

Forest or Phylogeny? : Untangling Phylogenetic Signal from Selection Pressure Using

Barronopsis texana

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Précis

Behavioral trait correlations in *Agelenopsis* spiders have been shown to be both phenotypically and genetically linked. This manifestation suggests an adaptive quality that confers a survival advantage in the presence of trait linkages. If trait correlations persisted in the absence of directing selection pressures, the correlations could prove to be maladaptive. Although many studies have proven the existence of said linkages, few have considered the possibility of broken correlations across members of the same species that live in different environments.

This study examines the role of phylogenetic signaling in conjunction with that of environmental selection pressures. We tested boldness, aggression, and general activity levels of local *Agelenopsis aperta*, local *Barronopsis texana*, and desert *Agelenopsis aperta* to determine whether trait correlations existed between members of the same species or species living in similar environmental conditions. Using Dr. Susan Riechert's established ethological tests, I conducted behavior trials on 69 penultimate *Barronopsis texana* individuals to compare their behavior profiles to those of the *Agelenopsis* spiders. After compiling the profiles, we discovered that the local *Agelenopsis* spiders behaved more similarly to their sister species, *Barronopsis*, than their conspecifics from the desert.

These results are a small part of the first study that will provide concrete empirical evidence to support the idea that environmental selection pressures, not phylogenetic relationships, control for the manifestation of behavioral trait correlations in *Agelenopsis* spiders. In time, the hope is that more researchers view natural selection pressures as enormous dictators of trait correlations in these spiders, and possibly in other organisms of the animal kingdom as well.

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Introduction

Within the disciplines of ecology and animal behavior, multiple discoveries have been made about the presence of correlations between certain behavioral traits in various species of animals. Trait correlations arise when two displays of animal behavior appear outwardly in tandem. To be clear, when an organism displays one trait, such as aggression, they also display a related trait, such as boldness. This correlation can be thought of as a behavioral syndrome, which has been defined as a complex of behavioral traits that are connected throughout various scenarios and contexts. Because these syndromes can have serious impacts for the fitness of implicated species, they are often studied in depth from an evolutionary perspective (Sih et al. 2004). The combination of ethology, ecology, and evolutionary biology involved in this line of research immediately piqued my interest in behavioral trait correlations.

In accordance with many other well-studied ecological and evolutionary ideas, there exists a prevailing hypothesis about the basis, the functionality, and the expected manifestation of behavioral trait correlations. First, experts in this field contend that because the behaviors are observable phenotypically, there must be a genetic component that dictates behavior expression (Riechert & Hedrick 1990). This belief stems from the generally accepted theory that DNA is the ultimate control of phenotypic manifestations, such as a given organism's body plan. Furthermore, the acceptance of a legitimate genetic basis for such correlations grounds the idea that the correlations could be subject to influence by natural selection (Riechert & Hedrick 1990). This contingency on the operation of natural selection is what provides interesting consequences for resulting fitness implications in given species.

Another portion of this prevailing hypothesis relates to the adaptive function of the trait correlations. Because natural selection is responsible for the slow process of fine-tuning

populations of organisms to improve their fitness, it follows that said correlations would have been eliminated unless they provided some variation of survival advantage for the organisms that possessed them. In other words, if these correlations were disadvantageous, natural selection would have surely weeded them out of organisms' gene pools. Otherwise, the trait correlations would prove to be maladaptive, meaning that they decreased a given population's chances of survival and reproduction.

These basic tenets of the prevailing hypothesis pave the way for the third, and possibly most puzzling, component of the widespread belief. This particular pillar comes into play with regards to predictions that can be made about the appearance of the behavioral trait correlations in different contexts. Studies have shown that across various species in the animal kingdom, behavioral suites are conserved across many different contexts. For example, some *Agelenopsis aperta* spiders are known to be more aggressive both towards conspecifics in disputes over territory and towards prey items that enter constructed webs (Riechert & Hedrick 1993). In seemingly distinct situations, the same behavior suite can be seen at work. Observations like these further support the belief that a genetic basis underlies all outward phenotypic manifestations of these trait correlations.

It follows from the three pillars of the prevailing hypothesis on behavioral trait correlations that when selection pressures for the traits are present, they will arise in a given population. However, researchers have found that these tenets do not always hold in the midst of different selection pressures. Renowned spider biologist, Dr. Susan Riechert of the University of Tennessee, conducted one of the most influential studies on this matter using the desert funnel web spider *Agelenopsis aperta*. In her study, she experimented with two separate populations of the *Agelenopsis* spider. One population lived in an arid desert habitat, while the other inhabited a

lusher riparian ecosystem. Differences between the two habitats lie deeper than just the climate and vegetation, however. There were also markedly distinct levels of predation in the two study ecosystems. While predation in the desert habitat was extremely rare, the riparian habitat was home to various species of insectivorous birds that preyed on the funnel web spiders in question (Riechert & Hedrick 1990). In this case, the predation and resulting selection pressures were considerably different for each habitat.

If trait correlations are acted upon by natural selection, then they should be able to be broken within the same species in the absence of directing selection pressures. Dr. Riechert's results showed that in terms of the *Agelenopsis aperta* spiders' aggressive behavioral syndrome, the predation pressures did indeed make a difference in the manifestations. The desert spiders were more aggressive, while the riparian spiders displayed more caution under the same testing circumstances (Riechert & Hedrick 1990). These findings had enormous implications for the way that scientists considered the causes of behavioral trait correlations in terms of evolutionary relatedness and selection pressures.

This particular research provided much of the motivation for the research conducted by my mentor, Jenn Bosco, before and during my time spent working in her lab. Because Dr. Riechert had already shown that trait correlations could become uncoupled across populations in the absence of a directing predation pressure, Jenn decided to take the research one step further on her own. To elevate the study, Jenn chose to analyze two genetically equivalent *Agelenopsis* species in conjunction with a sister species, *Barronopsis texana*. The addition of a sister species contributed depth, as well as a marker of potential behavior differences between members of different populations (Garcia & Sih 2003). Comparisons of the two *Agelenopsis* species from desert and forested habitats alongside the *Barronopsis* species from the forest yield great insight

into the mechanisms behind the emergence of these behavioral suites. Our research questions follows: when put to the test, is it phylogenetic signaling or selection pressure that dictates the presence of the aggressive behavioral syndrome in distinct *Agelenopsis aperta* populations? We hypothesize that selection pressure, not phylogeny, is the predominant controller of the emergence of this behavioral syndrome. If environmental selection pressures are different in the two *Agelenopsis aperta* populations, then we expect the forest-dwelling *Agelenopsis* spiders to be more behaviorally similar to their sister species, *Barronopsis*, than they are to their desert-dwelling relatives. This study will be the first to provide empirical evidence that supports the theory that environmental selection pressure, not evolutionary relatedness, drives the correlation of behavioral traits.

Methodology

The first step in conducting the anti-predator behavior experiment was the collection of the three spider populations. Dr. Riechert and Jenn were responsible for collecting the desert-dwelling *Agelenopsis aperta* spiders from the southwest region of the United States. Jenn collected local *Barronopsis texana* and *Agelenopsis aperta* from forested ecosystems in the Knoxville, TN area. Dr. Riechert bred multiple generations from the original wild-caught parents, which accounted for any purely environmental affects on the behavioral syndrome in the three distinct populations (Riechert & Hedrick 1990). Although three populations were tested in a standardized manner, I was personally responsible for testing only the *Barronopsis texana* populations. Because of this, the methods will specifically focus on the aspects of this particular population's experimental protocol.

Once the juvenile spiders had been hatched from their egg cases, they were placed individually in small sealed plastic portion cups and fed with 1 cricket once per week. Jenn marked their containers when they reached the penultimate life stage prior to complete maturation, and designated each spider as male or female. After spiders mature, they lose most of their drive to hunt prey, which makes feeding tests difficult to perform. At the penultimate stage, the spiders are large enough to feasibly handle and kill prey items. Each week, I began the first of two rounds of laboratory testing with the designated penultimate *Barronopsis texana* spiders. The spiders were tested 3 days after their last feeding to make sure that they were all hungry to the same degree (Riechert & Hedrick 1990). I observed a maximum of 4 spiders simultaneously during each round of testing. After a semester (12 weeks) of observations, I tested a total sample size of N=69 *Barronopsis texana* individuals.

The experimental setup consisted of 4 small plastic petri dishes placed inside larger containers and 4 stopwatches set atop a white background for contrast during observations. Using the eraser tip of a graphite pencil, I coaxed each spider out of its portion cup and into a clean, dry petri dish. Upon entry, the spider typically began to run around the circumference of the dish. I recorded the number of times the spider completed a circumference unit inside either the small petri dish or the larger dish. After running around, each spider would stop along the inside of the dish and assume a foraging position. At this point, I started the stopwatch and measured the latency to resume movement in the novel environment. This latency served as a measure of each spider's tendency towards boldness in unfamiliar situations.

Once the spider resumed movement, I recorded the latency and began to measure its activity level. For a period of 5 minutes after the first movement, I recorded each time at which the spider stopped moving and the time at which it resumed activity. After 5 minutes had passed,

I ceased recording the activity level measures and waited for each spider to be inactive for a period of 3 minutes. The next step in the first round of testing was to perform one front and one rear prod on each spider. I used the eraser tip of a graphite pencil to gently prod each spider on either the front side or backside of its body. I recorded the response (typically a flee or no response) and the distance traveled around the circumference of the petri dish after I made contact. I waited another 3 minutes after the spider stopped moving in response to the prod to proceed with the other half of the prod test. After completing both a front and a rear prod on each spider, I placed a lid on its petri dish and left them to rest until the second round of testing.

I typically conducted the second round of testing on each group of spiders the day after I completed the first round. The testing rounds must be completed on two separate days so that the spiders have time to construct webs inside the petri dishes overnight. Without webs, feeding tests are unsuccessful due to the fact that the spiders use novel vibrations on their webs to detect and locate prey items for consumption (Riechert & Hedrick 1990). The experimental setup was identical to that of the first round of testing, with 4 spiders tested simultaneously. I placed each petri dish into its own larger container, which prevented any spiders from escaping the testing site. Once the petri dishes were secure, I removed each lid and started the stopwatch so that the spider could get accustomed to the open air in its foraging position for a minimum of 5 minutes (Riechert & Hedrick 1990). When 5 minutes passed, I was able to begin with the first phase of the second testing round.

This initial phase was designed by Dr. Riechert to measure anti-predator behavior in *Agelenopsis aperta*, but was adapted by Jenn to test the *Barronopsis texana* population as well. Using a bulb syringe, I directed one puff of air towards the front side of each spider at a 45° angle. The puff is designed to simulate the type of vibrational cue that a predatory bird could

create while preying on one of the spiders (Riechert & Hedrick 1990). I recorded the response of each spider (turn away, flee, huddle, lunge, or no response) as well as the latency to return to its natural foraging position. These observations are indicative of a given spider's aggressiveness as part of the behavioral syndrome we were testing.

After the spider resumed the foraging position, I waited for a period of 3 minutes to begin the feeding tests. In these trials, I dropped 1 cricket onto the spider's web and measured the time it took for the spider to attack or bite the prey item. I recorded this time, and continued to run the stopwatch for another 3 minutes. I dropped 1 cricket at a time into the petri dish at 3-minute intervals. I recorded the number of attacks made by each spider, and continued to drop crickets in until the spider ignored 2 consecutive cricket drops and stopped attacking. At this point, I removed both of the unharmed crickets from the petri dish and did a final count of the number of crickets each spider attacked. Then I re-closed the petri dishes and left the spiders to rest and feed on their prey items.

I returned to the laboratory the following day and checked each spider's petri dish. To check the degree of consumption and feeding, I made a tally of the number of crickets in each dish that were unconsumed, partially consumed, or fully consumed. The unconsumed crickets had >90% of their body mass remaining. The partially consumed crickets retained 10-90% of their body mass. Finally, the fully consumed crickets retained <10% of their original body mass. After this final consumption check, both rounds of testing were complete. The spiders were fed once per week with crickets until they died in the laboratory.

Results

It should be noted that the work I performed in testing 69 members of the *Barronopsis texana* population is a tiny portion of an altogether extensive and much larger project that has been conducted by Dr. Riechert and Jenn Bosco over the course of 3 years. My limited contribution to the project will one day be part of a study that analyzes over 100 families of spiders. With that being said, I performed almost no data analysis with regards to the observations I made in the laboratory. This was a result of the limited amount of time I actually had in the Riechert laboratory. In addition, the strain of data analysis performed in these types of ethological experiments is more extensive than my substrate level training would allow me to explicate. However, I did uncover some general trends and information regarding the aggressive behavioral syndrome for which we conducted tests.

During the first round of testing, many of my *Barronopsis texana* individuals had a lengthy latency to resume activity in a novel environment. Frequently, I waited for them to investigate the unfamiliar petri dish for an hour or two, sometimes three. Other individuals had latencies of mere minutes before they became busy exploring and laying silk in their new environments. Once the spiders resumed activity, most stopped and starting moving multiple times during the 5-minute trial. This was partly due to the way these spiders lay silk in a periodic and rhythmic fashion. In the trials that involved the pencil prods, almost all spiders responded in some way to the foreign touch of the eraser. Most commonly, the spiders would turn away from the stimulus and flee, running around the inside of the container until they resumed the standard foraging position. It was rare for a spider to fail to respond to the prod of the pencil on either the front or backside of its body.

In the second round of testing, almost all of the *Barronopsis texana* individuals had visible anti-predator behavioral reactions to the puff produced by the bulb syringe. These reactions included the turn-away motion, where the spider would rotate its body so that it was positioned with its posterior side facing the bulb. Another common reaction was the huddle, in which the spider pulled its front four legs in towards its body and then upwards so that it was resting only on its back legs. In some cases, the spider performed a combination of both actions in response to the simulated predator cue. More often than not, the spiders that huddled and turned away showed substantial latency to resume the foraging stance. These results were much more common than more aggressive responses. Even so, there were a few anomalies that reacted to the puff of air by lunging forward and immediately returning to a foraging position. In these rare events, the latency was measured as 0 seconds. This kind of observation was made few and far between the rest of the fairly standard responses to the predator cue.

With regards to the foraging tests, the results were completely scattered across the board. Many spiders attacked their first cricket immediately upon entry into the web. Similarly to the anti-predator response, the latency to attack was measured as 0 seconds in these scenarios. Other spiders required minutes to make their first contact with the prey item. In some cases, the spider failed to attack because it had built an incomplete web. An incomplete web means that the spider is unable to feel and process vibrations that would typically lead it to the prey item. If the spider was unresponsive to the cricket drop for more than 6 minutes, I removed the cricket and re-tested the spider the next day when it had constructed a better web. Spiders that attacked the cricket immediately were also likely to attack multiple crickets, sometimes as many as 11, before reaching a point of indifference. On the opposite end of the spectrum were spiders that attacked just 1 or 2 crickets before losing interest in the prey. When it came to the measures of

consumption, by far, partially consumed crickets were the most abundant. The spiders that attacked fewer crickets were more likely to fully consume their collection of prey items. Those that attacked multiple crickets were more likely to leave some crickets unconsumed or partially consumed.

One interesting aspect about the results obtained is that there existed some continuity between both rounds of testing. The less bold spiders that were visibly disturbed by the simulated predator cue for lengthy time periods were also likely to attack a smaller number of crickets in the foraging tests. Their tendency towards being less active and less bold in a new environment was supported and upheld by their tendency to be less aggressive toward prey items in a feeding situation. On the other hand, the bolder and more active spiders that responded more indifferently to the predator cue were often likely to attack more crickets during the feeding trials. Similarly, these spiders' tendency to explore a novel environment carried over into their predator-prey interactions with the crickets. It follows that a genetic basis for the control of these trait correlations operates in a variety of different contexts for implementation. These observations, although made from a technically small sample size, support some of the beliefs that are part of the prevailing hypothesis about behavioral trait correlation.

Overall, the collaboration of results obtained by my trials using *Barronopsis texana* and Jenn's trials using both populations of *Agelenopsis aperta* currently shows that the Knoxville *Agelenopsis* spiders share more aggressive behavioral suite characteristics with their sister species from the forest, *Barronopsis*, than they do with their genetically equivalent desert-dwelling relatives.

Discussion

Although this section of Jenn's study is still in progress, we have been able to draw some conclusions from it that have larger implications for the way ethologists understand the driving forces that are responsible for behavioral trait correlations in the animal kingdom. We understand from the trials performed that the environmental similarities between the habitats of the local *Agelenopsis aperta* and *Barronopsis texana* populations have consequences for the behavioral suites possessed by the individuals. Even in generations reared from the original wild-caught parents, we observe the same trends in anti-predator and foraging behaviors reflected in each population. This observation points to the genetic and therefore heritable nature of this and other kinds of behavioral syndromes. Because the local populations are subject to comparable levels of natural predation in their similar habitats, over the course of evolutionary time, natural selection has selected for a certain style of aggressive behavioral syndrome in response to environmental pressures.

The type of aggressive behavioral suite observed in these two populations has been shaped by predation pressures to offer protection to those individuals that display more caution in unfamiliar environments and react to vibrational cues from a predator with some degree of hesitation. In a forested environment, insectivorous birds are plentiful and pose a serious threat to the local *Agelenopsis* and *Barronopsis* spider species. Displays of boldness and aggression have the potential to be maladaptive and result in more unsuccessful run-ins with predatory birds over time. On the other hand, in a desert environment with few dangerous predators, *Agelenopsis* spiders can afford to be more bold and unthreatened by predator cues. Predation in this type of habitat can be so rare that spiders are never forced to respond to the types of cues that are plentiful in forested habitats (Riechert & Hedrick 1990). It follows that if these traits are

heritable, and therefore eligible to be operated on by natural selection processes, they can be modified to fit the given set of circumstances in response to predation pressures.

In addition, other environmental selection pressures have shaped the aggressive behavioral syndrome of these two forest-dwelling spider populations. While the forest contains more natural predators than the desert, it also houses significantly more opportunities for foraging. In the arid desert, prey items can be scarce for the *Agelenopsis* spiders. It makes sense that these spiders are more aggressive towards crickets during the foraging tests. If natural selection has shaped their gene pool in response to lower incidences of feeding opportunities, it follows that selection favors quick attacks on prey items. If a spider is programmed by natural selection to expect sparse feeding events, then it will seize most opportunities to feed whenever they are available. On the other hand, spiders that live in environments with ubiquitous foraging opportunities can afford to be selective about when they choose to attack prey on their webs. If a spider is programmed by natural selection to expect frequent feeding events, then it may opt out of a meal opportunity for a number of reasons. The power of these natural selection processes is transmitted across generations and reflects the strength of the environmental selection pressures that send survival signals.

The view that it is ultimately environmental selection pressures, and not phylogenetic signaling, that dictates the strength and presence of this behavioral syndrome is extremely controversial simply because nobody has ever thought about behavioral trait correlations in this way. This study is unprecedented, and has the ability to completely alter the understanding of phylogenetic influence on phenotypic manifestations of behavior. Jenn's research challenges the currently prevalent idea that it is impossible for trait correlations to be broken within the same species. While many scientists in this field believe that the shared evolutionary, and implied

genetic, history of different populations within the same species is the main determinant of the presence of these behavioral syndromes, we contend that environmental selection pressures hold a larger role in this process.

Even though the two distinct *Agelenopsis aperta* populations share the same basic genetic instructions, differential selection pressures and resulting natural selection processes modified the degree to which the genes were expressed phenotypically. Although a study like this one has been conducted in years past, this research was able to extend the findings so that we could empirically demonstrate the effects of natural selection on the genes controlling the behavioral syndrome in question (Riechert & Hedrick 1990). As a result of this study, we are able to support a highly controversial, yet enlightening, hypothesis contending that evolutionary relatedness is not responsible for the control of aggressive behavioral syndromes in *Agelenopsis aperta*. Because of the striking similarities in the behavioral aggression suites of forest-dwelling *Barronopsis texana* and *Agelenopsis aperta*, we are able to answer our original research question. When put to the test, environmental selection pressures and subsequent signaling are, in fact, the ultimate determinants of the presence of this particular behavior suite in *Agelenopsis aperta* spiders.

Limitations

While this study is entirely unique in its scope, it does have its own set of limitations like any other. The majority of the limitations I will address here stem from my personal experience as a student research assistant on this project. As this study comprises only a small part of the larger and unfinished project that Jenn is working to complete, my comments on its limitations will be confined to my own work with the *Barronopsis texana* population. There were a few

limitations that I identified during my research, and the first deals with the limited amount of time I had to invest in the project.

Due to some initial confusion with my original thesis advisor, I had to scramble to find a backup project at the beginning of the fall 2014 semester. Thankfully, when I contacted Dr. Riechert about working in her lab, she pointed me towards my current mentor, Jenn Bosco. I was able to secure a place assisting her with this project, but I had less than a semester to complete my research efforts. Due to the holiday break, it is difficult to maintain the spiders' care throughout the winter. I was able to conduct testing on the spiders for a period of about 3 months before the holidays. Because this is a short time window, I was unable to learn more about the data analysis Jenn and Dr. Riechert use to evaluate the notes from the observations I conducted. If I had the opportunity to perform these experiments again, I would have devoted an entire year or more to the project so that I could provide more information about how the data becomes meaningful to our research question.

Another limitation rooted in the time constraints is the relatively small sample size of individuals I was able to test. I observed 69 individuals in 12 weeks, but with more time I may have been able to test over 100. Increasing the sample size can help to standardize variation that exists between each individual. A greater sample size and a more thorough understanding of the data I collected would significantly enhance my contribution to Jenn's study. By improving these two aspects, I could provide an even more reliable assessment of the *Barronopsis texana* population's aggressive behavioral suite.

Outside of time constraints, different kinds of limitations affected the quality of my participation in the study. One of the main concerns is the repeatability of the trials I conducted. Always, the trials were performed in the same location, on the same days each week, and done

on at least 12 individuals in the same day. However, due to shared space and equipment in the laboratory, on occasion I would have to use different stopwatches during the timed trials. That could be a contributor to some of the variation in the recorded latencies to resume movement or resume the foraging position. The other component of repeatability lies in relying upon the same observer. With observational experiments, having multiple recorders is always a risk. While I conducted all of my trials, Jenn was responsible for the two *Agelenopsis* populations and many of the *Barronopsis* individuals that were tested before my arrival in the laboratory. Although I was trained well in testing the individuals, my reporting guidelines could have accounted for some variation between my data and hers. As an expert on these types of spiders, Jenn is accustomed to classifying behaviors quickly. I, on the other hand, have little experience in identifying spider movements. Even so, in situations where I was unsure how to record a given body position, I was able to contact Jenn during trials and ask for verification of my assessment.

The last limitation I identify is the inability to observe more than one population of spiders involved in the study. Although I only worked with the *Barronopsis texana* population, I may have been able to glean a better understanding of the true differences between the desert and forest populations of the *Agelenopsis aperta* spiders by testing all 3 populations for the same traits. Furthermore, the observation of each population would increase my reliability when making comparisons as a student research assistant. This study was a completely collaborative effort, but if I could improve my contribution to the study for next time, I would absolutely want to perform experiments on members of all populations in the study system. Ultimately, I was thankful for the opportunity to contribute to this innovative study in any capacity at all.

Conclusion

The significance of this study lies in its unprecedented nature within the field of animal behavior. The experiments I described comprise a small segment of a larger study designed to determine what forces control the presence of the aggressive behavioral suite in various spider taxa, primarily *Agelenopsis aperta*. This behavioral suite consists of behaviors performed in anti-predator contexts, interactions with conspecifics, and predator-prey interactions during feeding. All of these behaviors have roots in the genetic instructions, DNA, of a given population. Scientists agree that the genetic basis and linkages contribute directly to the phenotypic manifestation of behavioral trait correlations in various species. The prevailing hypothesis about trait correlations suggests that due to the genetic origin of the traits, correlations should be conserved within a species, even among different populations living in distinct environments. Our hypothesis challenges this notion in a novel manner.

We agree with the theory that genes provide the directions for the presence and strength of the aggressive behavioral syndrome. We also agree with the theory that evolutionary relatedness influences many phenotypic traits that can be compared between populations of the same species. However, we contend that environmental selection pressures have tremendous impacts, greater than those of phylogenetic signaling, on the activity of the genes responsible for trait correlations. Because the behavioral syndrome characteristics are heritable and result in differential survival for members of populations, natural selection is able to operate on the genes that control them over evolutionary time. This finding means that environmental pressures related to predation patterns and foraging capabilities translate to measurable fluctuations of behavioral suite potency and presence in a given population.

After testing populations of desert-dwelling *Agelenopsis aperta*, forest-dwelling *Agelenopsis aperta*, and their forest-dwelling sister species *Barronopsis texana* for traits in the aggressive behavioral syndrome, we determined that the sister species living in similar ecosystems had more in common behaviorally than did the two genetically identical species of *Agelenopsis*. These findings provide empirical support for our hypothesis that when put to the test, environmental selection pressures trump phylogenetic signaling as the determinant of the emergence and strength of the aggressive behavioral syndrome in *Agelenopsis aperta*. While this belief will be controversial after it is published, it will allow scientists in ethology to understand the evolution of traits in a more comprehensive way.

Due to the relative ease of breeding and caring for multiple generations of spiders, experiments like this one are highly reproducible for insect populations. To replicate these in species that require more maintenance and attention would be a great feat, but could have interesting consequences for the understanding of behavior in different animals. In addition, the replication of this type of ethological experiment could prove enlightening if someone was interested in testing another type of behavioral suite. This study, while challenging and currently unparalleled, has the ability to affect countless schools of thought that are active in the fields of animal behavior and evolutionary biology. As a synthesis of ideas from different disciplines, Jenn's study will reach a diverse audience of researchers that can use it to rethink a broad range of scientific theories.

Although Jenn has made a tremendous amount of progress in her research efforts, there is still much work to do in her field of study. She plans to continue this study, broadening the scope to include more spider taxa from across the country. In addition, she intends to study the independent evolution of traits in various behavioral syndromes. The evolution of traits as part of

a correlation has been studied widely, but little work has been done to explore how one behavioral trait evolves and remains in a given population. I am grateful for the opportunity I had to work as a student research assistant underneath such a promising and ambitious PhD candidate. It has been an honor to have a meaningful hand in aiding Jenn with the completion of her study on the aggressive behavioral suite of North America's spider taxa.

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