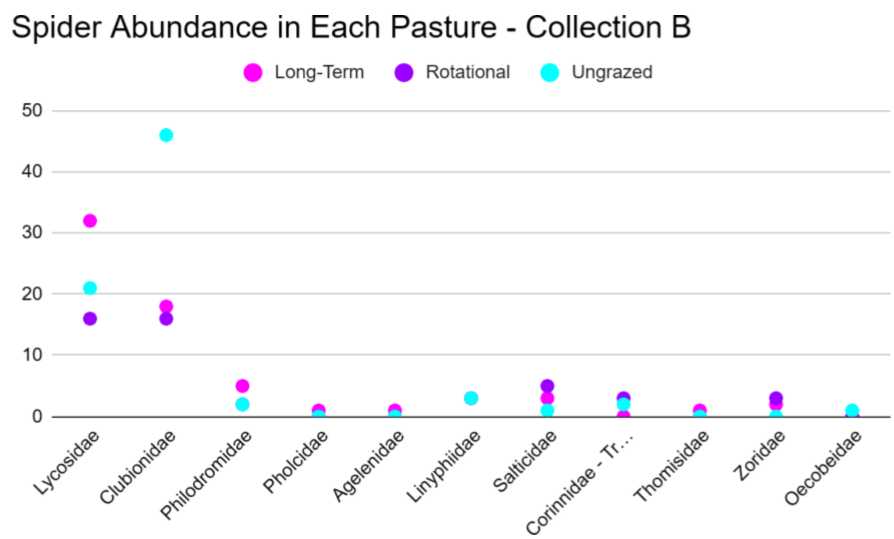
Spider Family	Rotational Pit A	Rotational Ramp A	Rotational Pit B	Rotational Ramp B
Lycosidae	20	13	12	4
Clubionidae	17	9	9	7
Salticidae	2	10	0	5
Agelenidae	1	1	0	0
Philodromidae	0	1	0	2
Pholcidae	0	1	0	0
Linyphiidae	4	1	0	3
Corinnidae-Trachelidae	2	1	0	3
Zoridae	0	0	1	2
			Rotationally Grazed A Total: 83	Rotationally Grazed B Total: 47

Table 3: Spider abundance by family in the long-term grazed pasture across both collection periods.

Spider Family	Long Term Pit A	Long Term Ramp A	Long Term Pit B	Long Term Ramp B
Lycosidae	31	14	20	15
Clubionidae	20	22	10	8
Salticidae	2	5	0	3
Agelenidae	0	4	0	1
Philodromidae	1	5	2	3
Pholcidae	1	0	1	0
Linyphiidae	0	2	1	2
Corinnidae-Trachelidae	2	4	0	0
Zoridae	0	0	2	0
Thomisidae	0	0	1	0
			Long Term A Total: 113	Long Term B Total: 69



a)



b)

Figure 4: Comparing spider abundance by family between pastures. Figure 4 a) represents spider abundance in Collection A, and Figure 4 b) represents spider abundance in Collection B.

Spider Diversity

H values were higher during the first round of data collection, and the long-term grazed area had the largest H value in the first round, larger than the rotationally grazed pasture by 0.021, and larger than the ungrazed pasture by 0.053 (Figure 5). The rotationally grazed area had the highest value in the second round, larger than the long-term grazed pasture by 0.094 and larger than the ungrazed pasture by 0.316 (Figure 5). There was a greater degree of difference in diversity between each pasture during the second round of data collection. In both rounds of data collection, the ungrazed pasture had the lowest family diversity.

Type of Pasture	Shannon Diversity Index A:	Shannon Diversity Index B:
Ungrazed	1.463	1.10
Rotational	1.495	1.416
Long Term	1.516	1.322

Figure 5: Shannon Diversity Index for each pasture during both collection periods.

Community Overlap

I calculated Sorenson's Coefficient (CC) for each combination of pastures during the two collection periods. See Table 14 for the results of the calculations. The CC value for pastures in the first round of data collection was higher than that of those of the second round of data collection. This means that there was less overlap between communities in the second collection. There was less community overlap when comparing a grazed pasture to the ungrazed pasture, and more community overlap when comparing the two grazed pastures to each other.

Type of Pasture	Sorenson's Coefficient A	Sorenson's Coefficient B
Ungrazed and Long Term	0.875	0.857
Ungrazed and Rotational	0.875	0.625
Long Term and Rotational	1	0.75

Figure 6: Sorenson's Coefficient for each pasture during each collection period.

Functional Group Composition

The majority of spiders collected were ground-dwellers, which hunt for prey by wandering fields instead of building webs (Figure 7). Lycosidae, Clubionidae, Salticidae, Philodromidae, Corinnidae, Thomisidae, and Zoridae are ground-dwellers. A small amount of the spiders collected belong to web-building families, which include Agelendiae, Pholcidae, Linyphiidae, and Oecobeidae. In the grazed pastures, the web-building population declined in the second round of data collection for the ungrazed and rotationally grazed pastures, but increased for the long-term grazed pasture (Figure 8).

Functional Groups	Rotational A	Rotational B	Long Term A	Long Term B	Undergrazed A	Ungrazed B
Ground-dwellers	**75**	**44**	**106**	**64**	**62**	**69**
Web-builders	**8**	**3**	**7**	**5**	**6**	**4**

Figure 7: Functional group composition across each pasture and both collection periods.

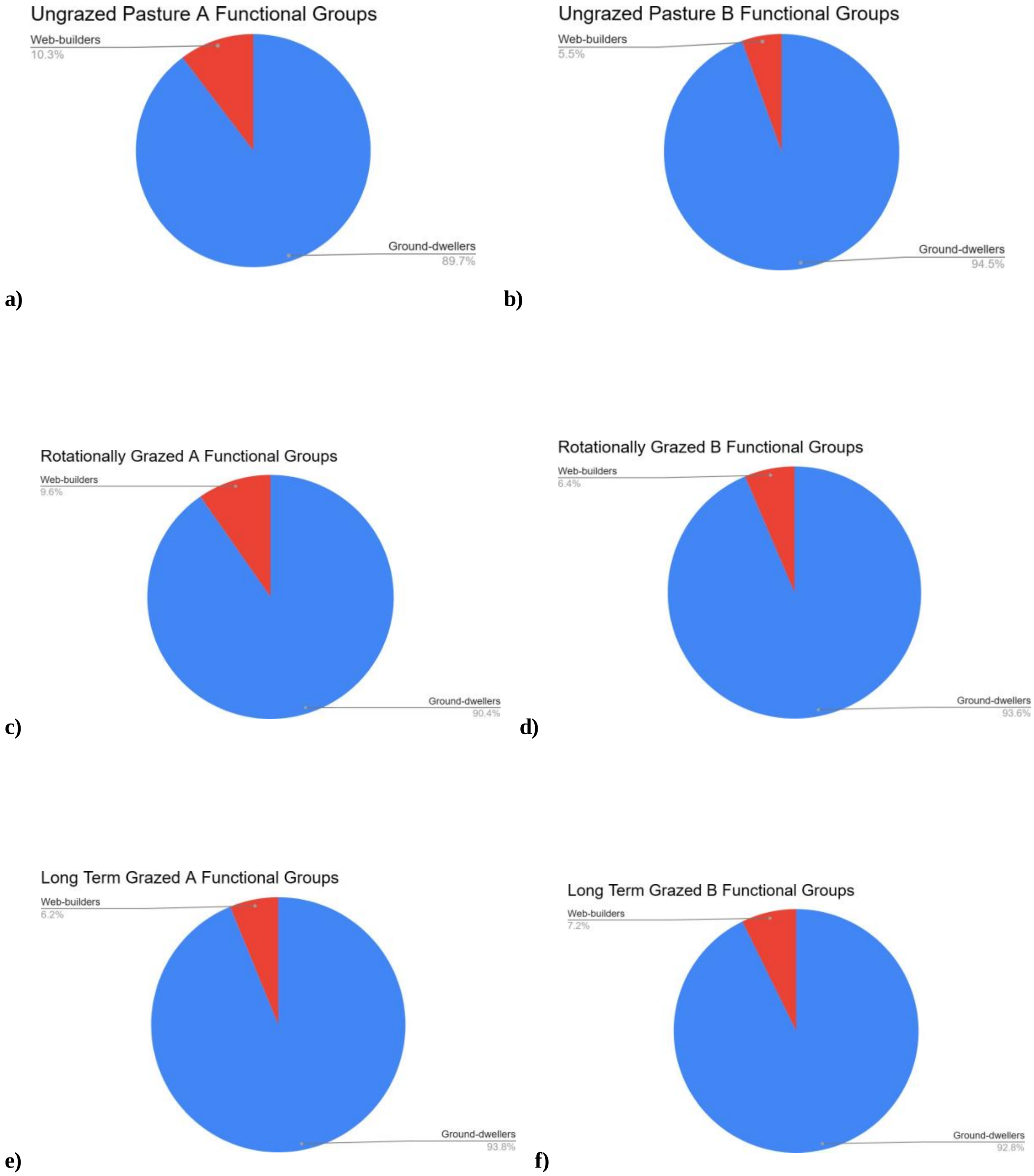


Figure 8: Percentage of each pasture occupied by web-builders and ground-dwellers. Figure 8 a) is the functional group composition of the ungrazed pasture in Collection A, and b) is the functional group composition of the ungrazed pasture in Collection B. Figure 8 c) is the functional group composition of the rotationally grazed pasture in Collection A, and d) is the functional group composition of the rotationally grazed pasture in Collection B. Figure 8 e) is the functional group composition of the long-term grazed pasture in Collection A, and f) is the functional group composition of the long-term grazed pasture in Collection B.

DISCUSSION

In this project, I studied spiders in pastures under different grazing treatments to determine which was the most beneficial for their communities, and by extension for the pasture as a whole. Spiders are ecological indicator organisms: the health of their communities indicates how well an ecosystem functions, and how much it has been disturbed by human activities (Pearce and Venier, 2005). Although the sheep population and pasture area were not standarized variables, and the impact of different grazing treatments cannot be accurately determined, the data can still be used to assess the habitat quality of each pasture.

In the long-term grazed pasture, 10-15 sheep graze over seven acres, while in the rotationally-grazed pasture, 70-200 sheep graze over 70 acres. If my study was at a larger capacity, then I would have taken samples from multiple sites on each pasture, and the varying sheep populations likely would have had a minimal impact on the data. Ten sheep grazing over seven acres is the same stocking density as an average of 100 sheep grazing over 70 acres. However, my study only sampled a 100 meter transect in each pasture. Due to their centuries-old instinct to band together for protection, sheep often graze in big groups (Cobb, 1999). This means that there were ten sheep impacting that transect in the long-term pasture, and an average of 100 sheep impacting the same sized transect in the rotationally grazed pasture, so that in effect, the rotationally grazed pasture had a higher grazing pressure than the long-term pasture.

Spider Abundance

In the first round of data collection, the long term grazed pasture had the highest spider abundance and the highest family diversity with a population of 113 individuals and the highest Sorenson's Coefficient (index used to measure family diversity and evenness) with a value of 1.516. The long term grazed pasture was thus the most favorable pasture for spider communities at that time of year. This pasture had the most well-functioning ecosystem: high levels of spider biodiversity means that the pasture has a sufficient insect population to attract spiders, and the habitat has not been degraded by overgrazing. In this pasture, a low stocking density of 10-15 sheep over seven acres allowed for minimal disturbance to the habitat, enhancing spider biodiversity. This effect is an example of the Intermediate Disturbance Hypothesis: local species diversity (in the case of this study, family diversity) is maximized by an amount of disturbance that is neither too occasional nor too frequent (Dial and Roughgarden, 1988). Grazing alters vegetative height, allowing more sunlight to reach the ground (Szamtona-Turi et al. 2019), and warmer soil temperatures increases spiders' activity levels (Pruitt et al. 2011). Sheep manure adds organic matter and nutrients to the soil, attracting soil organisms such as collembola that spiders prey upon (Agusti et al. 2003). These disturbances, in the form of vegetation height diversification and addition of nutrients, benefit the pasture ecosystem.

High intensity grazing has been shown to increase the decay rate (the steepness of the rank- abundance curve) of insect and spider species abundance (Simons et al. 2015), and this is evident in the rotationally-grazed pasture. The rotationally grazed pasture had lower spider abundance and lower family diversity than the long term grazed pasture in the first round of data with 83 individuals and a Shannon Diversity Index of 1.495. With a much larger grazing population of 70-200 sheep over 100 acres, this habitat experiences a higher level of disturbance. Higher livestock densities can overgraze an area, lowering the number of living plants per acre. When the photosynthesizing portion of a plant is continuously removed, its root systems begin to die off, and the plant is unable to take in water (Smith et al. 2011). With less living plants in the soil, the topsoil is more prone to erosion, while the lower layers of soil are compacted under livestock hooves (Liang et al. 2021). Compacted soil is less aerated, and water is unable to travel through it easily. With less plant stands and degraded soil, the habitat is negatively impacted and biodiversity lowers. Although my study did not measure the number of plant stands in each pasture, based on the lower spider abundance and diversity index I can extrapolate that this pasture is not functioning as well as the long-term grazed pasture, and has a lower capacity for biodiversity due to a larger grazing population. The higher livestock density was less beneficial to the spider community.

The abundance of spiders decreased from the first collection period from 276 individuals to 189 individuals in the second collection period. The colder weather likely caused this change: Spiders are more active during warmer months and are less active in cooler months - with less prey available, they survive the winter by conserving energy. They slow down their metabolism, limiting their need for hunting and feeding (Billings 2021). During the colder period of the second collection round, the ungrazed pasture supported the largest spider population with 73 individuals. Although moderate disturbance from low-intensity grazing has a positive effect on arthropod communities during periods when vegetation is productive, it has a negative effect during periods where vegetation is less productive, including winter (Torma et al. 2023).

The negative impact of low-intensity grazing during periods when vegetation is less productive may explain why the ungrazed pasture had a larger population than the grazed pastures in the second collection. The quality of habitat in the pastures also may have decreased due to the cold weather limiting prey availability (Owens et al. 2022). Web-building spiders in particular face limited prey during cooler months as cold weather constrains the activity of flying insects (Arbeiter et al. 2016). This is reflected in the functional group composition of the pastures: each pasture experienced a decline in web-builder abundance from the first collection to the second. The climatic impact on Agelendidae in each pasture is especially apparent: in the first collection, the ungrazed pasture had six individuals, and in the second collection, it had zero. The rotationally grazed pasture had two Agenidae in the first round, and zero in the second. The long-term grazed pasture had four individuals in the first round, and one in the second. Agenlediae are also called funnel web spiders, and build sheet-like webs in grass. The ungrazed pasture likely had the highest Agelenidae population because they build their webs close to the ground, which could be disturbed by livestock. But as the weather shifted, flying prey may have become less abundant, and the Agenlendiae population decreased.

One notable result of this study is that both grazed pastures had significantly higher spider populations than the ungrazed pasture in the first round of data collection. The higher spider abundances in the grazed pastures provide evidence that some level of grazing is beneficial to the population level of the spider community, and provides evidence that the Intermediate Disturbance Hypothesis can be applied to abundance in addition to diversity. Sheep grazing at Hopland, especially during the warmer months, created more favorable habitats for spiders than the ungrazed area that had been left fallow for 6 years. The presence of sheep manure provides nutrients for plants and attracts soil fauna, which serve as an alternate prey source when larger prey is infrequent. It has been documented that collembula can sustain Linyhiidae spiders in particular (Agusti et al. 2003), and across both collection periods the rotationally grazed pasture, which would have the most manure due to its large amount of sheep, had the largest Linyphiid population. Linyphiidae spiders are among the smallest in my samples, so while I assume that enhancing the collembola community would benefit other small spiders who would be unable to access larger prey, further research in this area is needed.

Family Diversity

I hypothesized that the rotationally grazed pasture would have higher family diversity than the long-term grazed pasture, and the results of the study do not provide evidence for my hypothesis. In the first round of data collection, the rotationally grazed pasture had a Shannon Diversity Index (H) of 1.495, while the long-term grazed pasture had the highest H value at 1.516, meaning it had the most even distribution of family abundance. Like the population, this likely results from the lower stocking density in the long-term grazed pasture. The rotationally grazed pasture, with grazing taking place every two weeks, had the largest Shannon Diversity Index in the second round of data with a value of 1.416. Daily grazing during the colder period was more strenuous on the community, and caused a lower diversity index for the long-term grazed pasture.

In both the first and second rounds of data collection, the ungrazed pasture had the lowest Shannon Diversity Indices, providing evidence that some level of grazing enhances spider family diversity. This result also supports the Intermediate Disturbance Hypothesis. Livestock have been found to have a positive impact on biodiversity in cases where land that was abandoned or ungrazed was compared to land that was restored or extensively grazed (Kok et al. 2019). Grazing increases plant species richness compared to a field left fallow (Bucher et al. 2015), creating a more diversified habitat and attracting a variety of spiders and their prey. Just as it enhanced spider abundance, the sheep manure in grazed pastures enhanced family diversity as well. Three families, Thomisdae, Zoridae, and Pholcidae, were exclusively found on grazed pastures. The individuals in these families were all very small, and likely benefitted from the additional food source of soil fauna attracted to sheep manure. The ungrazed area this study has been left fallow for at least the past 6 years, and the lack of disturbance and plant management from grazing may have led to a less diverse spider community compared to the grazed pastures. The grazed pastures also had more web-builders than the ungrazed pasture in the first collection. Enhancing the population of spiders across functional groups means that an increased variety of prey (e.g. agricultural pests) can be eaten.

Community Overlap

I calculated Sorenson's Coefficienet to measure overlap between pastures because I was concerned that the sites' relative proximity to each other would allow spiders to travel between communities, and compromise the data. The long-term grazed and rotational pastures did have a Sorenson's Coefficient of 1 in the first round of data collection, meaning that they had exactly the same families in each pasture. But these two communities likely had complete overlap because they are experiencing the same climate at Hopland, and the presence of sheep attracted the same families to each pasture. The ungrazed pasture and rotationally grazed pasture had a similarly high Sorenson's Coefficient of 0.875, even though they were the two sites that were furthest from each other. This allows me to conclude that community overlap is likely not due to physical distance between sites. In the second round of data collection, the Sorenson's Coefficients between each pasture were lower, especially when comparing the ungrazed pasture to the two grazed pastures. The ungrazed pasture had significantly lower family diversity, so the grazed pastures had less overlap with that community.

Limitations

Although my experimental design was intended to adequately address my hypothesis, the sheep population and pasture size were not standardized, and my data was skewed, resulting in higher grazing pressure than expected in the rotationally grazed sites.

The stocking density of the study sites were not similar enough for my data to accurately compare the impact of rotational and long-term grazing on spider communities. If this study was to be repeated, I would recommend that the two treated pastures have nearly identical areas and livestock populations. This study was also limited in scope because I conducted it without the assistance of a team, so I was unable to collect and process more than two rounds of data or place multiple transects in each pasture. The study would be strengthened by laying traps in multiple transects in each pasture, and collecting data year-round. Multiple transects in each pasture would eliminate the issue of uneven stocking densities between the rotational and long-term grazed pastures. If the entire areas of both pastures are considered, then their stocking densities would be equivalent. Collecting data year-round would also better illustrate fluctuations in the spider communities across the seasons. Widening the specimen pool by collecting from multiple areas throughout the year would allow more conclusive trends to be drawn. I was also only able to identify down to family, and identifying down to species would provide a more detailed description of the community composition. This study needs to be repeated so as to actually measure the impact of rotational grazing compared to long-term grazing on spider communities, and further research is needed to examine whether the grazing treatment or the stocking density is more impactful on the biodiversity of an area.

CONCLUSION

This study provides evidence that moderate disturbance from low intensity grazing is beneficial for local spider communities, and because spiders are bioindicators, for the function of the larger ecosystem (Garcia et al. 2021). High intensity agriculture such as high density grazing or feed crop production drives biodiversity loss (Kok et al. 2020), so transitioning to lower intensity grazing would support the flora and fauna of the pasture habitat. Pesticide application negatively impacts biodiversity because organisms other than the target insects are harmed, including soil fauna, pollinators, and predators like spiders. Enhancing the spider population near croplands, especially with practices that enhance the family and functional group diversity of spider communities, will contribute to the biocontrol of pests (McEwen et al, 2022). By practicing low density or rotational grazing, farmers can build a more resilient agroecosystem (Bellamy et al. 2018). A resilient ecosystem can resist or recover quicker from disturbances due to temperature or precipitation change, or extreme weather events which are increasingly frequent due to the climate crisis. A transition to biodiversity-friendly agriculture is necessary to protect our ecosystems and food supply in the near future, and this study shows that biodiversity-enhancing grazing near croplands can be part of the solution.

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