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MEETING ABSTRACTS

Arranged by first author's last name
Presenters in underline
* designates student competition participant

Global diversification of *Anelosimus* spiders driven by long distance overwater dispersal and Neogene climate oscillations

Agnarsson, Ingi, Yufa Luo, Seok Ping Goh, Marcelo O. Gonzaga, Adalberto J. Santos, Akio Tanikawa, Hajime Yoshida, Charles Haddad, Laura J. May-Collado, Matjaž Gregorič, Eva Turk and Matjaž Kuntner
University of Vermont

The major factors shaping the distribution and diversity of extant organisms include geological change (vicariance), organismal movement (dispersal), and fluctuating climate. *Anelosimus* spiders (Theridiidae) are solitary-social organisms with a cosmopolitan distribution in temperate to tropical areas. Their discontinuous distribution and patterns of diversification suggest that two factors, long distance overwater dispersal and climate change during the Neogene (23–2.6 Ma), have been the prominent drivers of their biogeographical history. We investigate the spatiotemporal biogeography of *Anelosimus* through culmination of a 20-year comprehensive global sampling at the species level (63 species or 85% of the known 74 species worldwide, represented by 268 individuals). Based on analyses of nucleotide data from seven loci (5.5 kb) for *Anelosimus* and outgroups. *Anelosimus* is monophyletic with an Oligocene (~30 Ma) South American origin. Major clades on other continents originate via multiple, overwater dispersal events, of solitary and subsocial—but not social—lineages, from the Americas. These intercontinental dispersals were to Africa, Madagascar (twice), and SE Asia/Australasia. The early diversification of *Anelosimus* spiders coincides with a sudden thermal increase in the late Oligocene (~27–25 Ma). Global Neogene climatic fluctuations subsequently influenced the diversity and distribution patterns of *Anelosimus* and appear to have driven radiation in the last ~6 Ma. Our findings offer rare empirical evidence of how ballooning and historical

climate change may interplay to drive diversification patterns.

Material properties and composition of cobweb weaving spiders' (Theridiidae) gumfoot glue proteins
Ayoub, Nadia, Kyle Friend, Joshua Frost, Lorden Hoff and Brent Opell
Washington and Lee University

The production of aqueous viscoelastic glue in aggregate silk glands is a potential key innovation of the meagadiverse spider superfamily Araneoidea. Araneoid orb-web weavers coat their capture spiral threads with aggregate glue. Cobweb weavers (Theridiidae) place aggregate glue droplets on "gumfoot lines", capture threads that radiate from the web to the ground to snare walking prey. Both orb-web and gumfoot glue droplets contain hygroscopic compounds that attract atmospheric moisture. Glycosylated proteins are likely responsible for adhesiveness, but the identities of the proteins are unknown. Despite similarities in gross composition, the total work to peel an orb-web capture spiral greatly exceeds that of a gumfoot line. However, the material properties of the proteinaceous core of individual droplets have not been compared between the two groups. We measured multiple gumfoot glue droplet-specific properties for two theridiid species: the Western black widow, *Latrodectus hesperus*, and the common house spider, *Parasteatoda tepidariorum*. When measured at 40-60% relative humidity the stiffness of theridiid protein cores was much greater than that of two orb-web weavers, *Argiope aurantia* and *Neoscona crucifera*, but less than that of a third orb-web weaver, *Verrucosa arenata* (Araneidae). We also identified the primary glycosylated proteins as novel members of the spidroin (spider fibrous protein) gene family. A further 65 (*P. tepidariorum*) and 64 (*L. hesperus*) proteins were unique to the portion of the gumfoot line with glue droplets, compared to the fiber-only portion. These glue proteins included hundreds of phosphorylated peptides, suggesting a previously unrecognized mechanism of adhesion for spider aggregate glues.

Detection of web builder size via chemical cues present on spider silk by web invading cellar spiders (Araneae, Pholcidae) *
Berry, Alexander and Ann Rypstra
Miami Univeristy

Chemical cues are an important way that animals gather information about their surroundings, find mates, and locate prey. Spider silk makes an excellent medium for chemical cues with some spiders being able to judge size, sex, and hunger level of other spiders. Cellar spiders (Araneae, Pholcidae) are known web invaders and detecting such cues may mitigate risk if they happen into a larger spider's web. We experimentally tested the hypothesis that *Pholcus manueli* and *Pholcus phalangioides* can detect the size and hunger level from cues in the webs of other spiders. We introduced spiders to webs built by conspecifics of varying sizes and hunger levels and recorded how long it took them to enter the foreign web. *Pholcus manueli*, but not *P. phalangioides*, was slower to invade webs built by larger spiders, while hunger level was found to have no effect on the latency to entering the web. We then washed webs with ethanol to remove chemical cues that may be utilized by these spiders. *Pholcus manueli* invaded washed webs faster than unwashed webs, but *P. phalangioides* entered webs at the same rate. *Pholcus manueli* entered washed webs at the same rate, regardless of the size of the web building spider, in contrast to unwashed webs. These results suggest that *P. manueli*, but not *P. phalangioides*, change their behavior based on chemical cues left on conspecific silk.

Sticky to dirty surfaces: capture silk of moth-specialist spiders
Blackledge, Todd, Candido Diaz and Ali Dhinojwala
University of Akron

Moths are difficult prey for orb-weaving spiders because their scales create "dirty surfaces" that rapidly erode adhesion as the scales detach from the moths and cover the aggregate glue droplets in the capture silk. However, cyrtarachnine spiders specialize upon moths and their webs routinely capture moths using only single capture threads in reduced orb webs or even enigmatic bolas webs. We compare the performance of Cyrtarachne capture

silk to typical orb-weavers test hypotheses about how their glue droplets overcome dirty surfaces. Cyrtarachne capture silk uses a combination of exceptionally large glue droplet size and unusually low viscosity to rapidly flow beneath the scales of the moths. Cyrtarachne supersaturates its glue droplets with water to achieve this fluidity, but circumvents the typical trade-off in adhesion between flowing across surfaces and maintaining cohesion during pull-off as much of the water is rapidly removed during spreading, hardening the glue. This recruits the moth's own scales against itself by increasing the total surface area for adhesion, but the instability of the supersaturation also explains the short lifespans of cyrtarachnine webs.

Evolutionary impacts of introgressive hybridization in the *Habronattus americanus* species complex (F. Salticidae) *

Bougie, Tierney, Alan Brelsford and Marshal Hedin
San Diego State University

The definition of a species and the delimitation of species boundaries are topics that have received much debate in the field of evolutionary biology. One of the difficulties in defining species is the presence of hybrids, and possibility of gene flow across species boundaries (introgression). The *Habronattus americanus* subgroup is comprised of five closely related species that show genetic and morphological signs of present and past introgressive hybridization. Colored ornaments of adult males are affected by hybridization leading to males with mixed ornament patterns of two or more species. To reconstruct the species relationships and infer introgression, we collected data using two different methods: Ultraconserved Elements (UCEs) and ddRADseq. Preliminary analyses using UCEs suggest that current and/or past introgression events are swamping species divergence signals of at least four *H. americanus* subgroup species. ddRAD data is used to infer more shallow level divergences, which may be better able to identify the true species signal. However, preliminary analyses using ddRAD data show similar results to those yielded from UCEs. In addition to these results, I will compare the efficacy of both methods to identify signals of species divergence and discuss ecological aspects and the natural history of the *H. americanus* subgroup.

Cover cropping to promote spider diversity in cotton agroecosystems *

Bowers, Carson, Jason Schmidt and Michael Toews
University of Georgia

Cover cropping potentially improves sustainability by enhancing multiple ecosystem services, including soil fertility, erosion prevention and weed control. Row crops are the dominant agricultural systems in many areas and ecosystem effects attributed to these systems can carry over to surrounding areas. Cover cropping in row crop systems may act as a "habitat bridge" to help maintain biodiversity by creating persistent arthropod communities during periods when crops are not in production. Our research targets cotton production in Georgia to understand the effects of cover cropping on spider communities and biocontrol services provided by these communities during major cotton development stages. The effects of common cover cropping treatments including rye and crimson clover were compared to conventional management practices. Rye and crimson clover were chemically terminated and cotton was planted with strip-till grain drill. The conventional system was tilled and pre-emergence herbicides were applied. Treatments with cover crops generally enhanced spider abundance compared to conventional plots, particularly in the early season. Conversely, the late season pest, southern green stink-bug, was not impacted by cover treatments. The presence of cover crops was shown to increase abundances of spiders following a rye cover crop, with potential implications for early season pest management. Differences in end of season yield between treatments suggest trade-offs for the effects of cover cropping on beneficial arthropods and crop production.

***Lentacosa* (Araneae, Lycosidae) and a morphological diagnosis of its species**

Brady, Allen and Lauren Fogg
Department of Biology, Hope College, Holland, MI

In Golden, Colorado we presented a comparison of the recognized genera *Gladicosa* Brady, *Rabidosa* Roewer and *Tigrosa* Brady with members of the proposed new genus *Lentacosa*. H. K. Wallace (1942) maintained that the name *Lycosa lenta* Hentz had been applied to "seven or more" different species found in the southeastern United States and Florida. In our 2016 study we recognized species of the genus *Lentacosa* as a new genus of Lycosidae distinguished by a combination of characters, including the color pattern on the dorsum of the cephalothorax, a solid black venter on the abdomen, and the structure of the female and male genitalia. These features in combination can also be used to separate *Lentacosa* species from *Lycosa* and *Hogna*. [They are presently incorrectly placed here.] In his study of the *Lycosa lenta* species group where he described eight distinct species, Wallace provided considerable clarification of the evolutionary relationships of the *Lycosa lenta* group, based upon genitalic characteristics, geographic range and ecological habitat preferences. In our study of what Lauren and I have tentatively recognized as a new genus we did encounter critical problems in the diagnosis of certain species in the paper by Wallace (1942). We have chosen two cases to illustrate the problems that we have discovered. They are what we choose to think of as challenges to a better understanding of species within *Lentacosa*. First we'll look at *L. timuqua*, divided by Wallace into *L. timuqua* central peninsular form (Fig 19) and *L. timuqua* typical form (Fig. 20). Now just glance at Fig. 21 of *L. ammophila* and compare it to Fig. 19. In a more recent part of our study we encountered a problem with *L. miami*, recognized by Wallace as a distinct species from *L. ammophila*.

The impacts of cover crops on generalist predatory Arthropod populations and crop yields in corn and coybeans

Cady, Alan B, Jeremy Fruth and Patrick Campbell
Miami University

Conventional agricultural practices often degrade local biodiversity and water quality via applications of pesticides, herbicides, and fertilizers. Current sustainable agricultural techniques include limited tillage, targeted input, and biological control to decrease collateral loss of beneficial organisms. These methods concurrently lower input costs, the use of fossil fuels, and human exposure to pesticides. Promoting Generalist Predatory Arthropod (GPAs) populations are a way to increase endemic predators (spiders, harvestmen, certain beetles, hemiptera, and certain ants), and are an inexpensive and ecologically sound way to help suppress pest species. They eat a variety of pests in many different habitats throughout the growing season and are closely adapted to their environments. Cover crops may promote GPA populations by supplying microhabitats providing GPAs with structure, cover, and food, thereby affecting predator mobility, prey accessibility, dispersal tendencies, and web attachment sites. However, few studies have evaluated the extent these crops enhance biological control. Winter wheat and tillage radish cover crops were tested relative to their utility to promote GPA populations. It was found that GPA populations were larger and more diverse in areas of tillage radish compared to control sites. Winter wheat did not produce similar results. The growth form and coverage of radish offered more cover, translating into greater abundance and diversity of GPAs. Crop yields are compared for the three combinations of cover crop plantings.

Multi-sensory guidance of whip spider homing behavior *

Casto, Patrick, Verner P. Bingman, Eileen A. Hebets and Daniel D. Wiegmann
Bowling Green State University; University of Nebraska-Lincoln

Amblypygi (whip spiders) are a charismatic group of nocturnal arachnids that exhibit robust navigational abilities hypothesized to be under multi-sensory control. While amblypygids have small camera-type eyes, their elongated antenniform forelegs are covered in thousands of receptor setae, tuned to different environmental stimuli, that provide sensory information to guide their spatial behavior. The rich sensory toolbox of amblypygids suggests that multiple sensory modalities may be used and perhaps integrated to enable flexible navigational abilities. However, olfaction may be more important for navigation according to existing data. To examine the relative contribution of different sensory stimuli that guide spatial behavior, a sensory-rich, circular arena (diameter, 1.81m) was developed to computer track the movements of Costa Rican amblypygids over a three-week period as they homed to an artificial shelter. The controlled stimuli included point sources of visual, olfactory and tactile cues, one per quadrant. Subjects were given three orientation nights to roam followed by randomized, pre-dawn displacement

trials of four treatments: Control (all environmental stimuli present), Light-removed, Odor-removed and Shelter-removed (shelter was replaced halfway through trials). Deletion of any one stimulus had little impact on subjects' ability to home or on various dependent measures of homing behavior including: latency, cue associations, spatial distribution, and homing path kinematics. However, the accumulated results show tendencies of stereotyped local navigation as well as behavioral flexibility. This project lays a foundation for further experiments to disentangle the relative contributions of each sensory input used in guiding the spatial behavior of Amblypygi.

Phylogenomics of the paleoendemic spider genus *Hypochilus*, with implications for species delimitation*
Ciaccio, Erik1, Shahan Derkarabetian2 and Marshal Hedin1
1San Diego State University, 2Harvard University

Hypochilus is an early diverging araneomorph genus that has long interested arachnologists, in part because of its disjunct montane biogeography and unique placement in the spider tree of life. *Hypochilus* is also fascinating from a molecular standpoint as species within the genus demonstrate extreme genetic divergence at both intra- and interspecific levels, in the face of strong morphological conservatism. This research utilizes a recently developed arachnid Ultra-Conserved Element (UCE) probe set to reconstruct phylogenomic relationships among all currently recognized *Hypochilus* species, plus members of the sister genus *Ectatosticta*. Our work confirms the placement of Rocky Mountain taxa as sister to the California and Appalachian groups, with each of these regional faunas strongly supported as monophyletic. Our results within the California clade reveal *H. bernardino* as nested within *H. petrunkevitchi*, a pattern requiring closer examination. Overall, our phylogenomic hypothesis has important implications for resolving the biogeographic history of these Nearctic paleoendemic spiders and will furthermore be useful in uncovering potential cryptic speciation in the mountains of California.

The state of knowledge and resources for arachnid genomic research
Coddington, Jonathan
Smithsonian Institution

Genomic science is revolutionizing biodiversity research. This talk will summarize what is known about arachnid biodiversity in terms of the literature, distribution, biological knowledge, genomics, and genetic resources, identify strategic gaps, and outline criteria and goals for priorities and to advance arachnid genomics.

Comparative venom gland transcriptomics of the U.S Ctenidae (Order: Araneae) *
Cole, Jeff and Michael S. Brewer
East Carolina University

Wandering spiders of the family Ctenidae comprise over 500 species mostly distributed across neotropial habitats and have known medically relevant venoms. For example, the bite of the highly aggressive Brazilian wandering spider (*Phoneutria nigriventer)* causes pain, cramps, priapism, and arrhythmia with a median lethal dose (LD 50) of 134 μg/kg in mice. Alternatively, the bites of ctenids dwelling in the temperate forests of North America have no recorded adverse symptoms. The aim of this study was to determine what venom homologs are shared between four species of ctenids in the U.S with their neotropical counterparts using venom gland transcriptomics. Homology searches inferred numerous multi-gene venom families containing homologs to confirmed noxious venom proteins in *Phoneutria*. This research provides the first insight into the venom components of U.S ctenids, and provides a framework for investigations of the evolutionary processes that have contributed to the drastic toxicity differences within this family.

Preliminary observations of viscous globule desiccation in the defensive silk of the western widow spider (*Latrodectus hesperus*)

Corbit, Aaron, Matthew Lopez, Chris Hansen and David Nelsen
Southern Adventist University

Widow spiders (*Latrodectus* sp.) are known to produce a unique silk that is actively secreted for defense when these spiders are under threat from potential predators. One component of this silk is large viscous, sticky globules, which are produced by the spider's atypical aggregate glands. Unlike the viscous globules produced by the aggregate glands of orb weaving spiders and cover the spiral aspects of the web, the defensive globules in widow spiders desiccate rapidly. We used microscopy and time-lapse imagery to observe both these viscous globules and water droplets suspended on fishing line as they dried. We used the resulting images to calculate rates of volume loss due to desiccation for both the viscous globules and water droplets. We also inferred aspects of the composition of the viscous globules by comparing the residual volume of the globules after desiccation with their initial volumes. Our results suggest that defensive viscous globules lose volume to desiccation more quickly than suspended water droplets. We also found that globules desiccated more slowly when the percent of residual volume was higher and that larger droplets tended to have a greater percentage of residual volume. The chemical and physical factors that cause the viscous globules to desiccate faster than water is unclear. Since other preliminary research suggests that these spiders produce larger viscous globules when under higher levels of threat, our results may suggest that these spiders can change the composition of their viscous globules in response to varying threat levels as well.

Amblypygids as model organisms in biogeography

de Miranda, Gustavo, Alessandro Ponce de Leão Giupponi, Lorenzo Prendini and Nikolaj Scharff
National Museum of Natural History, Smithsonian Institution

Whip spiders are low dispersal organisms and high habitat specificity, moist dependency, and a very ancient clade. Among the five families of Amblypygi, Charinidae is the largest with a worldwide distribution. Therefore, amblypygids are suggested as good model organisms for biogeographic studies. Here, the historical biogeography of Charinids is addressed for the first time based on a dated molecular phylogeny. Charinidae is estimated to have diverged from the other Amblypygi families during the Upper Carboniferous on the supercontinent Pangea. The first split between the most recent common ancestor of *Weygoldtia* and *Charinus+Sarax* happened around 267 Ma during late Permian. This branching probably occurred as the result of a series of extinctions at that time in Pangea, a period of big shifts in climate that created paleo-patches of tropical forest which housed the surviving fauna. The divergence of *Charinus* and *Sarax* coincide with the early fragmentation of Pangea around 220 Ma. The colonization of South East Asia by *Sarax* is proposed to have happened via Australia. The two main *Sarax* clades, the brachydactylus and seychellarum clades, were separated by vicariance events with the first clade moving northwards with Africa and the Arabian Peninsula and the second clade drifting eastwards with Australia. The genus *Sarax* is recorded for the first time for Wallacea filling the gap of biogeographic regions of charinids in SE Asia. Also, it demonstrates our lack of knowledge about amblypygids in that region. A further remarkable finding is a pre-Oligocene origin of the New Caledonian whip spider fauna. *Charinus neocaledonicus* and *C. elegans* are revealed as a relict Gondwanan species which diverged from *C. pescotti* (its Australian sister species) when the island separated from Australia around 80 Ma. This seems to be one of the best evidences so far of a relict species in New Caledonia. Preliminary results of ongoing research on the phylogeography of amblypygids in the Brazilian Atlantic Forest using genomic data will also be presented.

Using ultraconserved elements for species delimitation in short-range endemic harvestmen (Opiliones)

Derkarabetian, Shahan1, Stephanie Castillo2, Marshal Hedin3
1 Harvard University; 2 University of California Riverside; 3 San Diego State University

A commonly used and highly effective approach to phylogenomics is target capture of ultraconserved elements (UCEs). The ability of UCEs to reconstruct well supported phylogenies at higher taxonomic levels has been demonstrated in many taxa, and recent studies using an arachnid-specific UCE probeset similarly demonstrate this utility in arachnids. Comparatively few studies (in any taxa) have focused on species delimitation or population level analyses using UCE data, particularly in invertebrates. This talk will focus on integrative species delimitation

of the harvestman genus *Metanonychus* (Opiliones, Laniatores, Paranonychidae) combining morphology, Sanger sequencing, and sequence capture of UCEs. The utility of UCEs in species delimitation and population-level analyses will be explored specifically for short-range endemic taxa, which have low dispersal ability and high population genetic structure.

Behavioral consistency but not starvation effects in risk taking behavior of a harvestman*
do Monte Gonzalez de Segovia, Júlio and Rodrigo Hirata Willemart
Biosciences Institute, Department of Zoology, University of São Paulo

Individual consistency in animal behavior is sometimes called animal personality. Boldness is among the most studied behavioral traits in animal personality research. In short, it refers to a tendency for risk taking, with the bolder individuals exposing themselves more than their less bold counterparts. The harvestman *Mischonyx cuspidatus* is a good model in which to study boldness, since we can easily experimentally induce thanatosis (feigning death). Animal personality theory has suggested that an individual's state (size, morphological traits, energy intake, etc.) may influence its behavior. Thus, we tested whether i) boldness is consistent within individuals; and ii) boldness levels change according to starvation time (not starved vs. two weeks of starvation). We found within-individual consistency in boldness. On the other hand, while we predicted that starvation might influence the expression of boldness, we failed to find these differences across starvation levels. Our results show that boldness is a personality trait in the harvestman *M. cuspidatus*. However, level of boldness was not influenced by the starvation period. Thus, we provide some evidence that *M. cuspidatus* do not change risk taking behavior according to hunger level. To the best of our knowledge, this is the first study investigating personality among Opiliones.

Fossil spider diversity and taphonomic bias in Paleogene lacustrine deposits *
Downen, Matthew and Paul Selden
University of Kansas

Most fossil spiders are preserved in amber; however, there is a relative abundance of fossil spiders preserved in lacustrine deposits. Taxonomic surveys of several Paleogene lacustrine deposits conducted by Scudder (1890), Petrunkevitch (1922), and Gourret (1887) placed many fossil spiders in modern families and genera, or erected new families. Many of the identifications are incorrect, as diagnostic characters are not visible in the specimens—a common challenge associated with fossils preserved in lacustrine deposits. Here, collections of fossil spiders from the Green River and Florissant formations of Colorado (Eocene) and Aix-en-Provence in France (Oligocene) are revisited to identify and correct problematic interpretations in taxonomy. Biases related to size, sex, and life mode of spiders are investigated to see if spiders are preserved in lacustrine deposits in a uniform manner. The Green River Formation appears to be dominated by smaller web-building spiders, while in contrast, most spiders from Aix-en-Provence are larger ground-dwelling spiders. Overall, a more accurate view of spider diversity surrounding lacustrine environments in North America and Europe during the Paleogene is presented. This study was funded by Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP) processo: 2014/19191-3 to JMGS.

Studies on population dynamics and diversity of arachnids in Tolipir landscape of Lesser Himalayas of Azad Kashmir, Pakistan
Faiz, Abu ul Hassan and Lariab Zahra Faiz
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The landscapes are facing a rapid decline of biodiversity around the globe, which has critical implications on ecosystem functions and services. Successful conservation efforts to slow this decline rely on the ability to monitor species and understand their ecological role. Such efforts are often hindered by a lack of knowledge regarding arcane interactions. Arachnids provide several key regulating and supporting ecosystem services, including insect suppression and nutrient cycling. However, trophic interactions that occur in both natural and anthropogenically impacted systems remain largely obscured. The present study was conducted in the elevation range from 1367 m asl

to 2238 m asl. The recoded families were Lycosidae family, Linyphiidae family, Gnaphosidae family, Araneidae family, Selenopidae family, Opiliones, pseudo scorpion and scorpion (*H. longimanus*, *Hottentotta tamulus*, *Hottentotta minsulata*, *Hotentotta alticola*). Lycosidae family was sparse, in seasonal, and permanent streams and Linyphiidae spiders are sparsely distributed in shrub land, Gnaphosidae spider are widely distributed on grasses, the lycosid genus *Pardosa C*. are distributed around the courtyard vegetation of human habitation. The scorpion *H. longimanus* are abundant in courtyard vegetation and *H. tamulus* are abundant in mud houses while (*H. minsulata*, *H. alticola*). Selenopidae are abundant at wash rooms. The araneomorph spider are also sparsely distributed and Opiliones are abundant in grasses, forest and in crops (wheat, maize), *Neoscona vigilans* are sparsely distributed. There is no use of insecticide and pesticides and system reflect natural ecosystem. We have to plan for conservation by emerging methodologies and technologies to provide new windows into these otherwise opaque questions.

Systematics and evolution of *Kibramoa* Chamberlin 1924 from the California Floristic Province
Garcia, Erika1 and Charles Griswald2
1 California Academy of Sciences; 2 San Francisco State University

The eight-eyed haplogyne spider family Plectreuridae Simon, 1893 is one of the oldest of spider families, currently comprising two genera (*Kibramoa* and *Plectreurys*), thirty extant species and one subspecies. Plectreuridae have not been rigorously examined since 1958, with only three new species added to *Plectreurys*. Moreover, no phylogenetic hypothesis for the family was available until now. This study revisited Plectreuridae using a combined morphological and multilocus phylogenetic analysis. Environmental niche modeling (ENM) was used to investigate the current and paleo distributional patterns of the genus *Kibramoa* throughout the biodiverse region of the California Floristic Province (CFP). A reexamination of genitalic morphology reflected cryptic species, yet multilocus Bayesian and Maximum Likelihood analyses of mitochondrial (COI, 16S) and nuclear (ITS1, 28S) markers consistently suggest several divergent lineages. A time-calibrated phylogeny indicated that the most recent common ancestor of *Kibramoa* appeared in the Mid-Miocene and continued to diversify throughout the Plio-Pleistocene. Xerophilic *Kibramoa*, as inferred by ENM, had a much wider distribution during the Mid-Holocene, when climate was at its warmest. This body of work uncovered novel findings regarding the evolution of plectreurids, provided the first phylogeny of the family, and demonstrated similar biogeographic patterns displayed in other CFP taxa.

Exposure to atrazine is life-changing for an agrobiont wolf spider *
Godfrey, Jake and Ann Rypstra
Miami University

For animals that live in association with humans, a key ecological question is how anthropogenic factors influence their behavior and life history. While major negative effects are obvious, subtle non-lethal responses to anthropogenic stimuli may provide insight into the features that lead to the success of species that thrive in habitats heavily impacted by humans. Here we explored the influence of the herbicide atrazine on the behavior and various life history traits exhibited by *Pardosa milvina*, a wolf spider that is found in agroecosystems where this herbicide is commonly applied. We first found that exposure to atrazine altered activity patterns of this spider. In a second experiment, exposure delayed maturation and increased the probability of spiders having a faulty molt. Atrazine also decreased the probability of producing an egg sac after mating, increased mass of egg sacs that were produced, and negatively impacted adult lifespans. These results suggest that the atrazine-based herbicides that are routinely applied to agricultural fields result in altered behavior and life history traits of these spiders and may therefore influence the community of predators and their effects on the food web in complex ways.

The triangle spider drives prey capture through external power amplification *
Han, Sarah, HC Astley, DM Maksuta and Todd Blackledge
University of Akron

The triangle spider, *Hyptiotes*, hunts by slinging its web around insect prey. In preparation for hunting, the web is stretched and held under tension by the spider, similar to drawing back a bowstring. When an insect strikes the web, the spider releases the tension and the web shoots forward, rapidly entangling the insect. By using power amplification, the web reaches velocities far beyond the capacity of muscular contraction. While internal power amplification is well-demonstrated through the rapid jumps of grasshoppers and fleas, external power amplification has never before been recorded in a non-human system. Here we demonstrate the first example of external power amplification and examine how it drives prey capture in *Hyptiotes*.

Differential sensory reliance in the multimodal courtship and mate choice of two sister species of wolf spider

Hebets, Eileen1, Rowan McGinley1, Mitch Bern, Andy Roberts2, James Starrett3 and Jason Bond3
1 University of Nebraska-Lincoln; 2 The Ohio State University at Newark; 3 Auburn University

Animals possess multiple distinct sensory systems capable of acquiring and processing information from their environment. These same sensory systems can be co-opted for communication, making it unsurprising that numerous animals produce and receive signals across sensory modalities. Within the wolf spider genus *Schizocosa*, there exists tremendous variation in the degree to which closely related species incorporate and rely upon visual and vibratory courtship components. Using a systems-directed approach, we explore the form and function of multimodal courtship signaling across variable conditions in two sister-species that share a habitat but vary in their multimodal courtship form. Subadult spiders of both *S. crassipalpata* (predominantly vibratory courtship) and *S. bilineata* (vibratory and visual courtship) were first assigned to diet manipulations in order to quantify the extent to which visual and vibratory signal form changes across diet regimes. In *S. crassipalpata*, vibratory signal form was found to be diet-dependent, while brush size was diet-dependent in *S. bilineata*. Next, we explored the importance of visual and vibratory signaling for each species by comparing mating success across artificial environments that varied in signal transmission properties. For *S. crassipalpata*, the presence of vibratory signaling was important for successful mating, while the presence of visual signaling was important for *S. bilineata*. In summary, despite shared signaling environments, *S. crassipalpata* appears to rely more on vibratory courtship signaling while *S. bilineata* relies more on visual signaling. We propose that similarities in vibratory courtship signaling and shared habitat led to the elaboration of visual signaling in *S. bilineata*.

Phylogenomic reclassification of the world's most venomous spiders (Mygalomorphae, Atracinae), with implications for venom evolution

Hedin, Marshal1, Shahan Derkarabetian2, Martín J. Ramírez3, Cor Vink4 and Jason Bond5
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Australian atracine spiders (family Hexathelidae), including the notorious Sydney funnel-web spider *Atrax robustus*, produce venom peptides that can kill people. Intriguingly, eastern Australian mouse spiders (family Actinopodidae) are also medically dangerous, possessing venom peptides strikingly similar to *Atrax hexatoxins*. Based on the standing morphology-based classification, mouse spiders are hypothesized distant relatives of atracines, having diverged over 200 million years ago. Using sequence-capture phylogenomics, we instead show convincingly that hexathelids are non-monophyletic, and that atracines are sister to actinopodids. Three new mygalomorph lineages are elevated to the family level, and a revised circumscription of Hexathelidae is presented. Re-writing this phylogenetic story has major implications for how we study venom evolution in these spiders, and potentially genuine consequences for antivenom development and bite treatment research.

Personality linked to parental origin in the scorpion *Heterometrus spinifer*

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The parental effect on animal personality may be the result of a parental epigenetic and genetic transmission. Personality studies in chelicerates focus principally on spiders, with the definition of two groups of personalities: bold and shy. Bold personality is used to describe active and aggressive individuals, while shy personality traits are associated with those less active and less aggressive. In scorpions, one of the older terrestrial arthropods, this is the first study of personality. In this study, we describe variation in behavioral responses in *Heterometrus spinifer* scorpions from different mothers to assess the parental effect on scorpions' personality. We specifically addressed the following questions: 1) are there behavioral variations in responses that can be described as personality traits (shy versus bold), and 2) are any observed differences in behavior linked with parental origin suggesting a genetic origin of personalities in scorpions. We used three groups of scorpions from three different mothers named F, B and H (F n=21, B n=14, H n=16) and reared in identical conditions. We performed three behavioral tests to determine personality among individuals: 1) a brush test in which the scorpion opisthosoma was gently touched with a paintbrush, 2) a puff test, blowing air at the scorpion, and 3) a locomotory activity test. For the brush test we recorded reactions to the brush including attempts to grab the brush or movement away from it. For the puff test we recorded if the individual retreated. For both these test we also recorded activity within 5 minutes after the stimulus was removed. For the locomotory activity, we used a video-tracking system to determine distance and ambulatory time of scorpions released into an arena. Results indicated differences in individual responses to the tests; some scorpions are more active (longer distances traveled and longer ambulatory time) and responsive (trying to grab, retreating or walking after brush and puff test) than others. Additionally, responses were related to parental origin; scorpions from the F mother were more active and responsive, while those from H or B mother were less active and responsive. This study suggests that for scorpions reared in strictly identical conditions, behavioral responses may differ according to individual. Behavioral differences are linked with those observed in spiders as bold or shy and considered as personality traits. Additionally, personality traits depended on parental origin showing that, in scorpions, inter-individual variability described as personality traits likely has a genetic origin.

Spiders on the clock: pushing the limits of circadian biology

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Circadian rhythms are endogenous oscillations, with a period of about 24 hours, which become synchronized with the daily cycle regardless of external temperature. It is widely believed that these internal rhythms are advantageous in that they allow organisms to anticipate regular changes in the environment such as the transition from day to night. Thus, there is a presumptive advantage to having an internal clock which resonates closely with the 24 hour day. Recently, however, we have been discovering species of spiders with internal clocks drastically disparate from 24 hours, including species representing the longest, and the shortest, known natural circadian rhythms. Furthermore, we have documented a species which can adjust to drastic phase shifts in the light cycle far faster than has been observed for any organism. This presentation will review what we know about spider circadian rhythms so far, and argue for developing spiders as a model system to gain general insights into the fundamentals of chronobiology.

Impacts on the abundance and distribution of *Wendilgarda clara* keyserling, 1886 along headwater streams of northeastern Puerto Rico affected by major hurricane disturbances

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The species *Wendilgarda clara* Keyserling, 1886 (Theridiosomatidae: Araneae), is a specialist of tropical aquatic ecosystems. These spiders spin simplified web structures that include a couple of structural bridge lines between rocks and vegetation along streams with various lines that are then attached to the water surface to snare insects (e.g., water striders) that float by in the current. In September 2017 the island of Puerto Rico was struck by two major hurricanes, Hurricane Irma on September 6th and Hurricane Maria on September 20th. These storms, and in particular Hurricane Maria, had a severe impact on the forests of northeastern Puerto Rico. To determine what possible effects the damage from the hurricanes could have on riparian spiders and their prey we utilized data from

monthly sampling of *W. clara* and water striders (Veliidae, Hemiptera) that were conducted from March – December 2017. Along two headwater streams in the El Yunque National Forest we collected data on the abundance and distribution of *W. clara* and Veliidae, including information on stream discharge and other physicochemical and morphological information for each stream. There was a sharp decline in the abundance of both *W. clara* and Veliidae following the hurricanes. Veliidae populations quickly recovered by the next month and there was no significant difference for pre-and post-hurricane abundances, but *W. clara* continued to have significantly lower post-hurricane abundances. As severe tropical storms are expected to become more common in the Caribbean it is important to determine the resilience of organisms to catastrophic disturbances and how this could impact predator-prey interactions.

Orb weaver glycoprotein is a smart biomaterial capable of extensive reuse *
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Spider orb webs trap prey using a capture spiral formed of regularly spaced glue droplets supported by a pair of protein fibers. Each droplet consists of an outer aqueous layer and an adhesive, viscoelastic glycoprotein core. Organic and inorganic compounds in the aqueous layer make droplets hygroscopic and cause droplet volume to change with environmental humidity. When droplets contact a surface, they adhere and extend as an insect struggles to escape. This sums the adhesive force of a series of droplets as the support line bows. Thus, both droplet extensibility and adhesion are essential for prey capture. Preliminary observations show that droplets can adhere and extend several times, although this phenomenon has not been investigated. We hypothesized that orb-weaver droplets would continue to perform through repeated adhesion, extension, and pull-off cycles. We predicted that droplet performance would decrease as a result of cycling and that this performance would be influenced by humidity. Our study extended individual droplets of *Argiope aurantia*, *Neoscona crucifera*, *Verrucosa arenata*, and *Larinioides cornutus*. Droplets were subjected to 40 extension cycles, with videos and images captured at cycles 1, 2, 4, 8, 16, 24, 32, and 40. This allowed us to characterize changes in droplet volume, glycoprotein surface contact, glycoprotein volume, droplet extension, and the force on a droplet at pull- off. These tests were conducted at a constant temperature and at two humidities, selected to represent optimal and suboptimal values for each species. As hypothesized, droplets were capable of extensive cycling, with a slight decrease in performance, due in part to glycoprotein stiffening. However, humidity did not impact the percent decline in droplet performance. Although spider droplets are not normally subjected to such extensive cycling, their durability is advantageous because droplets often have an opportunity to reattach to an insect during its struggles. The environmental responsiveness of orb spider glue droplets has been described previously. By documenting the ability of these droplets to cycle, our study fully characterizes them as smart biomaterials and increases their biomimetic potential for construction and engineering applications.

The utility of spiders in forensic entomology
Kissane, Kelly
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Forensic entomology is used to estimate the post-mortem interval, cause of death, and any change in the corpse's position since the time of death. The utility of spiders in forensic entomology, however, has not been studied. Carrion would provide a rich source of food for spiders, and previous studies have indicated that wandering spiders may use chemical cues in their foraging decisions. Previous studies have also indicated that wolf spiders respond to airborne chemicals, suggesting that they may be attracted to the same airborne chemicals that attract blowflies and other insects. I explored the possibility that spiders might contribute to the field of forensic science by testing the attraction of four different wolf spider species to airborne chemicals produced by decomposing pig carrion. I used a white foam apparatus with four round chambers to test the spider's attraction to three different sources of airborne chemicals: decomposing pig carrion, fresh pig carrion, and live flies. These results and the potential utility of spiders in forensic entomology will be discussed.

Good vibrations: Female response to signal components in *Schizocosa* ethospecies *
Lallo, Madeline and George W. Uetz
University of Cincinnati

Communication signals have evolved to convey accurate information from a sender to a receiver through different sensory modalities. These signals may vary in their complexity to ensure successful transmission through the environment and enable receiver discrimination. Sibling wolf spider species, *Schizocosa ocreata* and *S. rovneri*, have recently diverged and are reproductively isolated by their behavior. Males of both species court females using multicomponent vibratory signals that vary in their complexity. The vibratory signal of male *S. ocreata* represents a complex pattern of stridulation and percussion components, compared to that of *S. rovneri*, which produce a regular pattern of brief pulses of combined components. We examined the role of signal complexity in species recognition and mate preference using vibratory playback via piezoelectric disc benders of separate individual components (percussion and stridulation) from each male signal. Female *S. ocreata* and *S. rovneri* were exposed to either conspecific or heterospecific signals within four treatment groups: complete signal, percussion only, stridulation only, or white noise. The number of female receptivity displays varied significantly among treatment groups for both *S. ocreata* and *S. rovneri* males. Interestingly, there were no significant differences in the number of female receptivity displays for both *S. ocreata* and *S. rovneri* when presented with playback of complete conspecific vs. heterospecific vibration signals. However, each species responded differently to individual vibration components of conspecifics: *S. ocreata* presented no preference for individual conspecific or heterospecific signals; *S. rovneri* showed more receptivity to isolated conspecific percussion signals. Our results show that females of these two ethospecies recognize isolated vibratory signaling components of conspecifics and heterospecifics.

The effects of two commonly applied pesticides, resmethrin and methoprene on a key salt marsh predator *
Mahadeo, Vashtidevi and Matthias Foellmer
Adelphi University

The pesticide Scourge and the larvicide Altosid are used on Long Island salt marshes to control mosquito populations. Pesticides often affect non-target species by increasing mortality or by altering behavior or physiology through sub-lethal or fitness-decreasing effects. Since the wolf spider *Pardosa littoralis* is a key predator in this ecosystem, changes in their behavior have the potential to affect ecosystem function. This study investigates the behavioral effects of Scourge's active ingredient Resmethrin and the synergist Piperonyl Butoxide on adults, and the active ingredient of Altosid, Methoprene, on juvenile individuals. Locomotion abilities were tested for both pesticides. Scourge was tested at 5μg /L with combinations of salinity (0.01 % and 0.05% NaCl) since pyrethroids have been shown to effect voltage regulated sodium channels. Juvenile spiders were tested at 10 mg/L of methoprene, which has been shown to affect development as a juvenile growth hormone mimic. We found that at low salinity, exposure to Resmethrin resulted in reduced burst distances. Low salinity was associated with decreased burst speed. Therefore, lower salt concentrations may be stressful, leading *P. littoralis* to be more susceptible to the effects of resmethrin. However, exposure to methoprene did not cause any significant differences in speed or endurance. Body size and condition was consistently positively related to performance measures. Methoprene and resmethrin may not directly affect *P. littoralis*' speed and endurance; however, presence of stressors in the environment can alter these outcomes and lead to other immediate fitness consequences.

The effect of wildflower strips on spider abundance and diversity in Florida
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Wildflower strips have recently been used near agricultural fields to increase pollinator biodiversity and to improve habitat health. Spiders are often good indicators of pollinator biodiversity to their predatory relationship with

insects. To investigate the effectiveness of these wildflower strips at increasing biodiversity, we examined the abundance and diversity of spiders in agricultural habitats with and without wildflower strips in Florida. In 2015 and 2016 and at eight sites throughout Northern and Central Florida, we set up wildflower (treatment) plots and fallow (control) plots. We collected spiders with bowl traps, pitfalls traps, and random sweep net samples during the growing season in Florida (April to November). The data - from two years of study - indicate a significant difference in the abundance and maturity of spiders between control and treatment plots. Moreover, there was a significant difference between control and treatment plots in the taxonomic family, genus, species, and guild composition. However, there was no significant difference between the treatment and control plots in the sex ratio or Shannon diversity (at the family level) of the spiders. Furthermore, within these data we discovered new spider distribution records and multiple potentially undescribed spider species. These data show the importance of wildflower strips at increasing pollinator abundance near agricultural plots.

Humidity-mediated prey retention by orb spider capture threads: linking glue droplet properties to insect retention time

Opell, Brent, Cassie Burba, Pritesh Deva, Matthew How Yew Kin, Malik Rivas, Mary Hendricks
Virginia Tech

An araneoid orb web relies on its sticky, viscous capture spiral to retain prey. As an insect struggles to escape from a web, the adhesive forces of the capture thread's regularly spaced glue droplets are summed by the thread's flagelliform fibers. Each droplet is comprised of an adhesive, viscoelastic glycoprotein core surrounded by an aqueous layer. Low molecular mass compounds (LMMCs) in the aqueous layer attract atmospheric moisture, causing the glycoprotein's performance to change with environmental humidity. The objective of this study was to determine how these changes affect prey retention time. We compared the active struggle time required by a housefly to escape from four equally-spaced strands of *Argiope aurantia* and *Argiope trifasciata* capture threads at 37%, 55%, and 72% relative humidity (RH). *Argiope aurantia* threads retained flies an average of 16.5 seconds longer than did *A. trifasciata* threads. *Argiope trifasciata* retention time increased with humidity, being 8.8 seconds longer at 72% RH than at 37% RH. In contrast, *A. aurantia* threads performed best at 55% RH, where insects were retained an average of 12.5 seconds longer than at the other two humidities. A model developed from these retention times, those of Araneus marmoreus from a previous study, and characteristics of the three species' glycoprotein volumes, viscosities, flattened surface areas, and maximum extension lengths described the contribution of each property to prey retention time. Although a common model explains fly retention time, each species' unique LMMCs mix governs the response of its capture thread to environmental humidity and establishes its prey retention profile.

Predator kill zones: Do wolf spiders chemically detect where a predator has killed a conspecific and respond adaptively?

Persons, Matthew, Eric Pressler and Darren Wright
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The wolf spider *Pardosa milvina* exhibits adaptive antipredator responses in the presence of silk and excreta from a larger co-occurring predatory wolf spider, *Tigrosa helluo*. Since wolf spiders deposit silk as they move through the environment, the quantity and quality of silk deposition may change in areas where wolf spiders capture and consume prey. These "kill zones" may provide information about increased predation risk to prey and induce corresponding increased antipredator behavior that, in turn, enhances prey survival. We measured silk patterns produced by the predator, *Tigrosa*, as well as the prey, *Pardosa*, across six substrate treatments that varied in prey type (*Pardosa* or cricket) and whether prey capture occurred. We also measured predator attack behavior, *Pardosa* activity level, and survival on each of these substrates. The six treatments included: 1) a blank substrate (negative control), 2) a substrate occupied by three *Pardosa* (positive control), 3) *Tigrosa* cues alone, 4) *Tigrosa* and cricket cues with cricket predation, 5) *Tigrosa* and *Pardosa* cues without predation, and 6) *Tigrosa* and *Pardosa* cues with predation (n=18; N=108). The quantity of different silk types and excreta significantly varied among treatments with and without predation indicating that *Pardosa* could use this as a source of information to assess risk. *Pardosa*

activity level was significantly lower in treatments with *Tigrosa* cues and lowest in the treatment with *Tigrosa* and predated *Pardosa*. *Pardosa* also survived significantly longer but was not attacked less frequently in the treatment where *Tigrosa* killed *Pardosa* compared to when they did not. Our findings suggest that *Pardosa* can identify areas of predation (i.e. kill zones) using only information in silk and excreta and that this information translates into increased survival in the presence of a live predator.

Running for cover: increasingly risk-prone behavior of male wolf spiders
Roberts, J. Andrew1, George Uetz2 and Dave Clark3
1Ohio State Newark; 2University of Cincinnati; 3Alma College

Male animals of many taxa spend a significant portion of their daily time budget seeking potential mates. While we know a great deal about relatively few, larger animals, very little information exists concerning estimates of, and factors influencing, movement of small, hard to track animals, especially arthropods. Male wolf spiders (Lycosidae), popular models for exploring complex communication, spend a significant portion of time moving in search of mates. Males who are more active and travel greater distances are arguably more likely to encounter potential mates and/or cues left behind by potential mates, but are also exposing themselves to predators. As part of a multi-year field survey of behaviour, activity patterns, and population dynamics of brushlegged wolf spiders (*Schizocosa ocreata*), we measured the displacement distance (linear distance between start and end points) of individual males during ten-minute observation periods. Male spiders traveled significantly greater distances as the breeding season progressed. The Adult Sex Ratio (ASR) and Operational Sex Ratio (OSR) remain essentially unchanged over the course of much of the field season, most likely due to subadults molting to maturity as the season progresses. The Risk Ratio (ratio of potentially cannibalistic, mated females to adult males) steadily increases. Males that move greater distances as the season progresses are more likely to encounter mated females, increasing risk of predation.

The effects of climate-induced forest disturbances on spiders in northern Michigan *
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We examined the effects of forest disturbance on spider diversity in the Forest Accelerated Succession Experiment (FASET) in northern Michigan, initiated by the University of Michigan in which plots were subjected to different severities of disturbances. Our study aimed to use FASET to mimic a scenario of co-dominant tree mortality as a result of an insect outbreak. We hypothesized that the diversity indices of forest-floor spider assemblages would be negatively influenced by higher disturbance severities. We measured variables known to affect spider assemblages: prey (abundance of non-spider arthropods), downed woody volume (DWV), length (DWL) and area (DWA), and the number and status of trees. In total, 245 spiders representing over 12 families and over 3,200 terrestrial arthropods were captured. Our results supported our main hypothesis, as we found that the total abundance, diversity and richness of spiders were lower in more disturbed plots. Interestingly enough, the diversity and richness of spiders were significantly less in plots with higher DWA. Family-level multivariate analyses revealed complex patterns. Despite the commonly occurring positive relationship of downed wood and spider diversity in previous research, our results did not always support this. Indices of forest-floor arthropods, leaf litter composition and biomass, vegetative structural complexity, and temperature measurements, should be taken into consideration in future studies. The interaction between spiders and forest disturbances, as well as the impact that climate change may have on these interactions, are important to study to better predict how future forest pest outbreaks and other disturbances may affect spiders in northern temperate forests.

Exercise and fitness? Impact of a training program on the activity and mating success of wolf spiders
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Wolf spiders (Lycosidae) are known to run in short bursts and to fatigue easily. It is not known if training can enhance their physical fitness or influence their behavior. We tested the hypothesis that repeated periods of sustained activity would affect the behavior of *Pardosa milvina* wolf spiders later in life. We trained spiders by placing them on a moving surface and forcing them to walk for three periods daily for 7 days. We first trained juveniles in their 4th instar and quantified their activity once they reached the 5th instar. Trained individuals moved more and covered more distance at a higher speed than untrained individuals. We then trained penultimate males and quantified their activity as adults and found that trained males were more active. We then paired those males with either well-fed or food-limited females and documented mating behavior. Trained males started courting well-fed females sooner and with more intensity than untrained males. Likewise, well-fed females were more likely to mate with trained males. There were no differences in the courtship behavior or mating success of trained and untrained males with food-limited females. However, food-limited females were more likely to attack untrained males. Well-fed females that mated with trained males produced eggsacs sooner than females in any other treatment but there was no effect of male training on eggsac size or egg number. These data suggest that physical fitness may warrant further study in wolf spider mating systems.

Evolution and functional specificity in venom toxins from Sicariid spiders *

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Venom contains a complex cocktail of chemicals and proteins. Because it is optimized for prey capture and contains a variety of proteins that aid in this endeavor, venom is a useful model for studying protein evolution. Venom from sicariid spiders, which include the brown recluse and six-eyed sand spiders, is particularly interesting as a model because the phylogenetic relationships of a family of proteins that make up a large portion of this venom are well-characterized. This family, called SicTox, is made up of phospholipase D proteins, and its members are further known to act with varying specificities for phosphosphingolipids, such as sphingomyelin and ceramide phosphatidylethanolamine (CPE). Sphingomyelin and CPE are common phospholipids in the membranes of many arthropod prey and only differ their in head group: choline and ethanolamine, respectively. In order to understand the evolution of this specificity, we reconstructed and expressed a hypothetical ancestral SicTox protein and comparing its activity to proteins of known specificity. Preliminary results suggest the ancestral protein has low specificity toward sphingomyelin and CPE, suggesting specificity may have evolved in extant proteins through subfunctionalization by losing affinity for one phospholipid head group or the other. Because some sicariid venoms retain multiple variants of SicTox proteins with differing specificities, it is possible that the evolution of specificity in some copies conferred more functional versatility of the venom as a whole.

Habitat disturbance affects predatory responses in early instar scorpions (*Heterometrus spinifer*: Scorpionidae)

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Scorpions, like all animals, may face unexpected changes to their habitat. To survive these changes, they must demonstrate behavioral plasticity. Moreover, disturbances may affect future actions, particularly if occurring during first-time prey capture. Prey capture is an innate response, and success is directly linked to growth and survival. We examined how disturbance impacted predation behavior in young scorpions (*Heterometrus spinifer*) during their first encounters with prey. Lab-reared scorpions were housed in stable environments and were separated into three testing groups: non-disturbed (ND) and disturbed (D). and a control (C). The ND group was fed in-situ in their home containers for four trials. The D group had three trials in a feeding arena, which contained substrate from their home containers, then a final trial back in their home containers. The C group, comprised of naïve scorpions, was fed a single time in their home containers. Behavioral variables recorded were capture strategy (active vs sit-and-wait), sting occurrence, and capture latency. For the first three trials, ND and D groups showed behavioral differences in prey capture technique (analyzed with a *G*-test). ND scorpions alternated between active searching and adopting a sit-and-wait ambush position, and only stung prey during active searching. The D group primarily

used active searching to capture prey, had longer latency to capture times, and higher sting occurrences. In the final trial in their home containers, D scorpions continued to have a longer latency to capture and were more likely to sting than either ND or C groups. The C group overall had equivalent responses to the ND group. Our results suggest that habitat disturbance initiates a behavioral shift to more costly hunting strategies, and that this shift continues to influence future prey capture events.

Cotton food webs: implications of spiders as natural pest managers
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Over the past 500 years, cotton has become the preeminent global commodity for meeting fiber demands. The current generation of cotton farmers need information on the importance of beneficial communities in cotton production systems, and how to promote natural pest management. In this study, for the first time, we document the spider community and trophic interactions in a cotton production system in Georgia, U.S.A. Spiders were sampled during 2015-2017 in a 36 hectare cotton system. Seventeen sample points spaced at minimum 50 meters apart were taken from the canopy of cotton on three occasions each year for a total of 153 samples. Molecular gut content analysis was then applied to a total of 800 predators using published primer sets for common pests and alternative prey (total of 7 target prey items). Results show that spiders are consuming all economically important pests. Our study assembled a molecular system that will be useful in further studies to understand the seasonality of trophic interactions associated with key cotton developmental stages.

Heat stress in the wolf spider *Schizocosa ocreata* (Araneae: Lycosidae) *
Sidoti, Salvatore and J. Andrew Roberts
The Ohio State University

Organisms from temperate zones must cope with widely-varying climatic conditions as they are exposed to the changing seasons, but high variability within a season is also possible. Extremes in dry and warm conditions can promote desiccation in all animals, especially ectotherms like spiders, and may have other, unexpected consequences for behavior and reproduction. We explored the effects of episodic heat stress on courtship, mate choice and reproduction in the brush-legged wolf spider, *Schizocosa ocreata* (Hentz 1844). To accomplish this, we simulated an ecological scenario in the laboratory whereby a male and/or female experience the thermal environment associated with above and below the leaf litter. This factorial study consisted of two treatment groups for each sex: 1) short heat burst 24 hours prior to mating (30 min/45°C) versus 2) stable laboratory temperature range (18°C—20°C). Our hypothesis is that episodic thermal stress will result in reduced reproductive success. We expect this effect to be greater for heat-treated males who have significantly less mass to buffer against changes in the external thermal environment. Males who have been heat stressed may exhibit increased courtship latency, reduced courtship vigor, and therefor reduced mating success. Additionally, heat-treated females may exhibit altered receptivity towards courting males and/or other behavioral perturbations such as egg sac abandonment. Finally, we examined the effects of maternal heat stress on reproductive performance parameters including clutch size and offspring mass.

Phylogenomic investigation of the *Schizocosa ocreata* group
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Understanding the role of complex courtship traits in driving speciation requires a robust phylogeny. The wolf spider genus, *Schizocosa*, has been the subject of decades of important courtship studies. Here we focus on the *Schizocosa ocreata* group, which consists of six species that are distributed in eastern North America. *Schizocosa ocreata* group species are characterized by having a finger-like pileal process on the palp in males. In their courtship behavior, males use a combination of vibratory signals and ornamented leg waving displays, which have

diverged rapidly among species. Inferring the phylogenetic relationships in *Schizocosa* has been hampered by limited availability of molecular markers, with mitochondrial DNA sequences primarily used. In addition, little is known about potential intraspecific population structure, as geographic sampling has typically been limited to a few localities. We have sampled *Schizocosa ocreata* group species throughout much of their distributions and used a combination of reduced representation genomic methods to infer interspecific relationships and intraspecific genetic structuring. Hundreds of nuclear loci, generated using anchored hybrid enrichment, were used to generate a well-resolved phylogeny with high nodal support. We use RADseq data to investigate for genetic structuring within more geographically widespread species, to shed light on potential regional differences in courtship behavior. These data will be important in understanding complex courtship traits and their role in species divergence and subsequent reproductive isolation.

Towards spider glue: sequencing the longest known silk family gene

Stellwagen, Sarah and Rebecca Renberg
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Spider silks are composed of extremely large, highly repetitive proteins called spidroins (spider fibroins) encoded by a single gene family. Short read sequencing technology cannot resolve the repetitive regions of silk genes, resulting in relatively few fully characterized spidroins of several silk types and species. The aggregate gland glue that coats the capture threads of orb and cobweb weavers, an evolutionary relative of solid silks and also part of the spidroin family, has not yet been fully characterized. We used third generation sequencing technology to sequence the transcriptome of glue glands from *Argiope trifasciata*, acquiring a >16 kb read belonging to the aggregate spidroin (AgSp1). This large read terminated within the repetitive region, however in conjunction with assembled non-repetitive regions using short read data, it establishes that the gene is at least 27 kb, the largest spidroin currently known after aciniform silk (19 kb). The main repetitive motif, described here for the first time, consists mostly of O-glycosylated threonine flanked by proline and glycine, results that are consistent with previous suggestions that the glue shares similar structure with mucin-family proteins. As more aggregate spidroin sequences become available, comparisons across species with different functional characteristics will provide insights for designing bio-inspired adhesives.

Social experience, biogenic amines, and plasticity in mating behaviors of the brush-legged wolf spider, *Schizocosa ocreata*

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Biogenic amines (BA), such as octopamine (OA) and serotonin (5-HT), have been shown to regulate an array of behaviors in arthropods, including both aggression and mating. Further, these biogenic amines can be affected by social experience. Therefore, biogenic amines might be a mechanism through which plasticity in mating behaviors or tactics occur. In the brush-legged wolf spider, *Schizocosa ocreata*, fitness trade-offs resulting from male coercion, female sexual cannibalism, and plasticity in mating behaviors, make the regulation of such behaviors important. We used topical application, HPLC, and playback techniques to manipulate OA and 5-HT levels and examine the role of these biogenic amines in regulating both male and female mating behaviors. If provided multiple encounters with female chemical cues, males had lower levels of OA, suggesting a mechanism through which they increased their subsequent courtship. In females, previous social experience resulted in higher 5-HT levels. In live trials, females treated with 5-HT resulted in higher mating success. Our findings demonstrate the importance of OA and 5-HT in the regulation of mating behaviors of *S. ocreata*.

Population genetic structure of kleptoparasitic spiders (Argyrodinae: Theridiidae) – A comparison between group-living and solitary species

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Group-living behavior is commonly seen in Animals. However, group-living in spiders is rare. Group-living spiders in the subfamily Argyrodinae (Theridiidae) are kleptoparasites group-living in other host spider's web. As some species of the group-living kleptoparasites may have cooperatively steal food from their hosts, this natural system, which has several independent origins of group-living, is a good system to study the transitioning from solitary status to primitive stage of sociality in animals. We investigated whether these kleptoparasitic groups are kin groups in the field. By comparing population structure of two group-living kleptoparasitic species, *Argyrodes miniaceus* and *A. cf. fissifrons*, and two solitary kleptoparasitic species, *A. fasciatus* and *Neospintharus trigonum*, we carried out DNA finger-printing for each individual using the TE-AFLP method (three-enzyme amplified fragment length polymorphisms), and used genetic clustering analyses and spatial autocorrelation analyses to assess the relatedness of group members. The results showed that: (1) In both group-living species, genetic-geographic autocorrelation is highest among spiders sharing the same host web and declines quickly when distance increased. Results from both solitary species showed no significant autocorrelation at all. (2) High relatedness was found in two webs/groups in group-living species while other groups of these species showed random or low relatedness among group members. Neighboring individuals in solitary species did not have high relatedness. (3) Group membership cannot fully explain the genetic structures in group-living species; nor in solitary species. These results, along with observations on reproductive behavior, suggest that population genetic structure in the group-living species is caused by limited dispersal of group members; the absence of genetic structuring in populations of solitary species indicates a high level of individual exchanges. For further study, we are also conducting SNPs based methods to test the relatedness of the natural groups in Argyrodinae populations.

Singing in the rain: the effects of leaf moisture on complex signal transmission and mating in the brush-legged wolf spider

Sweger, Alexander and George Uetz
University of Cincinnati

Complex microhabitats contain numerous obstacles to effective communication, generally leading to the emergence of complex or multimodal signals in species that attempt conspecific communication in these environments. The brush-legged wolf spider *Schizocosa ocreata* (Araneae: Lycosidae) utilizes multimodal communication- visual ornaments and complex, multi-component vibrations- to overcome some of the limitations of its complex deciduous leaf litter habitat. Previous studies have shown that plasticity in the use of these multimodal signals may help compensate for the limitations of less-than-optimal substrates. However, seasonal rainfall may create an additional obstacle, in that it may change the transmission properties of an otherwise ideal substrate. The goal of this study was to identify the impact of leaf moisture on vibratory signal transmission, use of visual versus vibratory signals, and overall mating success in *S. ocreata*. Using both live male spiders and piezoelectric elements, we recording controlled vibratory simulations of signals and actual courting spiders on both wet and dry leaf litter in order to test the effects of moisture on signal transmission and range. We also paired male and female wolf spiders on wet and dry leaf litter substrates to assess the effect of leaf moisture in live mating encounters. We found that wet leaves had a significantly decreased signal-to-noise ratio and impacted transmission of male vibratory signal components. Mating success was also significantly lower in wet environments, despite no significant difference in male courtship. However, we found that males did tend to favor visual signals as a higher overall proportion of courtship when courting on wet environments. Our results suggest that during particularly high periods of precipitation throughout the mating season, substrate moisture may impact signal transmission and overall mating success.

Through a lens darkly: female detection of male signals against complex chromatic backgrounds

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Female *Schizocosa ocreata* (Hentz) wolf spiders have dichromatic vision, yet may be able to perceive differences in chromatic intensity contrast of visual signals of males against complex color backgrounds of their forest floor leaf litter microhabitat. We used video playback to examine responses of female wolf spiders to manipulated male spider coloration and background chromatic contrast. Three male spider color treatments (control, gray

monochromatic and RGB average monochromatic) were displayed against two background color treatments (natural leaf litter color vs. grayscale leaf litter). We found that female spiders were more likely to detect males that contrast more highly with their background, although detection latency varied significantly depending on both male exemplar color and background color, suggesting that intensity of chromatic contrast affects detection. Against a natural colored leaf-litter background, control and RGB mono spiders are more detectable than the gray mono spider, but with a complex (colorless) grayscale background, detection latency did not differ significantly among spider exemplars. A different set of patterns emerged in data for mate recognition and receptivity. Against a complex color background, the receptivity score for the gray mono spider was very low, while the control and RGB were equally high, suggesting that color matters. Against the complex grayscale background however, results were different – the RGB mono spider elicited very low receptivity, while control and gray mono were equally high. Analyses of chromatic and luminance intensity contrast values for spiders and backgrounds may explain these different results, and suggest that for female wolf spiders, intensity of chromatic contrast influences detection and mate recognition in complex ways.

Bold or shy? Behavioral syndromes in the brush-legged wolf spider, *Schizocosa ocreata*
Walls, Trinity and George W Uetz
University of Cincinnati

Recent studies have shown that spider “personality” demonstrates consistent behavioral variation at the individual level that persists across life stages and contexts, and may have fitness consequences. “Bold” individuals may be more likely to challenge predators or seek potentially dangerous prey, while “shy” individuals may gain increased self-preservation but forego foraging or mating opportunities. While behavioral syndromes exist in social spiders, advantages of differing personality traits in solitary species are less apparent. We examined behavioral syndromes in the brush-legged wolf spider, *Schizocosa ocreata*. Spiders were repeatedly given open field tests and later exposed to simulated predator stimuli. All spiders were tested as juveniles and adults. Results of open field tests showed individual *S. ocreata* exhibit consistent behavioral patterns associated with either bold (exploratory) or shy (freeze) behavioral syndromes. These differences persisted across contexts, as well as life stages (juvenile, adult). Mature females were given a two-choice test using video playback of male courtship to analyze differences in mate choice, while males were exposed to female cues to assess courtship vigor. Bold spiders showed more variation in behavior but exhibited shorter latencies to explore in a novel environment and to resume exploration after a simulated predator stimulus than their shy counterparts. While males did not show differences in courtship based on bold-shy personality traits, bold females showed greater activity when choosing mates than shy females. However, only shy females showed a preference for males with larger tufts. The effects of bold-shy personality traits on overall mating success will be discussed.

Geographic variation in male phenotype in relation to female mate choice *
Watts, J. Colton, Brigitte Tenhumberg and Eileen A. Hebets
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Sexual selection is widely hypothesized to facilitate the evolution of reproductive isolation through divergence in sexual traits and sexual trait preferences. Although there are many examples of closely related, reproductively isolated groups that have diverged in sexual traits and preferences, the relative importance of sexual selection in the earliest stages of evolutionary divergence remains poorly understood. Using the wolf spider *Schizocosa crassipes*, we characterized geographic variation in putative sexual traits and related this variation to patterns of female mate choice within and among locations to test whether divergent mate choice might cause intraspecific trait variation. We found that male morphological and behavioral traits vary over small spatial scales and are under direct and/or correlative phenotypic selection through mate choice, but we found no evidence that selection on male traits varied among locations. These results suggest that mate choice may play a relatively minor role in the earliest stages of trait divergence in *Schizocosa* wolf spiders. More generally, this work contributes to a broader literature demonstrating that the presence of divergent sexual traits and trait preferences at coarser taxonomic scales (e.g., among closely related species) does not necessarily implicate sexual selection per se as the initial cause of

divergence.

Mite domatia in plants: a widespread, yet often overlooked, plant-arthropod defense mutualism
Weber, Marjorie
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Domatia are morphological structures on plants that provide housing for beneficial arthropods in return for protection from natural enemies. Domatia that house ants have received a large amount of research attention, becoming a paradigm example of a trait that mediates mutualism in ecology and evolution. However, mite domatia (small structures on plant leaves that typically house predacious and microbivorous mites) remain shockingly underexplored relative to ant domatia, largely due to their cryptic nature. Here, we introduce mite domatia as a novel model system for the study of mutualism. We use compile up-to-date list of mite-domatium-bearing plant species, and evaluate the evolutionary and ecological correlates of mite domatia globally. We find that mite domatia are highly phylogenetically and geographically wide-spread, and display striking convergent evolution of form in temperate and tropical ecosystems. Together, our study suggests that mite domatia represent a promising system for the study of defense mutualisms beyond ant-plant systems.

Shifts in cheliceral muscle anatomy among palpimanoid spiders
Wood, Hannah
Smithsonian Institution

Spiders are important predators in terrestrial ecosystems and, with over 47,000 described species, they are notable in terms of species diversity, global ubiquity, and diversity in behavior and ecology, properties that are widely attributed to their innovative use of silk and venom. Yet, while great advances have been made in research on spider silk and venom, we know very little about the principal feeding structures of spiders, the chelicerae, which are an extremely important aspect of spider biology. In particular members of Palpimanoidea have evolved highly unusual cheliceral morphologies and functions, including the high-speed, ballistic movements in mecysmaucheniid spiders (the “trap-jaw spiders”), the fastest arachnid movements known thus far. Here, I perform a comparative study examining the cheliceral muscular morphology of the five palpimanoid families using micro-CT scanning techniques. Results show a highly derived cheliceral muscle organization in mecysmaucheniids, with a reduction of muscles. In contrast, the archaeids, or “pelican spiders”, with their highly maneuverable chelicera, show an increase in musculature. This is the first step toward understanding homology among cheliceral muscles and evolution of cheliceral function across spiders.

Relative gene expression study on *Centruroides vittatus*: investigating sodium toxin gene activity
Yamashita, Tsunemi, Chloe Fitzgerald, Alyssa Kool, Ashlyn Tedder, Aimee Bowman, Taylor Bishop and Cody Chivers
Arkansas Tech University

Centruroides vittatus, colloquially known as the striped bark scorpion, populates an area as far as the western border of New Mexico to the Interior Highlands of Arkansas. The Arkansas scorpions presumably have a medically mild sting compared to individuals of the western populations. These scorpions inject a venom that consists primarily of sodium β neurotoxins that alter the kinetics of sodium channel gating. This exploratory study on the sodium β toxin gene activity of eastern *C. vittatus* scorpions specifically focused on gathering relative quantification data for eight neurotoxins. Five variants are found in the genome of both eastern and western populations and may have toxic effects. However, two neurotoxins appear to only exist in the genome of eastern populations. We hypothesized that if eastern populations are expressing the less toxic variants more than the others, then those differences should be correlated to differences in threshold cycle (Ct) value and differences in relative gene expression ratio. Preliminary experiments have been conducted on both male and female organisms and Ct values were statistically and computationally analyzed through the ΔΔCt method, which generated a tentative activity

ratio for these gene variants. This information lends insight into how venom variation and toxicity has evolved among scorpion populations which will allow us to better understand toxin protein interaction to their targeted membrane channels.

POSTER PRESENTATION ABSTRACTS

Arranged by first author's last name
Presenters in underline
* designates student competition participant

Examination of behavioral lateralization in juvenile tarantulas in the presence of prey odors
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Behavioral lateralization, also known as behavioral asymmetry, is the result of the functional and/or structural specialization of one hemisphere in the brain over the other. For decades, studies have provided evidence for this trait throughout all classes of vertebrates. More recently, research has shown this trait among various invertebrates as well, however, information on behavioral lateralization in regards to arachnids is limited. In this study, we examined the presence of behavioral lateralization in response to prey odors in the juvenile tarantula, *Pterinochilus murinus*. Spiders were observed in a T-maze with the following prey odor conditions: crickets in both arms, crickets in the left or right arm, and crickets absent. From our behavioral and data analyses, it was found that for all conditions a significant percentage of the population did not make a choice (>64% for all conditions). From the data on individuals that did make a choice, it was found that there was no clear directional choice across all trials (p>0.5 for all comparisons). Although our results indicate an absence of behavioral lateralization, the amount of usable data was extremely limited, and therefore, we are currently unable to provide clear evidence for the presence or absence of behavioral lateralization. Additional studies with a different species are in progress.

The effects of glyphosate and body condition on courtship and cannibalism in an agrobiont wolf spider *
Archdeacon, Megan and Katrina Culbertson
Miami University

Courtship in sexually dimorphic species can be dangerous, especially in spiders, where males risk being cannibalized by the larger female. In this experiment we tested the effects of exposure to a glyphosate-based herbicide on the courtship, mating success, and rates of pre-copulatory cannibalism for *Tigrosa helluo* and mapped these variables on the female's immune function. We randomly assigned pairs to arenas treated with either Roundup® (treatment) or distilled water (control) and recorded interactions for 90 minutes. Recordings were scored for courtship behaviors, mating, and cannibalism. We ran lysozyme assays as a proxy for immune function. We observed higher cannibalism rates and increased male aggression in the herbicide treatment. The more vigorously a male courted, the more likely he was to be cannibalized without mating, but exposure to herbicide decreased pre-copulatory cannibalism. Males courted females with low lytic activity more vigorously, which could be a result of males evaluating risk for individual females and increasing courtship activities when cannibalism was likely to occur. Females showed receptivity sooner on substrates treated with the herbicide. Clearly, glyphosate-based herbicides impacted reproduction in *T. helluo*. Likewise, males adjusted their courtship activity based upon the female's immunocompetency, which we presume was an indication of her condition.

Effects of bacterial infection on female mate choice in the brush-legged wolf spider, *Schizocosa ocreata* (Hentz) (Araneae: Lycosidae) *
Olivia Bauer-Nilsen*, Alexander L. Sweger, George W. Uetz
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Animals are vulnerable to infection by a variety of pathogens and parasites, although maintaining an immune system to combat these infections often comes at a high energetic cost. This can lead to a trade-off between the physiological costs of an effective immune response and investment in other beneficial traits, such as secondary sexual ornaments or effective behavioral decision-making. In the brush-legged wolf spider, *Schizocosa ocreata* (Hentz), males exhibit secondary sexual ornamentation in the form of foreleg tufts, and previous studies have shown that bacterial infection adversely affects the development of these ornaments. Females of this species usually mate only once, resulting in an emphasis on effective mate choice, though the impacts of infection on their decision-making remains unknown. The goal of this study was to examine the effects of bacterial infection on the selectivity of female *S. ocreata*. We infectedfemales with *Pseudomonas aeruginosa*, a common bacterial pathogen in arthropods, and then presented them with a choice of courting male stimuli of differing quality using video playback on iPods. We then scored female receptivity behavior and overall activity. We found that infected females did not vary significantly from control individuals in their selectivity of courting males. This suggests that any impacts of bacterial infection on decision-making could be latent, and future studies will likely investigate additional facets of infection and how it might affect mating behavior.

Now you see me, now you don't: Eavesdropper detection of signals against complex backgrounds for male wolf spiders, *Schizocosa ocreata*

Clark, David and George Uetz
Alma College; University of Cincinnati

Male *Schizocosa ocreata* wolf spiders search the leaf litter for females by walking about and then initiating active courtship behavior when chemical cues from female silk are detected. While active courting displays have been shown to increase male detection, studies of animal coloration and camouflage suggest that there are risks involved for animals which exhibit both disruptive and/or cryptic coloration and conspicuous courtship behaviors that facilitate detection by females. For this study, we used video playback to examine the responses of social eavesdroppers, i.e., competing male wolf spiders, and interceptive eavesdroppers, i.e., a vertebrate predator, the American toad, to manipulated male spider coloration and background chromatic contrast. Three male spider color treatments (control, gray monochromatic and RGB average monochromatic) were displayed against two background color treatments (natural leaf litter color vs. grayscale leaf litter color). For the social eavesdropper experiment, we presented test males with a lateral view perspective of male performing courtship behavior. For each trial, the number of tapping bouts towards the stimulus was scored. Results of a 2-Way ANOVA analysis showed significance overall, however, neither spider color or background alone accounted for this result. However, the interaction of spider color x background was significant, reflecting the differences in patterns of male responses. Overall, results suggest that for male wolf spiders, intensity of chromatic contrast affects detection. For interceptive eavesdroppers, toads were presented with a dorsal perspective of a courting male wolf spider against leaf litter backgrounds. We found that latency of visual detection of a courting male stimulus by toads (indicated by a head tilt or orient response) varied significantly with background. Predator detection latency was longest for control males against a natural colored leaf-litter background compared to a simple grayscale or RGB mono background. These results suggest that courting male wolf spiders that contrast with background are at higher risk of predation by visually acute toads. Importantly, males must balance conspicuous courtship behaviors and visual contrast with the background, which may influence detection by social and/or interceptive eavesdroppers.

Habitat exploration, preference and memory in scorpions (*Heterometrus spinifer*: Scorpionidae)

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In a dynamic and complex environment, natural habitats provide many elements for animals to interact with. For captive-born scorpions (*Heterometrus spinifer*) in a controlled environment, we examined how they select between environmental features. We specifically addressed the questions: 1) do scorpions show a preference between surface textures; 2) do they show preference for environmental complexity; and 3) are they able to remember tactile cues associated with those preferences? Using a video-tracking system, three consecutive trials were conducted. Trial one provided choices between smooth and rough paper (texture choice). The second trial introduced stones solely

on the smooth paper, to test if complexity was favored over texture. The final trial was a return to the simplified smooth and rough paper, but run following a 1-hour waiting period, to test memory. We compared exploration of environment in distance traveled, ambulatory time, number of visits (onto each offered substrate), and, as a measure of preference, resting time spent in each particular region. The first trial showed a marked preference for the rough substrate. Stone introduction shifted this preference, with increased resting time on smooth paper between the stones. Once the stones were removed and the scorpions reintroduced, the number of visits to smooth increased, suggesting a memory and search response for the preferred habitat feature.

Male orbweavers change cryptic sperm removal strategies based on female mating status gleaned from web-based cues

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Males of the orbweaver *Tetragnatha elongata* exhibit an ability to distinguish between virgin and non-virgin females. Recent work has shown that males use web-based pheromonal cues to determine female mating history. Here we examine whether males also change their cryptic sperm removal strategies based on web-borne cues. We examine both the pedipalp insertion frequency and duration as well as the amount of sperm removed during mating. The preliminary analysis of pedipalp insertion frequency, duration, and inflation rate indicate that the web-borne cues alter male mating behavior. We are currently analyzing sperm counts to determine whether it also alters male behavior such that more cryptic sperm removal behavior occurs for virgin females on webs with cues that indicate nonvirgin status. This would indicate that physical markers, such as the presence of rival sperm, are not the only trigger of cryptic sperm removal behavior.

Optimal duration of hard copulation in *Argiope aurantia*

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The duration of copulation is one of the most variable reproductive traits across spiders, ranging from seconds to hours. Some species, for example in the araneid genus *Argiope*, exhibit very short copulations of a few seconds per insertion. This has been hypothesized to be result of cannibalistic females imposing selection on males to escape the attack by reducing insertion duration. However, copulation duration is positively correlated with the number of sperm transferred and fertilization success in many species. Thus, given the tradeoff between sperm transfer and the risk of being cannibalized, males may optimize the duration of copulation to maximize lifetime reproductive success. Here we test whether male *Argiope aurantia*, which face a female attack in 80% of insertions, are optimizing the duration of the insertion of the first pedipalp to maximize the number of sperm transferred during all achieved insertions with potentially cannibalistic, post-molt females. As covariates in our analysis we include male and female somatic and genitalic traits, which had previously been shown to be important for sperm transfer. Indeed, we found an optimal insertion duration of 4s, which was close to the average of 3.3s. Further, male size was positively and conductor length negatively related to sperm transfer, confirming the importance of male body size and genital trait dimensions. Thus, we found evidence for the adaptive significance of very short copulations during "hard copulations" (with post-molt females), but the relevance of copulation duration remains to be tested in the context of "soft copulations" (with females while molting).

The sensory equipment of a sandokanid: an extreme case of tarsal reduction in harvestmen (Arachnida, Opiliones, *Laniatores*) *

Gainett, Guilherme, Prashant P. Sharma, Gonzalo Giribet and Rodrigo H. Willemart
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The sensory structures of arachnids are usually concentrated on the pedipalps or on the distal podomere (tarsus) of the anterior walking legs, the latter being the case for armored harvestmen (Opiliones, Laniatores). Therefore, modifications on the tarsus could have direct impacts on their sensory equipment. Using scanning electron

microscopy, we investigated the sensory equipment of the harvestman *Sandokan truncatus* (Sandokanidae), whose tarsi is reduced to a single tarsomere in all pairs of legs. Tarsomeres of all legs are equipped with gustatory sensilla, mechanoreceptors and a pore organ, but wall-pored olfactory sensilla are restricted to tarsi I and II. Tarsi II present a higher density of olfactory sensilla and also putative campaniform sensilla (strain detectors), which indicates a special sensory function of this pair of legs. Other leg segments are covered with shelled sensilla, a probable chemoreceptor previously unreported in Opiliones. Overall, *S. truncatus* has types of sensilla largely comparable to harvestmen with a longer and segmented tarsi. However, *S. truncatus* also exhibits extra-tarsal sensory fields of putative thermo-/hygroreceptors, and unique pore organs. Our results establish a basis for further research investigating the natural history, as well as the evolutionary correlations and causes of the tarsal reduction in this enigmatic lineage.

Post-glacial expansion of the black-clawed scorpion, *Anuroctonus phaiodactylus* (Scorpiones: Chactidae)
Graham, Matthew R, Haley Grimason and Jeff R. Jaeger
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The black-clawed scorpion, *Anuroctonus phaiodactylus*, is an arid-adapted arachnid distributed throughout the Mojave and Great Basin deserts of the western United States. Northern areas of the Great Basin were not desert-like during Pleistocene glacial periods, whereas much of the Mojave Desert remained warm and dry. Did desert scorpions like *A. phaiodactylus* persist throughout the Great Basin during the cooler and wetter glacial periods? Or did they colonize northern regions as climates warmed during the Holocene? According to phylogeographic theory, areas recently colonized by dispersal-limited taxa like scorpions should be less genetically diverse than their source populations. We collected *A. phaiodactylus* from throughout the species' range and sequenced mitochondrial DNA (COI) from leg tissues. Phylogeographic analyses of the DNA data indicate that populations are much more diverse in the Mojave Desert, consistent with our hypothesis of recent northward expansion in the Great Basin. This result is contrary to patterns from co-occurring vertebrate taxa, suggesting that the Great Basin is home to a remarkably young desert fauna.

Anti-adhesion traits related to foraging behavior in a spider hunting wasp: preliminary results
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Chalybion californicum, known also as the blue mud dauber wasp, provisions its nests with web-building spiders collected using aggressive mimicry. The wasp lands in the web and feigns entanglement to draw the spider closer, a behavior which is not observed in other, closely related spider hunting wasps. While this strategy may entail close contact with viscid capture silk, this wasp does not appear hindered in its ability to leave the web after contacting it. This ongoing research is investigating the novelty of this behavior by testing the hypothesis that *C. californicum* adheres to viscid silk less strongly than other, similarly sized wasp species. This is being done by testing the strength of adhesion of various wasp surfaces (tarsi, tibias, wings, and abdomens) to viscid capture silk, and comparing these results between species. Differences in the ability to escape from spider webs between these species are also being measured by recording the amount of time it takes each wasp to free itself from entanglement in an orb web. The morphological or chemical basis for any differences in adhesion is also being investigated. Scanning electron microscopy has revealed that *C. californicum* tarsi have the same qualitative features as those of the closely related *Sceliphron caementarium*, another spider hunting wasp, suggesting that morphological traits are unlikely to explain the novelty of web landing behavior in *C. californicum*. Preliminary adhesion and escape time data of various wasp species are presented. Future tests, such as applying washing treatments to *C. californicum* legs to test for a chemical basis for anti-adhesion, are also described.

Mechanical properties of spider silk enriched with carbon nanomaterials
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Description: cleardot
The dragline silk of spiders is of particular interest to science due to its unique properties that make it an exceptional biomaterial that has both high tensile strength and elasticity. Spider silk is comprised of a combination of amino acids that form α-helix chains and β-sheet nanocrystals that according to their alignment can form a natural polymer that rivals even the toughest man-made materials such as Kevlar. In an effort to improve these natural fibers, researchers have begun to try infusing metals and carbon nanomaterials that have the potential to improve mechanical properties and other aspects such as conductivity of spider silk. In this study, we fed solutions containing graphene and carbon nanotube particles to an orb-weaving spider, *Nephila pilipes*, with the objective that these materials would then be incorporated into their dragline silk. *N. pilipes* is a large orb-weaving spider common throughout S.E. Asia and are known to have some of the toughest silk of web-spinning spiders. Adult females were collected from the field and in the lab were fed 250 μL of solution over a period of five days, which resulted in each spider receiving 2.5 mg of either graphene or carbon nanotubes. Single strands of major ampullate silk were collected by manually silking each spider and were then tested using a UTM Micro Bionix tensile tester to determine the ultimate strength, extensibility, toughness and Young's modulus for pre- and post-treatment silk samples. We also utilized methods including atomic force microscopy (AFM), X-ray diffraction (XRD) and high-performance liquid chromatography (HPLC) to confirm the presence of nanomaterials in the silk samples and how they may influence the nanostructures of the silk.

Effects of autotomy on locomotion, prey capture, and predator avoidance in *Pholcus phalangioides*
Khowpinitchai, Benyapa, Todd Levine, Kerri Wrinn and Gary Gerald
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Many spider species are able to autotomize a leg to avoid being captured by a predator or to escape being trapped in a molt. The cellar spider *Pholcus phalangioides* is a species that frequently autotomizes, but does not regrow limbs. We explored the effects of autotomy of either a first or fourth limb on the behavior of cellar spiders. Specifically, we examined effects of leg loss on vertical locomotion, web construction, prey capture, and response to simulated predator attacks. Marginally significant differences among leg autotomy treatments were observed ($0.05<p<0.1$) in vertical locomotion and web building studies. Autotomy of a front leg negatively impacted vertical locomotion, whereas loss of a fourth leg increased silk release. Therefore, impacts of leg loss may be tied to specific uses of each leg. For example, first legs may pull the spider up during vertical locomotion, while fourth legs may regulate silk release. Losing a fourth leg may be costly if spiders are unable to compensate for this loss and release excess silk as a result.

High-resolution histological preparation of Araneomorphae and Mygalomorphae chelicerae using a modified petrographic technique
Laudier, Damien
Laudier Histology

Producing quality histological preparations of spider chelicerae with articulated fangs and cheliceral teeth is exceptionally challenging, if not impossible, using conventional histology techniques. Typically, these structures are examined with topographic or radiographic imaging methods, such as scanning electron microcopy (SEM) and micro computed tomography (mIcro-CT). While both are very useful tools for morphological analysis, they're not capable of revealing the fine tissue structure and cellular details, that a histological section viewed under light microscopy can provide. This study describes a modified petrographic/hard tissue histology technique to prepare high-resolution histology sections, for qualitative and quantitative assessment of both cheliceral soft tissue and fang microstructure.

Spider genomics: Role of protein-coding variation in spinneret diversity *
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Changes in gene expression underlie phenotypic differences across multiple levels of biological organization. Genomic studies have detected adaptation in protein-coding regions, including transcription factors, and alterations in these factors that control gene expression are important part of phenotypic evolution. In this study, we investigated the presence/occurrence of rapid changes in the coding sequences of genes involved in spinnerets in a phylogenetic context in Araneae. We find one-to-one orthologous transcripts shared between species, amino-acid sequences of all orthologs are aligned and the alignments are back-translated into DNA. Next, the ratio of synonymous to non-synonymous substitutions, are used to measure the evolutionary rates by maximum likelihood and detect proteins undergoing adaptation. We correlate the rates of evolution of sequences by coding morphological spinnerets characters and we test the role of coding regulatory variations in the emergence of different morphologies. Publicly available genomic and transcriptomic data of 300 samples of Araneae will be compared in this phylogenetic framework, allowing the investigation of genes with evidence of selection and/or correlated with patterns of diversity. We present preliminary results of correlations between the morphological traits and the rates of evolution of a selected subset of coding sequences tested using the multivariate phylogenetic latent liability model.

Distribution of *Brachypelma vagans*, the red-rump tarantula, and implications for its conservation

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1 El Colegio de la Frontera Sur, Chetumal, Mexico: 2 University of Toulouse, France: 3 Eastern Michigan University

Brachypelma spiders include around 20 species that are not only one of the most beautiful spiders but also one of the most endangered. *Brachypelma vagans*, the red-rump tarantula, is considered widely distributed in Mexico from the north of Veracruz state to the south including Chiapas, and covering a large part of the Yucatán Peninsula, while the northern Yucatán Peninsula is occupied by *Brachypelma epicurianum*. *Brachypelma vagans* was also observed in Belize towards Costa Rica where another species, *Brachypelma albopilosum*, is also described. *Brachypelma vagans* has an exceptionally large geographical distribution compared to other *Brachypelma* species. This tarantula was also observed invading new regions as reported for Florida, and Cozumel Island. We propose to modeled the potential worldwide distribution of *B. vagans* and determine what climatic and environmental variables are the most important to define its ability to establish in a new area. We developed a database of locations of *B. vagans* based on information available in the current literature and personal observations. We used MaxEnt and 19 bioclimatic variables from WorldClim dataset to model the distribution of *B. vagans*. Results showed a high potential for dispersion of *B. vagans* principally in Mexico (all the Yucatan Peninsula and Gulf of Mexico coasts), and Belize. Also, results suggest the possibility of invasion in Cuba, and other worldwide tropical regions. The principal variable to explain the potential distribution is temperature and more specifically isothermality (quantifies how large the day-to-night temperatures oscillate relative to the summer-to-winter (annual) oscillations). Although, potential distribution for *B. vagans* suggests a high capacity to invade new regions, we have observed a decrease in many local populations suggesting a sensitivity to sudden population collapse. In addition, based on the conservation state of this tarantula, these results should be considered with caution because this species faces threats due to extreme climatic events and human activities.

The evolution of visual signals with relation to daily activity patterns in the wolf spider genus, *Schizocosa*

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Effective communication requires the transmission of signals from signalers to receivers through the signaling environment. Therefore, the signaling environment is expected to play an important role in the evolution of signals. Since visual signals are likely to be more salient during the day than at night, we examined the daily activity patterns of *Schizocosa* wolf spiders with reference to the visual signals used in their courtship. Courtship displays within the genus *Schizocosa* vary widely in the use and type of visual signals, even between closely related species. Males of all *Schizocosa* species produce species specific substrate borne vibrations, while some species also incorporate movements of the body and legs as visual signals in their courtship displays. Among these species, male secondary sexual characteristics often include ornamentation of the first pair of legs, including varying degrees of pigmentation or the addition of brushes. We examine a selection of diurnal, crepuscular and nocturnal

species across the genus, representing varying degrees of visual signaling and ornamentation.

Prey capture by the striped bark scorpion, *Centruroides vittatus* (Scorpiones: Buthidae) in blackbrush habitat of South Texas.
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The effect of the size of the scorpion, microhabitat used for foraging and seasonal changes in availability of prey on prey capture for the striped bark scorpions, *Centruroides vittatus* will be considered. This study was in blackbrush habitat on the Campus of Texas A&M International University, Laredo, Texas. Scorpions were observed using an ultraviolet light, and data were collected on the size classes of *C. vittatus*, microhabitat used, height of scorpion on vegetation, number of prey captured and prey taxa. The data collection was for 10 years. The largest scorpions (size class IV) capture a higher proportion of orthopterans and intraguild prey and next size class (size class III) of scorpion capture a high proportion of caterpillars. Caterpillars were captured at a high frequency in January-April, and a high proportion of orthopterans and intraguild prey were captured during September-December. For all size classes of scorpions, high proportion of scorpions were captured in blackbrush acacia and very few scorpions had prey on the ground. Scorpions with caterpillar prey were higher in the vegetation and with orthopteran or intraguild prey were lower. The size class III scorpions are perhaps more active foraging in blackbrush for caterpillars especially early in the year, but all size scorpions will capture caterpillars in blackbrush. The low frequency of scorpions on the ground with prey suggest that scorpions will climb with prey captured on the ground. The scorpion with prey such as caterpillars captured in vegetation such as blackbrush will remain in vegetation to feed.

Courtship investment and male mate choice differences between lab-reared and field-reared male *Schizocosa ocreata* (Hentz): a summary
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The courtship behavior of the brush-legged wolf spider, *Schizocosa ocreata* (Hentz), has been studied in-depth under laboratory conditions by utilizing live-animal encounters and cue-isolated procedures (both natural and artificial). However, some field studies have presented results which contradict those obtained from lab studies or have shown evidence of male spiders exhibiting novel behaviors in natural environments - such as eavesdropping during courtship. Recent work has also shown that female spiders raised and tested under laboratory conditions can develop different mate preferences after repeated exposure to mature males. This evident influence of experience and environment on *S. ocreata* mating behavior leads to questions regarding what other differences may exist between spiders raised in isolated laboratory conditions and spiders raised under field conditions. The work presented here is a summary of previous and recently collected data investigating male mate choice (exhibited as modification of courtship investment) in field and lab-reared males under different contexts. When presented with cues from females representing a range of potential fitness benefits, in a no-choice cue-isolated design, field-reared males showed a higher degree of mate selectivity than their lab-reared counterparts. Conversely, in a live-mating encounter, field males showed no preference for female state – mirrored by a lack of preference from their matched females – while lab-reared males preferred to court virgin females and courted these at a higher intensity than mated females. These results highlight the possibility of further differences between populations and the potential for greater plasticity in this system, while also providing a basis for future research into the ecological context and benefits of these differences.

Preliminary visual comparison of silk structure, composition, and organization
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The varieties of spider silk structure and organization are astounding. Although spider silk has been the subject of intense study, many types have yet to be characterized. One such type is the silk black widow spiders, and their close kin, produce during defensive encounters (defensive silk). The small amount of research that has been done

suggests that this silk has unique chemical and physical properties. Here we present preliminary data comparing the defensive silk produced by *Latrodectus hesperus* with the gumfooted line silk produced by this same species, and the sticky spiral silk produced by orb weaving spiders. To compare the silk, we collected each silk type and, using light microscopy, we compared the structure and organization of unaltered silk, silk soaked in water, silk stained with Coomasie R-250, and silk stained for glycoproteins. We also include a discussion of spinneret behavior during the production of defensive silk. Our results suggest that defensive silk has a different internal structure than both gum footed line and orb weaver silk. Similar to gum footed lines, defensive silk lacks the granular cores that are present in the sticky spiral silk of orb webs. The defensive silk is able to be stained by the Coomassie R-250, where this procedure disrupts the organization of gumfooted lines and sticky spiral lines. Glycoprotein staining is ongoing and will be presented. Taken together the uniqueness of defensive silk merits a more detailed chemical, physical, and ecological investigation.

Are whip spiders metal heads? A study of elemental enrichment in Amblypygi *

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The arthropod cuticle consists of lipids, proteins and chitin, which come together to form a complex and multilayered exoskeleton. In recent years, the arachnid exoskeleton has been the subject of many detailed studies, some of which have focused on the presence of metals that are hypothesized to reinforce the cuticle in select regions that function in locomotion, predation and defense. Here, we follow these studies of cuticle metallization with a focus on whip spiders (Order Amblypygi), which have been shown to possess a remarkable cerotegument, but have yet to be studied for the presence of metals. We use energy dispersive x-ray spectroscopy to determine the elemental composition of the chelicerae, pedipalps (tibiae, tarsi), and walking leg tarsi (claws) in three species from different habitats and geographical locations: *Charon cf. grayi*, *Damon diadema*, and *Phrynus marginemaculatus*. Our results so far reveal the presence of alkaline earth metals (Ca), transition metals (Zn), and metalloids (Si) in portions of these appendages. We think that with further studies, we can begin to appreciate how metal enrichment reinforces the skeleton of whip spiders and permits them to remain light-weight, agile predators, and yet very delicate in appearance.

Feed or fight: does the presence of multiple prey items decrease prey-sharing in juvenile tarantulas (*Heterothele villosella*)?

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Prey-sharing is not uncommon while juvenile tarantulas are still in the maternal retreat, but generally ends when the young disperse. Previous work with lab-reared *Heterothele villosella* has shown that this behavior persists past when the spiderlings are able to hunt for themselves and would permanently leave their natal retreat. Other spider species have been shown to participate in prey-sharing more often when prey is larger or harder to handle but monopolize prey when it can be subdued and consumed by a single individual. In the previous work with *H. villosella*, all groups were offered a single, cricket larger than any one group member. This study sought to determine if prey-sharing would still occur when tarantulas were presented with multiple small prey items that could be easily captured and consumed by a single spider. Groups of four, third-instar *H. villosella* (n=80) were presented with one of two prey choices: either a single cricket or four crickets. Regardless of prey number, all prey was in the same size class. All groups were given both prey options, but order of which was given first was random, with a week separating the feedings. Variables recorded were capture latency, presence of cooperative capture or feeding, and presence of agonistic interactions over prey. Results were analyzed using a two-way mixed ANOVA.

Tainted love: female orbweavers touched by males (without sperm transfer) are treated as nonvirgins due to web-based pheromones *

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Males with the ability to detect female mating history may gain advantages such as using behavioral means to increase their paternity in the presence of rivals. In the orbweaver *Tetragnatha elongata*, males that can detect female mating history can change their behavior and remove rival sperm from the female reproductive tract. Here we tested whether males use contact pheromones or web-based pheromones to determine female mating status. To measure male assessment of female mating status, we recorded the number of cryptic sperm removal strategies employed by males which are used when mating with nonvirgin females. To examine the presence of contact pheromones, we placed virgin females on webs spun by females who had been touched (but not mated by) rival males and vice versa. We found that males treated touched females the same as virgins, so there is no evidence for a contact pheromone. However, males treated virgin females as nonvirgins if they were placed on the webs of females who had been previously touched by a male. Females touched by males (but without receiving sperm) appear to change the chemical composition of their webs in a way that is detectable to males. We explain the advantages to females of signaling their mating status to males and suggest the possible fitness advantages may accrue to males who use web-based pheromones to determine female mating status.

Environmental changes and locomotory activity in juvenile tarantulas (*Grammastola pulchripes*)

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Tarantulas are sit-and-wait predators that remain in close proximity to their retreats and many live their entire lives in close association with this retreat. Retreats are lined with web and can be closed to provide protection and moderate effects of the microclimate. Because of this presumed stability, we wondered how a constantly changing environment might affect behavior. Specifically, we examined locomotory activity among juvenile tarantulas in response to environmental changes. We hypothesized that individuals exposed to a dynamic environment would display increased activity levels. Initially, all juvenile tarantulas were housed in similar individual containers. We obtained baseline data on their activity in an arena using video-tracking equipment and recorded total distance moved as well as distance travelled at the periphery (i.e., close to the arena wall which is considered region of neophobia) versus in the center of the arena (> 1.5 body lengths away from the arena wall). Individuals were then separated into three groups group with varying changes to their home container environments: Group 1 experienced substrate changes only, Group 2 experienced no changes, and Group 3 was moved between dynamic environments every 3-months. Additional locomotory trials were run after 3- and 6-months. We compared movement among the groups and within the different regions of the arena. All groups travelled significantly longer distances in the arena periphery in all of trials, however there were no differences among groups. Between the baseline and 3-month trial there was a slight decrease in overall movement suggesting familiarity with the arena. Surprisingly, in the last trial, many individuals showed increased movement and there was also more individual variation in movement across the groups. Thus, results do not show a clear effect of environment on locomotory activity; however, there are clear individual differences and age may also play a role.

Survey of autotomy and its effects on web building and prey capture of *Argiope trifasciata* in goldenrod fields

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Eisiner and Camazine (1983) found that *Argiope trifasciata* were more likely to survive injection with insect venom if they quickly autotomized the affected leg. Members of this species frequently build webs in patches of goldenrod during late August-September in southern Wisconsin. These spiders often encounter stinging insects in these “pollinator heavy” areas, so I predicted that frequency of leg autotomy for this species would be high. Although autotomy provides an immediate survival benefit, it has been known to have longer-term consequences. To study this, I surveyed the frequency of leg autotomy and regeneration in adult female *Argiope trifasciata* in and around

goldenrod patches. I also measured individual body and web size and prey captured for intact spiders and those with autotomized or regenerating legs. I found that 36% (20 out 55) of the spiders observed were either missing a leg (13) and/or showed signs of past autotomy via a partially regenerated leg (8). Size (cephalothorax width) was similar across all three groups of spiders, however, presence of prey in the web and web size did differ between groups. Although spiders that were regenerating a leg were found more often in smaller webs, they were also more likely to be found with evidence of recently captured prey compared to those that were intact or missing leg(s). It is possible that adult spiders that have a partially regenerated leg must compensate in some way to deal with the challenges of having a shorter appendage on one side. Further surveys to increase the sample size of studied spiders will help to parse out the effects of autotomizing and regenerating a leg in this species.

A comparison of egg diameter and number in fertilized and unfertilized egg sacs of an orbweaver

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Investigating whether female orb-weavers invest more resources into fertilized egg sacs versus unfertilized eggs that are “dumped” prior to mating is vital to understanding reproductive behavior in arachnids. We collected *Tetragnatha elongata* from the Rouge River in SE Michigan and reared them to adulthood. We first allowed females to lay an egg sac (unfertilized). Within one day of egg laying the female was then mated to a male and subsequent fertilized egg sacs were collected. After mating, females took between 7-14 days to lay an egg sac. Each egg sac was carefully dissected to measure the diameter of the eggs and count the total number of eggs within each sac. Eggs within sacs that were collected after females were mated were found to have a significantly larger diameter than eggs from unfertilized egg sacs. Although there was a significant difference in egg diameter, we observed no significant difference in egg number per egg sac between fertilized and unfertilized egg sacs. This result suggest that females may use the time between mating and laying subsequent egg sacs to invest in higher egg quality and put more care into fertilized egg sacs.