



American Arachnological Society  
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# The American Arachnological Society

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hosts

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### Poster Presentation Abstracts

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Abstracts listed in alphabetical order by last name of presenter

**Cladistic analysis of Macroibunidae new rank and revision of Macroibuninae (Arachnida: Araneae).**

**Almeida-Silva** (1,2) LM, CE Griswold1 & AD Brescovit (3)

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Macrobuninae Petrunkevitch are revised and submitted to a cladistic analysis. Macrobuninae, once considered the biggest subfamily of Amaurobiidae Thorell is now shown to be only distantly related to Amaurobiinae, the "true amaurobiids". Our matrix, composed by 82 terminal taxa and 107 characters, includes representatives of all Macrobuninae genera and new taxa we believed to be part of Macrobuninae. As out-groups, we include representatives of the families Agelenidae Koch, Amaurobiidae, Amphinectidae Forster & Wilton, Chummidae Jocqué, Desidae Pocock, Dictynidae O. P.-Cambridge, Phyxelididae Lehtinen, Stiphidiidae Dalmas, Tengellidae Dahl, Titanocidae Lehtinen, Zorocratidae Dahl and Zoropsidae Bertkau, which were suggested as related to Macrobuninae by previous studies. Our main result confirms Macrobuninae as not forming a monophyletic group with Amaurobiidae and shows the need to erect Macrobunidae Petrunkevitch, 1928 new rank to include Macrobuninae and relatives. Three other subfamilies are proposed here: Retirinae subfam. nov., Pakehinae subfam. nov. and Zanomyinae Ubick, 2005 new rank. Chummidae, currently composed by one genus and two species, are considered a junior-synonym of Macrobunidae. Newly delimited Amaurobiidae appear as sister group of the "Oval Calamistrum Clade" and the "Fused Paracribellar clade". The subfamily Macrobuninae is revised at the generic-level and delimited to include a total of 26 genera, thirteen newly described and thirteen already known. Eight genera are removed from Macrobuninae and assigned to other subfamilies and/or families.

### **Faunistic inventories of Araneomorphae (Arachnida: Araneae) in Mexico: A comparative approach**

**Alvarez-Padilla F**, U Gracilazo-Cruz, & FA Rivera-Quiroz

Universidad Nacional Autónoma de México, Facultad de Ciencias, Departamento de Biología Comparada, Laboratorio de Aracnología, México

The Order Araneae has approximately 45,000 described species, most of which are included in Araneomorphae, and this number is estimated to represent between one-half to one-fifth of the total. The spider fauna of tropical and subtropical regions has been poorly studied and is expected to contain most of the new species. In Mexico about 2,000 species have been recorded in various catalogs, but this represents only a fraction of the total due to the lack of biological inventories. Also, the few published faunistic studies do not allow comparisons between areas. The main problems for these comparisons are: the high number of unidentified specimens, species determination without voucher specimens to assess identification accuracy, and the difficulty to access this information. This presentation discusses the use of several tools available on the Internet that allow comparisons of voucher specimens determined to both species level or only as spp and a detailed description of these species, including an extensive image dataset that complements the publication and provides easy access to this information. We use as examples two inventories of Araneomorphae in a tropical forest of San Luis Potosi and an oak forest in Veracruz. Finally, species estimation richness for these forests is also presented.

### **\*\*Homogeneous structure of glue-droplet explains the superior adhesive performance of spider silk**

**Amarpuri (1) G**, V Chaurasia (2), D Jain (1), TA Blackledge (3), & A Dhinojwala(1)

1. Department of Polymer Science, The University of Akron, Akron, OH; . 2. Department of Mechanical Engineering, The University of Akron, Akron, OH; 3. Department of Biology, Integrated Bioscience Program, The University of Akron, Akron, OH

Modern orb-web spiders use micron-sized viscid silk glue droplets to capture and retain prey. The major components of the glue include proteins and low molecular weight organic salts. The combination of salts and proteins makes the glue a viscoelastic and humidity responsive adhesive. However, the macro-structure arrangement of these components in the glue droplet and its role in glue adhesion is not well understood. Here, we construct a spatial map of the chemical components in the glue droplet, before and after immobilization, using

confocal Raman spectroscopy. Both salts and proteins were detected in similar proportion throughout the glue droplet. This finding is in contrast to the present paradigm where proteins are confined to the core region and salts are only present in the peripheral region of the glue droplet. Based on presented evidence, a new model of glue droplet structure is proposed. The new model explains the superior prey-capture performance of spider orb-webs.

### **The response of *Schizocosa ocreata* to volatile cues of an intraguild predator, *Tigrosa helluo***

**Bell (1) R & JA Roberts (2)**

1. Department of Evolution, Ecology, and Organismal Biology, The Ohio State University, Columbus, OH; 2. Department of Evolution, Ecology, and Organismal Biology, The Ohio State University at Newark, Newark, OH

The ability to perceive and respond to airborne chemicals has the potential to impact the behavior of an individual in ecologically important ways. Olfaction of volatile chemicals may aid in finding potential mates, in the case of conspecifics cues, or in finding a meal in the case of cues from potential prey. Additionally, volatile cues from potential predators in the environment may be detected, providing information about the presence and location of that predator. Avoidance of volatile predator cues has been demonstrated in other spiders, including Lycosidae. In this study we examined the ability of the wolf spider *Schizocosa ocreata* to detect and respond to volatile cues emanating from *Tigrosa helluo*.

### **Spider phylogenomics: Reevaluating the history of Earth's most diverse predator lineage and the origin of the orb web**

**Bond (1)JE, NL Garrison (1), CA Hamilton (1), RL Godwin (1), M Hedin (2), I Agnarsson (3)**

1. Department of Biological Sciences and Auburn University Museum of Natural History, Auburn University, Auburn, AL; 2. Department of Biology, San Diego State University, San Diego, CA; 3. University of Vermont, Department of Biology, Burlington, VT

Spiders represent an ancient predatory lineage known for their extraordinary biomaterials, including venoms and silks. These adaptations make spiders key arthropod predators in most terrestrial ecosystems. Despite ecological, biomedical, and biomaterial importance, relationships among major spider lineages remain unresolved or poorly supported. Current working hypotheses for a spider “backbone” phylogeny are largely based on morphological evidence, as most molecular markers currently employed are generally inadequate for resolving deeper level relationships. We present here the first phylogenomic analysis – based on transcriptome data comprising 327 loci – of spider relationships that includes taxa representing all major spider lineages. Our robust phylogenetic hypothesis recovers some fundamental and uncontroversial spider clades, but also shows some rather surprising results that may prove controversial. These results may compel a fundamental shift in our view of spider phylogeny that will likely have broad implications for interpreting the evolution of spiders, their remarkable biomaterials, and a key extended phenotype—the spider web.

### **Do wolf spiders orient and navigate using magnetic cues?**

**Brady M & M Persons**

Biology Department, Susquehanna University, Selinsgrove PA

Geomagnetic detection and navigation is a taxonomically widespread phenomenon among animals but has not been

studied in spiders. We tested and compared changes in adult male and female orientation and movement in the wolf spider *Tigrosa helluo* in response to changes in magnetic fields. To test for magnetic detection and orientation, a 20 cm circular arena was placed inside a Helmholtz coil, which allowed magnetic north in the arena to be manipulated for each experimental trial. Using a magnetic field approximately five times stronger than Earth's (2.7 Gs), we recorded locomotory patterns and directional headings under four experimental conditions for each spider: 1) no magnetic field manipulation (negative control), 2) magnetic field north but Helmholtz-field induced (positive control), 3) magnetic field east, and 4) magnetic field west. Using digital tracking software, we recorded spider directional orientation twice per minute over a 50-minute period. Males showed a significant non-random directional heading within each treatment and the mean vector heading significantly differed with the field, but the spider's heading was not congruent with the magnetic field orientation. Males also moved significantly further and more frequently in the negative control compared to treatments with a Helmholtz-induced field. Females showed no significant directional orientation within treatments or between treatments. Females also showed no significant difference in activity between treatments. Our results suggest that males, but not females, use magnetic fields for directional orientation, but males likely integrate geomagnetic information with other directional cues.

### **Changes in spider communities following wildfire in northern New Mexico**

**Brantley (1) SL & M Ward (2)**

1. Museum of Southwestern Biology, University of New Mexico, Albuquerque, NM; 2. Valles Caldera National Preserve, Jemez Springs, NM

The western United States is experiencing severe wildfires due to drought and large areas of over-dense forests as a legacy of past fire suppression. In June 2011 a catastrophic wildfire occurred in north-central New Mexico, affecting a large part of the Valles Caldera National Preserve. Although there were no pre-fire data, pitfall trapping began immediately after the fire in mountain grassland and mixed-conifer habitats to monitor the recovery of ground arthropods, including spiders. Traps were placed in 6 burned and 6 unburned sites per habitat in July and collected every 2-3 weeks through early November. In 2012 samples were collected between mid-May and early November. There were 72 spider species in mountain grassland and 65 in mixed-conifer, with a large Bray-Curtis dissimilarity value (94.04), although the two habitats are close together spatially. Dominant species in mountain grassland were *Pardosa distincta*, *P. concinna*, and *Grammonota gentilis*; and in mixed-conifer were *P. uncata*, *Cicurina spp.*, *Gnaphosa muscorum*. *Haplodrassus signifer* was important in both. MDS ordination revealed that species in mountain grassland were returning to pre-burn conditions more quickly than in mixed-conifer. Permanova results were significant for the effects of the burn and year at mountain grassland, but were significant only for the burn at mixed-conifer, not for year, suggesting that a year's time was not sufficient for the spider community in the burned area to have changed much. Continued drought conditions will increase wildfire risk in this region and likely delay species recovery in previously burned areas.

### **Biomechanical diversity of reproductive structures in leiobunine harvestmen is continuous rather than clustered suggesting combined effects of female choice and intersexual conflict**

**Burns MM & JW Shultz**

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Reproductive traits have a long history as taxonomic characters, but their precise functions and the evolutionary processes underlying their diversification are not well understood. Many researchers attribute diversity in reproductive structures to the mutually-exclusive action of sexual selection by female choice and intersexual conflict and predict that species can be categorized into choice- and conflict-dominated groups. Other workers contend that the two mechanisms act simultaneously to different degrees and anticipate a continuous spectrum of

species ranging from high-conflict, low-choice at one extreme and low-conflict, high-choice at the other. We assessed these predictions through multivariate analyses of biomechanical reproductive variables from 29 harvestman species. We found that linear discriminant and clustering analyses could not partition biomechanical diversity into two or more statistically significant groups but that canonical correlation and principal components analyses organized diversity into continuous and essentially linear distributions. These results corroborated the hypothesis that female choice and intersexual conflict act simultaneously with differing intensities to generate a continuous spectrum of reproductive forms.

**\*\**De novo* assembly, characterization and comparative analysis of entelegyne spider transcriptomes (Araneae: Entelegynae)**

**Carlson D & M Hedin**

Department of Biology, San Diego State University, San Diego CA

The entelegyne spiders are a species-rich and interesting group of araneomorphs, however the evolution of this clade at a genome-wide scale is only beginning to be studied. In order to better understand entelegyne molecular evolution, transcriptomes—i.e., the set of RNA sequences transcribed from DNA prior to protein synthesis in a particular tissue and lifestage—were sequenced and assembled *de novo* from six species representing three genera (*Nesticus*, *Cicurina* and *Habronattus*) that span much of the diversity of the Entelegynae. This congeneric sampling strategy enabled the identification and comparison of evolutionary trends at multiple hierarchical levels. The contents of each transcriptome were characterized to assess the overall quality and completeness of each assembly. In addition, the gene contents of each transcriptome were investigated through functional annotation, and novel sequences representing putative lineage-specific orphan genes were discovered. In order to elucidate the broad patterns of genomic evolution across entelegyne spiders, approximately 3,400 orthologous sequences present in the transcriptomes of all six taxa were identified. Utilizing these orthologs, patterns of molecular divergence were explored and variation in the types of selection acting at different loci and in different lineages has been estimated with pairwise dN/dS ratios in a phylogenetic framework. The results from these analyses increase our understanding of the evolution of the entelegyne spiders and the forces that have shaped their diversification.

**Cellular changes associated with tubuliform silk production in the Western black widow spider, *Latrodectus Hesperus***

**Casem ML, E Herrera, & W Ouriel**

Department of Biological Science, California State University Fullerton, Fullerton CA USA

Tubuliform glands are responsible for the synthesis of the silk fibers used to surround and protect a spider's egg mass. Unlike other silk glands, tubuliform glands cycle their protein synthetic and secretory activity in parallel with the reproductive stage of the spider. For the black widow spider this means that the cells responsible for the synthesis of egg case silk must go through multiple rounds of activation and inactivation since individual spiders are capable of producing multiple egg cases during their life time. The cycle of accumulation and depletion of egg case silk proteins causes the tubuliform glands to undergo dramatic changes in size. At a cellular level, the silk secreting epithelial cells that make up these glands also go through significant alterations of their ultrastructure associated with reproductive activity of the spider. Initiation of silk synthesis, linked to the progression of vitellogenesis, results in the stimulation of the synthesis of ribosomes and an increase in membranous compartments in the cell. The secretory vesicles responsible for the transport of the nascent silk proteins out of the cell are not obvious. Instead, electron lucent granules can be observed within the cell and lumen coincident with the accumulation of luminal silk product. Tubuliform glands return to their pre-vitellogenic size following production of an egg case. The cells of a "post-egg case" gland appear to use the process of autophagy to recover and return to

a pre-vitellogenic state in advance of the next round of reproduction.

**\*\*The conspicuous marking of a nocturnal wandering spider attracts flying prey**

**Chang C-C**, C-C Huang, H-L Chen, K-y Chen

Department of Life Science, Tunghai University, Taichung, Taiwan

In many diurnal hunters, the body coloration may be served as a lure for prey. However, certain nocturnal insects have been shown to use color vision to search for food resource during night time. Some nocturnal spiders, such as orb weaving *Neoscona* and wandering *Heteropoda* have conspicuous markings on their bodies. The conspicuous markings of certain nocturnal orb web spiders have been shown to serve as a visual lure to prey, but the function of the equivalent traits in wandering spiders remains unclear. In this study, we tested whether the conspicuous markings of nocturnal wandering spiders also function to visually lure prey. *Heteropoda venatoria* dummies were made and categorized into control group (with a narrow white strip on clypeus) and experimental group (without a narrow white stripe on clypeus). Infrared video cameras were used in the field to monitor prey's responses to two types of dummies. The prey attraction rate of the control group was significantly higher than that of the experimental group with flying insects as the major prey attracted. Such result suggests that the conspicuous marking may function to attract flying insects for nocturnal wandering hunters. In the near future we will use living *H. venatoria* to perform a further test of the hypothesis.

**\*\*Can BAF index reflect biodiversity of landscape mosaics in coastal areas? A case study using spiders as indicators**

**Chang S-T**

Department of Life Science, National Chung Hsing University, Taiwan

Biotope area factor (BAF) is a commonly used methodology while evaluating the ecological effectiveness of urban areas. However, this traditional method only considers the land use surface types of the landscape mosaics using aerial photos and expert questionnaire method. It is not clear whether the ecological effectiveness of areas estimated by BAF system is congruent with the actual ecological characteristics and diversity of inhabiting organisms. In this study, the practicality of the BAF systems is evaluated by comparing the BAF values of landscape mosaics located in four coastal areas in central Taiwan with the vegetation structure and spider diversity data collected in situ. We first determined the BAF values of various landscape homogenous units in these coastal areas by expert questionnaire method using aerial photos. Then sampling plots were established in these homogenous units to systematically survey vegetation structure and spider diversity. The results showed that the vegetation structure and spider diversity of sampling plots were not congruent with the designated BAF values of the homogenous unit in which the sampling plots were located. Such result indicates that a new generation of weighting system is needed to realistically and precisely designate the ecological effectiveness of landscape mosaic units.

**\*\*Contesting territories: Asymmetric resource value and assessment strategies in a whip spider**

**Chapin KJ**

Department of Ecology & Evolutionary Biology, University of California, Los Angeles



Whip spider agonistic interactions are highly ritualized, stereotyped, and well-studied relative to other areas of their biology, but the function and assessment strategies of these interactions is unresolved. I hypothesized that whip spider agonism has evolved to dispute territories and that interactions and their outcome fit mutual-assessment models. I staged paired trials of territory holders and considered the effect of residency on contest duration. Results show that the whip spider *P. longipes* is territorial, exhibits asymmetric resource value, and uses self-assessment strategies to make contest decisions. While counterintuitive given the complex behavioral repertoire and neurobiology of whip spiders, self-assessment is strongly supported. Body condition and pedipalp display duration were the best predictors of contest outcome. Size symmetric contests lasted much longer and escalated to aggressive physical contact more often than size asymmetric contests. I conclude with future directions of integrating across-site comparisons and genetic data to achieve a deeper understanding of whip spider behavioral variation.

### **Risky courtship behavior of the male wolf spider, *Schizocosa ocreata***

**Clark (1) DL, A Karson<sup>1</sup>, & GW Uetz (2)**

1. Dept. of Biology, Alma College, Alma, MI; 2. Dept. of Biological Sciences, University of Cincinnati, Cincinnati, OH

It is well documented that female preferences can select for male traits. However, males must balance the risk of detection by potential predators against reproductive success based on these female preferences. Male wolf spiders (*Schizocosa ocreata*) actively search the leaf litter by walking about and then initiating courtship behavior when chemical cues or the sight of a female is detected. During this search process, males may place themselves at risk of detection by visually hunting predators. For this study, we used video playback to simulate male wolf spiders walking vs. actively courting in the leaf litter to determine which behavior was riskier in terms of predator detection and attack probability. American toads (*Bufo americanus*) a common leaf litter predator of spiders, were shown two versions of a male spider stimulus against a digitized natural leaf litter background; 1) a courting male; and 2) a walking male. We found that both latency to visual detection (visual orientation response), and latency to attack were significantly longer for a walking male compared to a courting male stimulus. Results support the hypothesis that the active courtship behavior of male *S. ocreata* may place males at higher risk of predation than other less conspicuous behaviors.

### **Seasonal and nocturnal behavior patterns of the Brown Recluse spider (*Loxosceles reclusa*: Araneae, Sicariidae), with notes on feeding**

**Cramer KL**

Department of Biology, Monmouth College, Monmouth, IL

I recorded nocturnal and seasonal behavioral patterns of the brown recluse spider, *Loxosceles reclusa* (Gertsch and Mulaik, 1940) in a synanthropic population in northwestern Illinois. Recluses are sit-and-wait predators that spend 80-90% of their nocturnal activity sitting motionless on a small network of silk they use as "trip lines" for prey detection. Time not spent in wait for prey is largely occupied maintaining the web by laying down new strands of silk. Feeding and sexual behavior constitute a minute, but obviously critical, portion of daily activity. Recluses became active in May and retreated to winter refugia in late October. Recluses typically seek a retreat during the day, but there were no consistent times of peak activity during their nocturnal perambulations. An exceptionally sedentary species, they occupy the same small area of less than 30 cm in diameter for days or even weeks at a time. The most common prey items in this population were isopods and other spiders, with beetles and crickets

comprising the majority of the remainder. Dead crickets offered experimentally were ignored or not found the majority of the time, particularly when placed > 1 m from a sedentary spider, suggesting (in addition to earlier studies) that recluses do not typically scavenge in a natural setting. Mating attempts were observed May-July, and sexual behavior was similar to that reported in earlier laboratory studies. Future research with individually marked spiders should elucidate more accurate information on their sporadic movement and dispersal.

### **Phylogeny of the nursery web spider family Pisauridae (Araneae: Lycosoidea)**

**Cruz da Silva EL & P Sierwald**

Division of Insects, Field Museum of Natural History, Chicago, IL

The phylogenetic relationships among the Pisauridae genera are analyzed using morphological and behavioral characters. The outgroup is composed by the families: Tengellidae, Zoropsidae, Senoculidae, Lycosidae and Trechaleidae. The analysis is based on a matrix containing 76 terminal taxa. The terminals were scored for 115 morphological and eight behavioral characters. An analysis using equal weights including all characters was performed using the program T.N.T. and resulted in 10 most parsimonious trees (L = 941 steps, Ci = 19, Ri = 56). In all trees, Pisauridae arouse as a monophyletic group. Pisauridae always appeared as sister to Trechaleidae, whereas Senoculidae appear to be closely related to the Lycosidae in this dataset. Several expected and unexpected clades appear consistently: a group formed by *Hala+Tolma+Voraptipus+Hygropoda* emerges as sister-group of all remaining pisaurids. The *Dolomedes*-group is formed by the worldwide distributed genus *Dolomedes*, and the endemic genera *Eucamptopus* (India), *Bradystichus* (New Caledonia) and *Megadolomedes* (Australia). Pisaurinae was also found as a monophyletic group, corroborating the results found by Sierwald (1997). A monophyletic group formed by the Neotropical genera: *Architis*, *Tinus* and *Thaumasia*, corroborates the results found in a previous study. Surprising is the clade composed of *Papakula+Pisaurina+Nilus*, with an Ethiopian and Oriental distribution in *Nilus* (formerly *Thalassius*), and *Pisaurina*, which is endemic to the Nearctic region. Also a clade comprising most of the pisaurid web builders form a monophyletic group containing the genera *Tapinothele*, *Shedanus*, *Caripetella*, *Walrencea*, *Dendrolycosa*, *Euprosthenops* and *Euprosthenopsis*.

### **\*\*Species tree inference, genetic species delimitation, and species descriptions in the *Sitalcina sura* species group (Opiliones, Laniatores, Phalangodidae)**

**DiDomenico A & M Hedin**

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The western United States is home to numerous endemic harvestmen (Arachnida, Opiliones), including members of the genus *Sitalcina*. Prior to this study, very limited genetic data was available for *Sitalcina* species and previous phylogenetic studies focused only on broad relationships within the genus, not on closely related species. Genetic data are well suited for testing species limits in the *Sitalcina sura* group because these dispersal-limited arachnids show minimal gene flow between morphologically conserved populations, resulting in possible cryptic speciation. Here, molecular phylogenetic and species delimitation analyses were conducted for all species in the *S. sura* group, plus several newly discovered populations. Species trees were reconstructed using multispecies coalescent-based methods implemented in \*BEAST. Species delimitation was accomplished using the program BP&P, as well as Bayes Factor Delimitation. Genetic analyses using DNA sequence data from seven genes delimit 13 species in the *S. sura* group, adding four new species. New species were formally described using a combination of molecules and morphology. Molecular phylogenetic evidence revealed distinctive desert versus coastal clades. Conservation may be an important issue for several species within the *S. sura* group given their restricted endemic distributions, and

defining operational taxonomic units provides a foundation for future conservation efforts.

### **What's up with dwarf males?**

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Some of the most extreme sexual size dimorphism (SSD) in all animals is found in the spider families Thomisidae and Araneidae. Males can be less than half the size of females and many times lighter. While this phenomenon has received considerable attention for many years, the explanation(s) for its evolution remains uncertain. Factors implicated have included habitat characteristics, life history traits and mating systems. The crab spiders *Misumenoides formosipes* and *Misumena vatia* exhibit the greatest SSD in the family and are also the best studied with respect to their behavioral ecology. I will highlight the similarities and differences between these two species and explore whether this knowledge clarifies or muddies the waters of extreme SSD.

### **\*\*Molecular systematics, historical biogeography, and paedomorphic character evolution in the harvestmen genus *Calicina***

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The California Floristic Province is a well-known hotspot for biodiversity, containing more endemic species of plants and animals than any North American region of comparable size. This astounding diversity is a reflection of the complex geologic history of the region, which has shaped the evolutionary and biogeographic histories of the biota in the region. The harvestmen genus *Calicina* is represented by 25 species, which occupy a disjunct distribution in the Sierra Nevada and Coast Ranges of California. Several species in the genus exhibit extensive variation in morphology, which is hypothesized to be correlated with differences in habitat. My thesis research focuses on the systematics of *Calicina*, with an emphasis on inferring patterns of historical biogeography and morphological evolution. These questions are addressed using a multilocus molecular phylogenetic approach, which will provide the framework for divergence time estimation, ancestral range reconstruction, and analyses of morphological character evolution and its association with environmental variables. This study is the first to use molecular data to infer the interspecific relationships within *Calicina*, and will provide insight into the role of geological and environmental processes in shaping patterns of distribution and morphological change.

### **\*\*Investigating the relationship between immune defense and secondary sexual characteristics in *Schizocosa ocreata* wolf spider**

**Gilbert R**, C Combs, & GW Uetz

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Ground-active wolf spiders must combat constant exposure to soil-dwelling parasites and pathogens, as well as the potential for exposure from food and water sources. As a consequence, these spiders have developed an effective innate immune system. The encapsulation response has been shown to be a good measure of immune function in spiders and other invertebrates, since the amount of melanization which forms around a parasite or pathogen can be

quantified. In this study, we evaluate the viability of this method in examining the impact of bacterial infection on a terrestrial wolf spider species, *Schizocosa ocreata*. This species has energetically-costly multimodal courtship, which has been shown previously to be negatively impacted by bacterial infection as a juvenile. We found that males who had been previously exposed to a bacterial pathogen *Pseudomonas aeruginosa* in the laboratory as juveniles had significantly higher adult immune function than those who had not been previously exposed to a pathogen. In addition, adult tuft size (secondary sexual character) was significantly correlated with adult immune function within males who had not been previously exposed to a pathogen. We also found that energetically costly courtship behavior significantly reduced male immune response, and that males with relatively larger tufts are better able to sustain an immune response after courtship. This supports the assumption that secondary sex characters enforce signal honesty by being good indicators of overall male health.

**\*\*Spacing of juvenile spiders in subsocial webs of *Anelosimus studiosus* (Araneae: Theridiidae) in relation to the presence or absence of an adult female**

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The subsocial spider *Anelosimus studiosus* is known for an extended period of brood care, during which mothers and their offspring cooperate to maintain the web and capture prey. Previous studies have shown, however, that the mother's presence significantly enhances juvenile survivorship and growth. Recent research suggests that the mother in these colonies acts as an organizational center, with the juveniles clustering around her, and that this enhances the foraging efficiency of the colony. The absence, or death, of the mother results in increased dispersion of the juveniles. Here we hypothesize that intentional removal of the mothers will lead to juvenile dispersal and that her replacement, or the presence of another adult female, would again act as an organizing center for the juveniles. To test this, three studies were conducted. First, adult females were removed from established colonies and the position of offspring was recorded every two hours over a 24 hour period. The spiders were left for two days during which their position was recorded once per day. Following this period the mother was replaced and the position of the spiders in the colony was once again monitored over a 24 hour cycle. In the second experiment, the reactions of a colony consisting of a female and her offspring were observed after the introduction of an unrelated female taken from a similar colony. Finally, we conducted an analysis of the distribution of distances among colonies in the field to determine the distance juveniles would have to travel if dispersing to find another colony.

**High stakes species delimitation in blind cave spiders from Texas (*Cicurina*, F. Dictynidae)**

**Hedin M**

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Systematists often argue that species delimitation hypotheses are fundamentally important for all biologists, i.e., "we need to know what the species are". However, at least for spiders, many original delimitation hypotheses are based on limited data, and most original delimitation hypotheses have never been subsequently tested using new data, analyses, etc. The project described here focuses on *Cicurina wartoni*, a blind cave spider species from central Texas. This species, described from a single adult female, is known only from a single, minute cave on the western edge of Austin. For several reasons, the spider population in this cave is imperiled, making it critical that we understand whether the spider population in this cave represents a unique species. To this end, DNA sequence data for one mitochondrial gene and eight rapidly-evolving nuclear genes was gathered and analyzed for ~ 40 specimens from a comprehensive sample of 27 regional caves. Variation in genitalic morphology was also assessed for adult specimens from the same sample, including previously unknown adult males. These multiple lines of evidence, including explicit tests for speciation, fail to support the evolutionary distinctiveness of *C. wartoni*. Although species status is not supported in this instance, this study illustrates the importance of modern systematics in

conservation biology.

### **Stressing out! The effects of stress on biogenic amine levels in female wolf spiders**

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Biogenic amines are implicated in mediating the stress response in invertebrates, yet the influence of environmental stress on biogenic amine production remains unclear. In this study, we explored the effects of acute stress (combining dehydration, restraint, and handling stress) on biogenic amine levels in the hemolymph of female wolf spiders, *Schizocosa ocreata* (Araneae; Lycosidae). We tested hemolymph from high-stress individuals that were restrained in small vials and forcibly dehydrated (using chemical desiccant) and compared it to hemolymph drawn from low-stress (mild handling stress only) females. The levels of biogenic amines in the hemolymph were measured using high performance liquid chromatography with electrochemical detection (HPLC-ECD). Stressed females had elevated octopamine levels, while hemolymph levels of serotonin, dopamine, and epinephrine were significantly higher in the low-stress females. This study demonstrates that severe stress alters circulating biogenic amine levels in spiders and provides a basis to further understand hormone influence on behavioral and physiological responses of stressed spiders.

### **\*\*Structural based blue appearance in tarantulas**

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Photonic crystals are periodic nanostructures that interact with electromagnetic waves, and can be found in nature not only in gems but also in living organisms, where they create so-called “structural colors”. These colors are usually iridescent and account for almost all of the blue hues found in animals. However, most research on structural colors has focused on bird plumage or butterfly wings, and collectively suggest that coherent light scattering by ordered photonic crystals is the main mechanism that results in iridescent structural colors. Here, we describe the proximate mechanisms responsible for blue color in several tarantula species. The reflectance spectra measured from single hairs from the tarantulas show that the blue hairs have peaks around 400~450 nm, while non-colored hairs do not. SEM images demonstrate that blue hairs have smoother surface morphologies while non-blue hairs are spiky. TEM images of the hairs’ cross sections present obvious multilayer nanostructure in the blue hairs of *Lampropelma*. Fourier transform analysis of these images show different degrees of periodicity, while images from non-blue hairs are amorphous and lack periodicity. A model based on the observed multilayer structure predicts a reflectance spectrum that closely matches our measurements. This study will help us understand if chitin-based structures in spiders evolve convergently with keratin/melanin-based structures in vertebrates, if they may serve some functions other than signaling and could contribute to creating biomimetic photonic crystal fabrication processes or products.

### **Can BAF values reflect ecological effectiveness of urban landscapes? A case study on university campuses in central Taiwan**

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Currently, how to apply ecological concepts in landscape design to enhance biodiversity in urban areas has become an important issue worldwide. One of the popularly adopted strategies is the development of systems to estimate ecological effectiveness of various landscape mosaics. Biotope area factor (BAF) is a commonly used methodology but it only considers the land use surface types of the landscape mosaic unit using aerial photos and expert questionnaire method. It is not clear whether the ecological effectiveness of areas estimated by BAF system is congruent with the actual ecological characteristics and diversity of inhabiting organisms. In this study, the practicality of the BAF systems is evaluated by comparing the BAF values of homogenous units in eight urban university campuses in central Taiwan with ecological and biodiversity data collected in situ. The results showed that BAF values of various homogenous units were partially correlated with certain vegetation structure, but were considerably incongruent with in situ diversity of various flora and fauna. Such results indicate that current way of quantifying ecological effectiveness of urban areas might not be appropriate. We suggest that in future studies the operation scale should be adjusted and factors influencing biodiversity should be considered in the weighting system to realistically and precisely designate the ecological effectiveness of landscape mosaic units.

### **Tracking the eyes of jumping spiders: A window into perception**

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Eyetracking technology has made it possible to understand how humans perceive their world by examining how the eyes move across a visual image. However, use of this powerful tool has been limited to only a handful of non-human species. The movable, spatially acute principal eyes of jumping spiders are ideal candidates for eyetracking. Each principal eye has a tiny retina positioned at the proximal end of a muscularized tube inside the spider's cephalothorax. That tube can move and direct the retinas at different areas of the visual field. Our eyetracker captures the reflection of IR light from the retinas of tethered spiders while they explore high-resolution video images. We describe these eye movements and how they differ from that of humans, confirming and expanding upon Michael Land's observations of 40 years ago. We present data on how spiders attend to different types of images. We also use eye-masking experiments to demonstrate how the motion-detecting anterior lateral eyes, which share a field of view with the principal eyes, guide the principal eyes in following targets. Our work provides an intriguing example of how an animal with limited neural processing power is able to efficiently gather and integrate information from multiple sense organs within a single modality.

### **Estimation of females' visual and seismic experience with courting males during the pre-mating period in *Schizocosa ocreata* (Araneae: Lycosidae)**

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It has recently been shown in laboratory settings that mating behavior in female *Schizocosa ocreata* is affected by their experience with courting males prior to the females becoming sexually receptive. It is therefore important to know how much experience with males females would have in natural settings, but direct measurement of female experience in the field is impractical. We therefore used the wealth of information available for this species to inform a spatially explicit agent-based model developed in the Netlogo programming environment. The model incorporates data on: 1) observed densities of males and females, 2) visual and seismic sensory ranges, 3)

movement patterns of spiders, and 4) distribution of male 'quality'. We modeled a five day period when females are mature yet reticent to mate, recording how many males the females had contact with seismically and visually, as well as the mean and variance of male quality they experienced. We also conducted a sensitivity analysis for various parameters. The data from this model can be used to interpret, and make predictions about, mating behavior with regard to sexual selection theory.

### **\*\*Brown recluse spider's nanometer scale ribbons of stiff, extensible silk**

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Spider silk, a protein-derived polymer with the strength of steel, has tremendous potential to inspire the next generation of engineering and biomedical devices. The silk of orb-weaving spiders has served as the model for silk studies to date, as the cylindrical, fibrillar silk strands that constitute the archetypal orb web possess tremendous mechanical properties and are relatively simple to extract. Alternatively, the cobweb silk from the Brown Recluse spider features a ribbon-like morphology unlike that of any other spider silk or synthetically spun polymer fiber. We report extraction of this fiber under controlled conditions and a first structural and mechanical analysis. The Recluse ribbons are essentially free-standing polymer films with a thickness of 40–80 nm, corresponding to only a few molecular layers of protein. This extreme thinness allows the fiber-films to conform tightly to substrates of varying topography. Furthermore, the thinness and flatness of the silk makes it ideal for study by atomic force microscopy (AFM), which revealed a fibrillar surface structure (similar to that of orb-weaving silk) dotted by 6–8 nm protrusions, or “nanopapillae”, hitherto unobserved on the surface of any other silk. We carried out a stress–strain analysis of individual fibers by indenting them with a blunted AFM probe, yielding a stiffness of  $20 \pm 6$  GPa and a maximum extensibility of 25–30%. These values assert that Brown Recluse silk possesses mechanical properties equivalent to or even surpassing those of orb-weaving silks, while simultaneously exhibiting the thinness and flexibility of a free-standing thin film.

### **\*\*Cognitive cross-modal integration in a wolf spider, *Schizocosa ocreata***

**Kozak EC & GW Uetz**

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Cross-modal integration, i.e., cognitive binding of information transmitted in more than one sensory signal mode, is important in animal communication, especially when the courtship signals of one animal occur simultaneously with others. In order to choose the best possible mate, females must be able to accurately perceive and assess male signals in a variety of sensory modalities and determine signal location. Males of the Brush-Legged Wolf Spider *Schizocosa ocreata* use multimodal communication (visual and vibratory/seismic signals) in courtship. Due to the complexity of the environment, signals of individual males may be perceived by females in the form of single sensory modes. Because females may be courted by multiple males at the same time, they must evaluate co-occurring male signals originating from separate locations. We used digital multimodal playback to investigate the effect of spatial disparity of visual and vibratory components of male courtship signals on female mate choice. Females were presented with male courtship signals with components that varied in spatial location (0°, 45°, 90°, 180° separation between modes). Females responded to spatially disparate signal components separated by  $\geq 90^\circ$  as though they were separate individuals, but responded to slightly disparate signals separated by  $\leq 45^\circ$  as though they originated from a single individual. These findings, to our knowledge the first for an invertebrate animal model, are consistent with those seen in both humans and other vertebrates, and provide insight into how animals overcome communication challenges inherent in a complex environment.

## **\*\*Spider brain morphology and behavior**

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Although the relationship between behavior and the brain is well studied in insects, the brains of only a few of the some 40,000 spider species have been described and comparative studies of spider brain morphology are limited in scope. The current project uses a novel histological technique that allows for the rapid processing and imaging of whole spider cephalothoraxes. This approach improves our ability to accurately measure brain regions and places the brain within the context of other tissues, giving a more holistic view of spider neuromorphology. Species sampled from across the Araneae show striking variation in general brain morphology and the size of different brain regions. By using a large number of species and mapping variation in brain morphology onto a phylogenetic tree, this study adds to the knowledge of the evolution of spider brains. Using a carefully selected subset of these study species, we examined the correlations between behavior, sensory system morphology and the brain in order to develop hypotheses about where different types of information are processed in the spider brain.

## **Spigot Ontogeny in *Tengella perfuga*: preliminary mapping results towards a comparative assessment of silk production in cribellate spiders**

**Mallis R**

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Mapping the spigots of adult spiders has been proven as a useful tool in constructing morphological phylogenies of spiders. Few studies have examined the ontogeny of spigots within a comparative phylogenetic framework, and that is what we intend to do with this dataset as well as that of other cribellate spiders. Each instar of *Tengella perfuga*, a cribellate lycosoid, was prepared for SEM imaging and images were taken of each spinneret and the cribellum. Spigots and tartipores will be mapped and the timing of appearances or disappearances of spigots, as well as differences between the sexes will be recorded. Here I present some preliminary maps of young instars and adult spiders and discuss the approach I will take to examine trends in spigot ontogeny in cribellate spiders.

## **\*\*A new behavioral assay for testing scorpion light sensitivity and its relationship to fluorescence**

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Scorpions display the mysterious property of fluorescing green under ultraviolet light. Several hypotheses have been proposed, but the function of the fluorescence remains enigmatic. One challenge is the inefficiency of current behavioral tests of scorpion sensitivity to light levels and hues. Scorpion eyes appear to have peak physiological sensitivity to green and ultraviolet light; photosensitive elements in their tails are sensitive to green light. We created a Y-maze choice chamber to quickly assay the effect of these wavelengths on scorpion behavior. In a darkened room, a plunger pushed scorpions along the stem of the maze; each animal could then choose to move toward a certain wavelength of light in one arm of the maze or toward darkness in the other arm. In preliminary tests, when both arms of the Y-maze were dark, scorpion movements were not different from random. However, scorpions moved toward the arm with white, green, or UV light more often than they moved toward darkness. When given a choice between darkness and blue light, a wavelength to which they are not physiologically sensitive, their movements were again not different from random. These early results are in line with physiological response profiles of light sensitivity in scorpion eyes. Furthermore, our new test greatly increases the efficiency of our



behavioral trials and allows us to test scorpions under light levels similar to what they encounter during their normal nighttime movements.

### **The effect of diet associated cues of *Pardosa milvina* (Araneae: Lycosidae) on the activity of *Sinella curviseta* (Collembola: Entomobryidae) in the laboratory**

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Detection of predator cues is an anti-predator adaption that helps prey to avoid risk of predation. Not much work has been done on the effect of diet associated cues of spiders on *Sinella curviseta*. We hypothesized that this collembolan would alter their behavior in the presence of chemotactile cues from the wolf spider, *Pardosa milvina*. We monitored the activity of *Sinella* in three sets of divided arenas: (1) with cues from *Pardosa* fed banded crickets, *Grylloides sigillatus*, (Orthoptera: Gryllidae) opposed to no cues, (2) with cues from *Pardosa* fed *Sinella* opposed to no cues and (3) cues from *Pardosa* fed *Sinella* opposed to cues from *Pardosa* fed crickets. *Sinella* spent more time and travelled further on the side with *Pardosa* cues regardless of the predator's diet. More food, organic matter, in the form of predator cues, feces, silk, might have attracted it to spend more time on that side. There were no differences in activity when the cues from predators on different diets were presented together however when we compare trials with where cues from *Pardosa* on different diets were presented with no cues, we found evidence that *Sinella* reduced their overall activity when cues from a predator that had consumed its conspecifics were present. The animal does not show differential activity on diet associated predator cues in paired arena but at least it behaves differently in separate arenas and reduction of activity on predator cues fed on *Sinella* might be an adaptation to avoid the predator.

### **Reexamining the suspension bridge mechanism of an orb-web's viscous threads**

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The viscous prey capture spiral of araneoid orb-webs is formed of small aqueous droplets, each with a glycoprotein glue core. This viscoelastic glue combines with the thread's elastic axial lines to form an effective adhesive delivery system, which sums the adhesion of multiple droplets and has been termed a "suspension bridge mechanism" (SBM). In this study we further test this hypothesis using the configurations of loaded threads and the distributions of forces on the extended droplet filaments to characterize the performance of *Argiope aurantia*, *Neoscona crucifera*, and *Verrucosa arenata* threads. This approach relies on engineering principles and was facilitated by our ability to film thread sectors as they are pulled from a surface. Like the main cable of a suspension bridge, the axial lines of loaded viscous threads assumed the configuration of a parabola. Using the diameters of thread axial lines, their Young's modulus of elasticity, and their deflections, we computed the forces on loaded viscous threads. Next, we used a formula describing the forces on suspension bridge cables to determine the force on each of a thread's extended droplet filaments. This showed that, as modeled by Opell and Hendricks (2009), force on droplet filaments decreased progressively from outer to inner droplets. However, rather than each droplet contributing 70% of the adhesion of the adjacent outer droplet, we found that it contributed 82% of the adhesion, showing the viscous thread's SBM to be more effective than previously thought.

### **The trichobothria and covering setae on the cuticle of ground spiders family Gnaphosidae**

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The previous study of the trichobothria on the legs and the covering setae on the body of ground spiders shows that these structures are genus specific (Forster, 1979, Ovtsharenko, 1983, 1985, 1989). Murphy (2007) points that setae are deserve a serious study. However, still now trichobothria and covering setae are universally neglected and their structure and diversity is little known. The study pursues the description of trichobothria and covering setae across the whole family Gnaphosidae to establish the relevant trichobothria and setae characteristics to ground spiders' systematics and phylogeny reconstruction. Scanning electron microscope imaging provides useful diagnostic characters for trichobothria and setae description and a further understanding of the relationships among gnaphosids. There are six major types of covering setae among gnaphosid spiders: squamose, plumose, lanceolate, pinnate, arborate, and sabre-shaped setae. Squamose setae are characteristic to *Anzacia*, *Micaria*, *Hypodrassodes*, *Herpyllus*, and *Nauheia* spiders. Plumose setae occur in genera *Berlandina*, *Nomisia*, *Minosiella* and *Pterotricha*. Genera *Apopyllus*, *Drassodes*, *Leptodrassus*, *Litopyllus*, *Parasyrisca*, *Sosticus*, and *Zimiromus* have lanceolate setae. Spiders of genus *Gnaphosa* have pinnate setae. *Fedotovia uzbekistanica* has arborate setae, *Aphantaulax* and *Poecilochroa* spiders have sabre-shaped setae. The study reveals the existence of different types of trichobothria and covering setae provides a set of characteristics important for classification and phylogenetic analysis of spiders family Gnaphosidae.

**\*\*Ontogeny of orb-web spiders' silk tailoring potential: do large spiders conserve silk diameters to optimally forage?**

**Piorkowski D & I-M Tso**

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Orb-webs built by spiders are designed to entrap large, rare prey where radial threads, composed of Major Ampullate silk (MAS), serve as the primary stopping component. MAS can be tailored to fit specific mechanical needs as it is drawn from the gland through the application of differential reeling forces. Many orb-web spiders exhibit dramatic changes in web architecture through ontogeny accompanied by probable changes in prey size and type, however, how material properties of MAS change is not fully resolved. We hypothesize that shifts in ecological niche through maturation are coupled with an alteration in silk tailoring potential that reduce effects of fiber-elongation on cross-sectional area during silk spinning. Here, we examine post-secretion plasticity of MAS across various levels of maturity in the giant wood spider, *Nephila pilipes*. We measure tensile properties of forcibly drawn MAS pulled at four separate reeling speeds and at supercontracted 'ground' state of juvenile and adult spiders. We also examine both: amino acid compositions to identify potential shifts in molecular profiles of MAS and orb-web structural parameters. Silk samples and web parameters were only collected from field-caught spiders whose diets were standardized and had built at least two complete webs while in captivity. As the tailoring process of MAS changes thread cross-sectional area, we speculate our results to illustrate larger spiders' silk to become stiffer than that of smaller spiders. This trade-off of tensile properties would conserve large diameters in bigger spiders to allow very large forces of very rare prey to be absorbed.

**\*\*Interactions in a tangled web: Competition between spider and carnivorous plant**

**Potts LJ**

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Competition is a global force influencing the structure of all levels of ecology. Studies of competition are cornerstones to furthering our knowledge of biodiversity maintenance. An often-overlooked facet of competition ecology is that of exploitative interactions for limited resources between plant and animal. Carnivorous plants and

arthropods are ideal organisms to compare competitive interactions due to their similar diet, mode of capture, and oftentimes close proximity. Answers of their influence on one another, and their ultimate coexistence mechanisms may provide unique insights. Here I investigate foraging decisions by a web-building spider (Linyphiinae) in response to presence of a carnivorous plant (*Drosera*). Results did not support the claim that these species experienced exploitative competition, however there are several mechanisms discussed. I suggest further sampling and studies of this system in order to adequately examine each of these hypotheses, and answer how these species coexist. This line of research will not only promote our understanding of competitive interactions between plant and animal, but also the structure of communities and ultimately species biodiversity.

**Environmental impact on the development of personality in a wolf spider, *Tigrosa helluo* (Araneae, Lycosidae)**

**Rypstra (1) AL & HF Voris (2)**

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The importance of personality in understanding spider behavior has been well established but comparatively less attention has been focused on the environmental factors that might shape individual differences. We maintained juvenile *Tigrosa helluo* in four distinct habitats for three months starting just after they completed their third molt. The environments included small containers with no structure, large containers with no structure, large containers with structural complexity and large simple containers where they provided a variety of prey types. We then ran each individual through a battery of tests monitoring overall activity, exploratory behavior, prey capture behavior and foraging success. There were consistent differences among spiders reared in the four environments. Animals in small simple containers were slow to move, quick to strike at prey, but not very successful. Animals in larger simple containers did some exploring but were slow to strike and capture prey and not very successful. Animals in large complex containers were quick to move but didn't explore much. In addition they were slow to strike at prey but highly successful. Animals provided a variety of prey moved a lot and were likely to strike at prey multiple times but were not all that successful. In a follow up experiment, we reared sets of five juveniles in large aquaria with complex structure, and provided them with a variety of prey. In these environments all four personality types emerged. These experiments verify that the rearing environment impacts the behavior of spiders and the development of personality.

**\*\*Abiotic microhabitat parameters of the spruce-fir moss spider, *Microhexura montivaga* Crosby and Bishop 1925 (Araneae: Dipluridae)**

**Seaborn T & K Catley**

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The spruce-fir moss spider (*Microhexura montivaga*) is a federally endangered species of spider found only in the high-elevation Southern Appalachian spruce-fir forests and confined to North-facing slopes underneath moss mats. Despite this fact, little is known about some of the basic ecology of the spider, more specifically the characteristics of the habitat found underneath the moss mats. The goal of this project was for the first time to determine the temperature and humidity parameters of this microhabitat around known spider locations. iButton temperature and humidity data loggers placed at Mt. Lyn-Lowry, Browning Knob, Whitetop Mountain and Mt. Rogers (a range that encompasses all metapopulations). No statistically significant differences in humidity or temperature data between positive and negative presence sites, among metapopulations, or individual sites were found. This research provides a number of applications for the conservation and management of *M. montivaga*, such as understanding metapopulation health and variation, better husbandry techniques, and using collected data to determine conversion factors for temperature data between microhabitat measurements and larger scale measuring methods, such as weather stations. For example, HOBO data loggers mounted in trees measured maximum daily temperature that were higher and lower daily temperatures that were lower compared to microhabitat measurements. This allows for

large scale monitoring to be done without having to actually measure the temperatures underneath the moss mats. It is hoped that this research, along with the continuing work of U.S. Fish and Wildlife Service, will contribute to a much more positive outlook for this endangered species.

### **Interactions between metamorphic frogs and spider predators: exploring an understudied aspect of amphibian life history**

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Predation is an important selection pressure that shapes the evolution of prey behavior. Prey species with complex life histories are particularly interesting, as individuals may experience distinct predator assemblages over the course of ontogeny. Amphibians undergo metamorphosis, though relatively little is known about their interactions with predators during their terrestrial stage, despite evidence that juveniles have low survival when dispersing. We quantified interactions between co-occurring metamorphic Blanchard's cricket frogs (*Acris blanchardi*) and the wolf spider *Tigrosa helluo*. Tadpoles were raised in field mesocosms in the presence or absence of cues (i.e., kairomones) from predatory dragonfly nymphs (*Erythemis simplicicollis*) allowed to feed on conspecific tadpoles. After metamorphosis, frogs were placed into an arena that had been previously occupied by an adult female spider or into a previously unoccupied arena, and we recorded all interactions between frogs and spiders. We found no effect of predator cues from the larval (i.e., from dragonflies) or terrestrial (i.e., from spiders) environments on predator-prey interactions. The best model for explaining the likelihood of a frog being captured by a spider included an interaction between frog size and the frequency of jumps made by frogs. Specifically, larger frogs were more likely to survive a trial if they jumped often, whereas smaller frogs were more likely to survive if they jumped infrequently. Survival in post-metamorphic amphibians is an under-appreciated aspect of their life history, and it is particularly important to consider as both cricket frogs and amphibians in general are in decline.

### **\*\*UV-B irradiance does not influence the extensibility of orb-weaving spiders' adhesive, viscous droplets**

**Stellwagen SD** & BD Opell

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Orb-webs of many species are exposed to full sun during the day. As ultraviolet radiation is known to degrade many biological materials, this study examined the effect of the harshest form, Ultraviolet B (UV-B), on the viscous threads of orb webs. The tiny adhesive droplets of these threads each contain a core of viscoelastic glycoprotein glue covered by a transparent aqueous solution, making them potentially vulnerable to damage. We hypothesized that species which build their webs in open, sunny habitats (*Argiope aurantia*) produce droplets that are less susceptible to UV-B damage than those which build their webs in partially shaded (*Leucauge venusta* and *Verrucosa arenata*) or completely shaded (*Micrathena gracilis*) habitats. Viscous threads were collected early in the morning and exposed to five treatments in the laboratory: 0, 1, 2, 3, and 4 hours at a fluence rate of  $\sim 2.5$  W/m<sup>2</sup> (typical noon exposure) and 4 hours at an extreme fluence rate of  $\sim 7$  W/m<sup>2</sup>. We assessed the effect of UV-B exposure on viscous thread droplets by filming the extension of individual droplets that had adhered to a surface and computed the energy required to extend them, as gauged by the deflection of the axial line supporting the droplet and the duration of droplet extension under a load. We observed no significant differences in the energy required to extend droplets. These results do not support the hypothesis, suggesting that glycoprotein within droplets is either not susceptible to UV-B damage or is protected by compounds within the droplets' outer aqueous material.

### **\*\*The effects of sensory experience on unimodal and multimodal preferences in a wolf spider**

**Stoffer B & GW Uetz**

University of Cincinnati, Department of Biological Sciences

Females across a variety of taxa, including spiders, benefit from assessing male quality in multiple signal modalities. Each modality, however, may have unique transmission properties that may be impacted by variation in an animal's microhabitat. Consequently, females may have different 'sensory experiences' depending on the environment in which they live. We tested the effects of sensory experience on subsequent mate preferences in the wolf spider, *Schizocosa ocreata*. Males of this species use a combination of visual and vibratory signals as a multimodal signal. In nature though, both modalities may not transmit with equal efficacy due to the complex leaf litter habitat in which *S. ocreata* live. We used playback techniques to simulate varying sensory experiences, allowing penultimate females to be exposed to unimodal visual signals, unimodal vibratory signals, multimodal signals, or no signals at all. Upon maturation, we counted the number of receptivity displays towards each unimodal signal and a multimodal signal during three separate trials. Results demonstrate that sensory experience affects unimodal, but not multimodal, preferences. While *S. ocreata* typically weigh unimodal signals evenly, they preferred the 'familiar' unimodal signal (e.g., females exposed to vibratory signals were more receptive toward those signals). However, regardless of sensory treatment, females preferred multimodal signals to each unimodal signal.

**\*\*Comparative bioacoustics and morphology in wolf spiders and the potential for acoustic communication**

**Sweger AL & GW Uetz**

Department of Biological Sciences, University of Cincinnati

Vibration is a common modality for communication in insects and spiders, and a recent hypothesis suggests that acoustic communication is actually derived from an ancestral vibratory modality. Wolf spiders present a unique opportunity to investigate this question, as many species produce complex vibrations during courtship and mating, and at least one species also produces an airborne sound. Our previous work has shown that the substrate upon which these spiders create vibratory signals during courtship significantly contributes to the production of the airborne signal, suggesting a complex relationship between the vibration source and the substrate. Spiders possess a sensory capacity for vibration reception, but not airborne sound, which raises a series of questions regarding the production of airborne sound, as well as its potential adaptive value. We investigated courtship communication, both vibratory and airborne, across a range of several co-occurring wolf spider species relative to their varying morphology. Courtship vibrations were recorded using a Laser Doppler Vibrometer and airborne signals were recorded with an omni-directional microphone. Morphological measurements, including mass, size, and dimensions of sound-producing organs were then related to production of various signals. Using piezoelectric elements for vibratory playback, we then modeled the relationship between vibration and airborne sound, while manipulating source and substrate factors that could affect signal production. Our results suggest that vibratory and airborne signal production vary dramatically across species independent of size, and that dynamic factors of both vibratory source and the transmitting substrate impact the potential for airborne signal production.

**Evidence for effectiveness of bird dropping and twig masquerading in spiders**

**Tso I-M**

Department of Life Science, Tunghai University, Taiwan

Masquerading comes in various forms with the principal benefit being the avoidance of predators. In *Cyclosa ginnaga*, the body size, shape and color when viewed against its white web decoration resembles a bird dropping. In *Ariamnes cylindrogaster*, legs are protracted and clustered in parallel against their bodies when resting consequently making them look like twigs. We hypothesize that these spiders' body coloration interact with web decoration or body posture to form bird dropping and twig masquerade to protect them from predators. We

monitored predatory attacks upon *C. ginnaga* when the spider's body and/or its decorations were blackened via video cameras and found that predator attack probabilities were greater when only the decorations were blackened. We also monitored predatory attention upon dummies resembling *A. cylindrogaster* in appearance and color but with legs either spread or clustered via video cameras and found that the latter received significantly less attention from predators. Results from these field experiments indicate that masquerading exhibited by *C. ginnaga* and *A. cylindrogaster* as bird dropping and twig respectively can effectively reduce their predation risk.

### **Learning to eavesdrop? Experience and social eavesdropping in wolf spiders**

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We examined responses of field-collected and lab-reared male *Schizocosa ocreata* wolf spiders to playback of computer-animated male courtship behavior to test for eavesdropping and social facilitation. Males collected from the field exhibited behavior consistent with eavesdropping (i.e. increased courtship behaviors during and after video playback of a courting male stimulus), but spiders that matured in lab isolation (without exposure to behavior of adult conspecifics) did not. Choice tests with two video screens showed that males respond to video stimuli of courting male wolf spiders more often and for a longer time than to videos of walking males or an empty leaf litter background (no spider). However, field-collected males clearly discriminated male courtship from other behaviors, showing more and longer bouts of courtship in response to courting male stimuli, while lab-reared males did not. We tested whether males can learn to eavesdrop by associating courtship of other males with cues indicating female presence. Lab-reared (naïve) males were exposed to stimulus combination treatments (male videos with female silk, silk only, video only, empty arena, and no exposure) for three days and tested for eavesdropping on day four. Results confirm males learn to associate the visual courtship behavior of other males with the presence of chemical cues from female silk. Our findings suggest that social experience gained in the breeding season influences eavesdropping, enabling male wolf spiders to obtain information about the presence of females and the status of potential rivals.

### **Scorpion phobia vs. spider phobia in undergraduates at five American universities: consistent results across geography**

**Vetter (1) RS**, EF Pace-Schott (2), ML Draney (3), CA Brown (4), JT Trumble (1), DH Gouge (5) & NC Hinkle (6)  
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When the general public learns of our profession, arachnologists often are then regaled with stories of self-professed phobia to spiders. However, noticeably lacking from this same group is a professed fear of scorpions. One theory regarding the origins of animal phobias is that a successful survival strategy is to treat all members of a group (such as spiders or snakes) as dangerous even though only a small subset are potentially toxic to humans. However, worldwide, scorpions pose a much greater threat to human morbidity and mortality than do spiders. If an innate, primordial fear exists for arachnids, scorpions would be a better candidate taxon for such reaction. We ran a questionnaire at five universities over a wide geographic area in the United States (Tucson AZ, Riverside CA, Athens GA, Cookeville TN, Green Bay WI). Almost 900 students participated in the study. At the writing of this abstract, statistical analysis had not yet been done but from eyeballing the data, the following conclusions seem to be evident: 1) females had higher fear scores to both taxa than males, 2) scorpion fear scores were higher than spider scores at each university, 3) there were no apparent differences between the two universities at the extremes

of potential exposure (i.e., Arizona vs. Wisconsin). This might support an innate human fear response to scorpions, although there are other contributing factors such as habituation from exposure in Arizona as well as fear of novelty in Wisconsin.

**\*\*Ecological implications of diel rhythms of foraging and antipredator behavior in *Cyclosa turbinata* (Araneae: Araneidae)**

**Watts JC**, A Herring, S Normark, M Miller, & TC Jones  
Department of Biological Sciences, East Tennessee State University

Diel rhythms are ubiquitous components of behavior and physiology that presumably enable individuals to exploit periods of favorable environmental conditions, yet evidence of their ecological adaptiveness remains limited. As both predator and prey, spiders offer a unique opportunity to explore environmental fluctuations and behavioral trade-offs that might drive the evolution of adaptive behavioral rhythmicity. We developed a model system for assessing the “adaptive rhythm hypothesis” by (1) describing diel changes in foraging and antipredator behavior in an orb-weaving spider, *Cyclosa turbinata*, (2) testing for correlations between aggression towards prey and boldness towards predators (i.e. behavioral trade-offs), and (3) observing individuals in the field to estimate diel patterns of prey interception, prey capture, and predation. We found that *C. turbinata* forages at all times of day but is more likely to attack simulated prey during the night, when prey are most abundant. Interestingly, *C. turbinata* was also more likely to leave the web hub in response to simulated predators at night, perhaps reflecting the use of camouflage to avoid attack by diurnal visual predators. We found no evidence of an among-individual correlation between foraging aggression and the likelihood of leaving the web hub in response to a simulated predator attack, suggesting that any behavioral trade-offs influencing the evolution of behavioral rhythmicity likely arise from time-budget constraints. Moreover, field observations suggest that variability in prey interception and predator encounter rates may be important for understanding the adaptive value of diel rhythms of behavior in *C. turbinata*.

**Poster Presentation Abstracts**  
**(\*\*Student Competition Entry)**

**\*\*Courtship behavior in male wolf spiders given mixed chemical and physical messages**

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Many species utilize chemical signals to relay information to predators, prey, and conspecifics. In the wolf spider, *Pardosa milvina*, chemical cues can be used to locate and assess the quality of a potential mate. This study aimed to investigate the relationship between visual and chemical cues in male *Pardosa*'s courtship strategies. Female quality was manipulated by placing them on different feeding regimes such that they were either well fed or food limited. Male courtship, which includes leg raises and body shakes, was quantified on female chemical cues alone and after a female was released. We tested all combinations of well fed and food limited cues with well-fed and food limited females. In the presence of only chemical cues, males courted the same amount regardless of female status. When a female was released, males performed more leg raises when chemical cues from a well-fed female were present regardless of the status of the actual female. However, mating was much more likely to occur when a male was presented with a well fed female on matching cues. Interestingly, mating success was related to the frequency of body shakes performed by the male but not leg raises. These results suggest that males depend on the chemical cues in their initial attempts to attract a female. Mating success is likely the result of communication between the courting male and a receptive female and it may be that males receiving positive signals from females shift their courtship activities to emphasize body shakes.

### **\*\*Activity differences between coexisting *Pholcus* species**

**Campbell (1) LD & AL Rypstra (2)**

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As urbanization continues to change habitats, populations of many species are threatened. However, while some species decline, others become more successful and even become invasive. Thus, there is a need to determine which behaviors enable some species to cope successfully in the presence of human-induced changes and others to fail. The species *Pholcus manueli* (Araneae, Pholcidae) has recently expanded its range and appears to have displaced some populations of *Pholcus phalangioides* (Araneae, Pholcidae) in SW Ohio. In order to begin to understand the relationship between these two species, we quantified activity and exploratory behavioral differences between the recently invading spider and its close relative, *P. phalangioides*. The spiders were individually placed in novel habitats and recorded their activity for ten minutes. We found that *P. manueli* had more movement events and spent more time active and exploring the new habitat than did *P. phalangioides*. We also found that, although *P. manueli* spent more time moving, *P. phalangioides* deposited more silk per time spent moving. These results show that the invader, *P. manueli*, is more active than *P. phalangioides*. In addition, the time that *P. manueli* moved was mostly spent exploring the habitat whereas *P. phalangioides* began to establish itself by building a web. These results verify that there are fundamental behavioral differences between these congeners, which may influence the success of one species over another. Specifically, the exploratory activity of *P. manueli* may suggest that they have a high propensity to disperse and ultimately to colonize new habitats.

### **\*\*Division of labor between jumping spider eyes**

**Carey1 A, SM Long2, & EM Jakob3**

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Jumping spiders have moveable, spatially acute principal eyes that share a field of view with their non-moving anterior lateral (AL) eyes. The AL eyes are known to be excellent motion detectors, and while their special acuity is not as great as that of the principal eyes, it still exceeds that of most insects. We tested whether the principal eyes, the AL eyes, either alone, or both together are necessary to distinguish two non-moving shapes, a cricket silhouette vs. an oval. We found that while spiders never attack the neutral stimulus, 45% of control spiders (N=20) attack the prey item, as did 20% (N=20) with their AL eyes masked. However, no spiders with their principal eyes masked attacked the prey (N=21). These results suggest that the principal eyes are necessary for jumping spiders to recognize the shape of prey items when movement is not an available cue. In addition, we used eyetracking technology to view the movement of retinas as spiders observed the stimuli used above. The principal eyes explore the cricket stimulus more actively than the oval stimulus.

### **\*\*Limb autotomy and regeneration in wolf spiders affects seismic courtship signaling**

**Fraser C, J Wede, & GW Uetz**

Department of Biological Sciences, University of Cincinnati, Cincinnati, OH

Previous studies have shown that males of the Brush-legged Wolf Spider *Schizocosa ocreata* suffer reduced mating success after autotomy and/or regeneration of forelimbs, as it affects visual courtship displays. However, since courtship of male *S. ocreata* is multimodal and contains seismic/vibratory signals, communication in this channel



may also be affected. Female receptivity in response to isolated male seismic courtship signals was recorded for three groups: males with intact forelimbs, one regenerated forelimb (natural or experimentally-induced), or a missing forelimb. Females exhibited greater receptivity to isolated seismic signals of intact males compared to males with a regenerated or missing limb. Although size and body condition did not differ among treatments, autotomy and regeneration had a negative impact on growth increment (% change in weight from penultimate instar to adult). To investigate further the impact of autotomy and/or regeneration, male seismic signals were recorded using a laser Doppler vibrometer (LDV). Analysis of LDV recordings revealed differences in signal structure, e.g., lower amplitude seismic signals in males with regenerated limbs compared to intact males and males missing one limb. More detailed analyses of differences in individual components of seismic signals showed that certain signal elements have significantly reduced amplitude in males regenerating limbs. Subsequent analyses suggest some seismic elements reflect male condition and influence female receptivity. These results demonstrate the potential fitness impact of autotomy and regeneration on the seismic/vibratory component of male courtship signals.

### **A new hypothesis for scorpion navigation: chemo-textural familiarity**

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All scorpions have exquisite chemosensory and tactile organs called pectines on their ventral mesosomas. Neurons in peg sensilla, the sensory units on these organs, are sensitive to mechanical deflection and a variety of chemicals. The organs are dimorphic in some species and appear (in part) to be used by males to track female pheromonal deposits. However, one lingering question is why the pectines have so many peg sensilla. For example, male desert sand scorpions, *Smeringurus mesaensis*, have about 120,000 morphologically and physiologically redundant peg sensilla distributed on their two pectines, with around 1500 per pectinal tooth. Here, we offer a chemo-textural familiarity hypothesis for pecten function. We propose that scorpions may use pectines to acquire ground-based chemical and textural information to recapitulate learned paths to their home burrows. This hypothesis is similar to the navigation by scene familiarity hypothesis proposed for homing insects, except that the cues are textural and chemical instead of visual. For this hypothesis to be viable, three prerequisites are: 1) sufficient sensory receptors to account for environmental complexity, 2) sufficient environmental information to reveal unique, discernible patterns, 3) the ability to establish initial training routes, possibly by path integration. We will present evidence that all three criteria apply to homing scorpions, and we will outline behavioral experiments designed to test the hypothesis.

### **\*\*Elemental cuticular composition of two species of *Typopeltis* (Arachnida: Thelyphonida)**

**Gallant J & R Hochberg**

University of Massachusetts Lowell

We have examined two species of whipscorpions, *Typopeltis dalyi* and *Typopeltis harmandi* (c.f) with a field emission scanning electron microscope containing an energy dispersive X-ray spectroscopy detector. EDS gives elemental composition of the scanned area, and allows for the quantitative collection of specific elements present in the whipscorpions' cuticles. The cuticles are mainly composed of carbon, nitrogen, and oxygen with trace levels of magnesium, aluminum, chlorine, potassium, and calcium. Sodium, and zinc were found at higher levels on different locations of the cuticle, including the pedipalps' tarsi and the walking legs tarsi. Silicon is only found at an elevated level on the prosomal carapaces. This indicates that whipscorpions incorporate specific elements into specific locations on their cuticle, but at different levels at different locations. These locations seem have similar purposes as one another, as the pedipalps' tarsi and walking legs' tarsi both function in grasping, and zinc and sodium may reinforce the cuticle at those locations. However, the prosomal carapace functions mainly in defense, and silicon bonds are often weaker than carbon bonds, meaning that silicon could theoretically weaken the cuticle where it is incorporated.

**\*\*Spider diversity of three families of the Dionycha clade (Araneae: Anyphaenidae, Corinnidae and Salticidae) in two mountain ecosystems of Mexico**

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The Order Araneae has approximately 45,000 described species and is estimated that this represents only a fraction of their diversity. The spider fauna of temperate regions has been well documented, whereas the tropical and subtropical areas are insufficiently studied. The use of cyber-taxonomy tools combined with standardized protocols for sampling spiders has permitted a better documentation, estimation of species richness and comparisons between areas. However, these methods have not been applied in Mexico where the spider fauna is poorly known and several new species are expected to exist. The present faunistic inventory documents, compares and estimates the species richness of three families (Anyphaenidae, Corinnidae and Salticidae) of the Dionycha clade. Standardized collecting methods were applied in an oak forest located in Veracruz and a tropical rain forest in San Luis Potosí. Currently the collected material has been sorted to ca. 50 morphospecies documented with nearly 800 high resolution images available through Morphbank. This image data set will also facilitate comparisons between areas. Finally species richness and seasonal variation will be estimated and analyzed respectively.

**Phylogeography of a large but little known scorpion from the Mojave and Sonoran Deserts, *Smeringurus vachoni* (Scorpiones: Vaejovidae)**

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The Mojave and Sonoran deserts are quickly emerging as a testing ground for assessing the capability of comparative phylogeography to reconstruct the history of biotic assembly for entire biotas. Here, we contribute the phylogeography of *Smeringurus vachoni* Stahnke, a large but little studied scorpion from the Mojave and Sonoran deserts, to this initiative. Based on phylogeographic patterns from co-distributed taxa, other scorpions, and geographic trends in morphology that are responsible for current subspecies designations, we tested the following hypotheses: 1) the distribution of *S. vachoni* was reduced and fragmented during Pleistocene glacial cycles, 2) *S. vachoni* populations are microallopatric, 3) *S. vachoni* experienced pre-Pleistocene divergence along the Mojave and Sonoran desert ecotone, and 4) *S. vachoni* is comprised of northern and southern clades corresponding to *S. v. vachoni* and *S. v. immanus* respectively, with intergrades distributed along the Colorado River Valley. We tested each of these hypotheses against a null model of panmixia with isolation by distance. Mitochondrial (COI, 16S) and nuclear (ITS2) data collected throughout the range of *S. vachoni* suggest that the species is not panmictic. Rather, populations of *S. vachoni* appears to be microallopatric along the southern Colorado River Valley, but experienced recent postglacial expansions in the northern part of the species' range, supporting hypotheses 1 and 2. No support was found for hypotheses 3 and 4. Strikingly, the phylogeography of *S. vachoni* shows little overlap with patterns uncovered in co-occurring taxa, highlighting the importance of vast, multi-taxon datasets for understanding how modern biotas have assembled through time.

**Molecular gut-content analysis of the web-invading spider, *Neospintharus trigonum***

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The web-invading spider *Neospintharus trigonum* displays plasticity in foraging behavior exhibiting a range of tactics including kleptoparasitism (stealing host prey) and predation on the host. Previous lab work has shown that *N. trigonum* may exhibit a conditional foraging strategy as it switches tactics based on factors such as food and host availability. While the percentage of host web invasions has been estimated in the field, the proportion of individuals exhibiting a particular foraging tactic at any time is difficult to determine. Furthermore, how the ratio of host predators to kleptoparasites may shift with seasonal changes is not known. Because it is difficult to determine through direct observation whether *N. trigonum* is acting as a predator or kleptoparasite in a natural setting, we utilized molecular techniques to analyze gut contents of field collected individuals. Specifically, we developed methods to determine whether an individual *N. trigonum* had consumed a host spider, *Pityohyphantes costatus*, or non-spider (presumably insect) prey. We analyzed cytochrome c oxidases I (COI) sequences to test for species-specific DNA fragments in samples of field collected *N. trigonum*. This technique will eventually allow us to examine how developmental and environmental shifts that occur with seasonal changes may influence the conditional foraging strategy of *N. trigonum* and shed light on the impacts of tactic switching on host populations.

**\*\*Diel rhythms in web-building behavior in the orb-weaving spider *Cyclosa turbinata* (Araneae: Araneidae)**

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Department of Biological Sciences, East Tennessee State University

Diel rhythms are commonly assumed to be adaptive strategies that coordinate behavioral and physiological functions with the ecologically appropriate time of day. For orb-weaving spiders, the timing of daily web-replacement is particularly important because the web's prey capture effectiveness declines over time, and the process of building the web increases the spider's exposure to predators. *Cyclosa turbinata* is a small orb-weaver which forages in its web both day and night, and relies on camouflage to avoid visual predators. Because of this, we hypothesize that this spider should have evolved to replace its web under the cover of darkness, but do so close to dawn to maintain capture effectiveness as prey density increases over the day. In this study we demonstrate that this species shows strong circadian rhythm in locomotor activity, thus we further hypothesize that they may use this internal clock to schedule web-building activity. In order to assess the timing and regulation of web-replacement behavior in *C. turbinata*, we video recorded 18 individuals maintained under either a hard Light:Dark (LD) cycle or a ramping LD cycle. We continued to observe individuals under the ramping LD cycle for several days in constant darkness (DD) to determine if web-building is endogenously driven (circadian). We found that *C. turbinata* replaces its web in the pre-dawn hours; however, frequency distributions of web-replacement behaviors appeared similar between the ramping LD and hard LD groups. Furthermore, we are finding some evidence that web replacement is under circadian regulation.

**\*\*Presence of pheromones in web influence the size based behaviors of courting spiders**

Hutton B & A Rypstra

Miami University

Web spiders with poor vision depend on chemical and vibratory stimuli to detect and respond to environmental stimuli. Pheromones are particularly important in setting the stage for courtship interactions. We designed an experiment to investigate the importance of pheromones in *Pholcus manueli* (Araneae, Pholcidae). Females constructed webs which we either washed with a gentle spray of ethanol or left unwashed for a similar period of time. Males and females were measured and released into the webs and their behavior observed. In unwashed, pheromone laden, webs large males deposited more webbing, tapped and pulled the web more frequently regardless of female size. When both males and females were large, the males tasted the web more often and engaged in a

more active search. When the webs were washed, larger males still deposited more silk and tasted the web more often but there was no size impact on pulling silk or searching. While the impact of male size on silk pulling and searching disappeared, when females were large, males across all size classes were more active in silk pulling. This behavior likely represents an attempt to determine the location and condition of the female in the absence of accurate chemical information. In conclusion, pheromones interact with body size in shaping male-female interactions in *Pholcus manueli*.

**\*\*The importance of multimodal courtship cues for male eavesdropping in the wolf spider, *Schizocosa ocreata***

**Kane (1) H**, DL Clark (1), & GW Uetz (2)

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Recent studies on the wolf spider (*Schizocosa ocreata*) have demonstrated that males respond to the visual cues of another courting male by eavesdropping. Furthermore, it has been demonstrated that females prefer larger males (i.e. large male leg tufts) and males that court more vigorously. In this study, we examined responses of male *Schizocosa ocreata* wolf spiders to playback of computer-animated courtship behavior to test the importance of multimodal signaling when eavesdropping on a courting male rival. We used a specially designed test arena that allowed us to present male wolf spiders with the following stimuli: 1) a multimodal courting male, where males displayed visually and generated the concurrent seismic cues through the substrate of the arena; 2) a visual only courting male stimulus (minus the seismic cues); and 3) seismic cues only (minus the visual cues). The response of test males was measured by the courtship tap display rate. When paired against seismic cues only, test males responded with significantly higher tap display rate to multimodal and visual stimuli. However, when seismic cues were presented alone, males displayed at a higher rate of tapping compared to the tap rate when presented with visual or multimodal stimuli presented alone.

**\*\*Listening in to eavesdrop: Male *Schizocosa ocreata* associate seismic/vibratory signals of other males with female cues**

**Lallo MM**, J Monhollen, B Stoffer, & GW Uetz

University of Cincinnati, Department of Biological Sciences

Eavesdropping has been demonstrated in a variety of animal taxa, yet the mechanisms involved are relatively understudied. Previous studies on the brush-legged wolf spider, *Schizocosa ocreata*, have shown that field-collected, but not lab-reared, males exhibit eavesdropping behavior (i.e., courting in response to other conspecific males). In this study, we investigated the mechanisms underlying how male *S. ocreata* learn to eavesdrop by associating the presence of female cues with male seismic/vibratory courtship signals. During three days of conditioning trials, males were exposed to the presence or absence of two components hypothesized to be involved in the learning process for eavesdropping behavior: 1) female cues paired with male seismic/vibratory signals, 2) female cues alone, 3) seismic/vibratory signals alone, or 4) neither. On the fourth day, all males were subjected to only the male seismic/vibratory signal. Exposure to the combination of female cues and male seismic/vibratory courtship signals increased male courtship bouts and number of taps and bounces over other treatments (i.e., seismic/vibratory signals alone or no exposure). However, males previously exposed to female cues alone also showed increased courtship, suggesting the possibility of context-dependent learning (e.g., an “arena effect”). These findings suggest that male *S. ocreata* are not only capable of learning how to eavesdrop using male visual signals (as previous studies have shown), but eavesdrop on male vibratory signals as well.

### **Color-mediated interspecific mutualism: Effects of *Argyrodes miniaceus* on foraging of *Nephila pilipes***

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Kleptoparasites are organisms which steal food from others. In spiders, the well-known kleptoparasites are members of genus *Argyrodes* (Theridiidae). Most previous studies showed that *Argyrodes* spiders tend to bring negative effects to their host. However, a recent study showed that *Argyrodes fissifrons* had conspicuous silver patches and such body color can attract prey to *Cyrtophora* host's webs to increase their foraging success. In the webs of in *Nephila pilipes* in East Asia, *Argyrodes miniaceus* with conspicuous orange body color are frequently found. In this study, I tested whether the conspicuously colored *Argyrodes miniaceus* can increase foraging success of hosts by visually attracting prey to webs of *N. pilipes*. I conducted field experiments in July and August of 2012 and 2013 in which the presence or body color of *A. miniaceus* were manipulated. Interception rates of diurnal and nocturnal prey of *N. pilipes* webs receiving different treatments on *A. miniaceus* were monitored by video cameras. The results showed that although presence of *A. miniaceus* had little effect on *N. pilipes*'s diurnal prey interception, they significantly increased host's nocturnal prey interception. According to these results, since presence of *A. miniaceus* can potentially enhance foraging of *N. pilipes*, the interactions between these two spiders indicate a color-mediated interspecific mutualism.

### **The effects of wind on microstructures of major ampullate silks produced by *Cyclosa mulmeinensis***

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Spider major ampullate (MA) silk is composed of crystal and amorphous secondary structures. In the production process of a MA silk, a series of post secretion processing such as ion exchange, dehydration and rearrangement of secondary structures occurs after the spidroin protein is secreted in silk glands. Such post secretion processing plays an important role in achieving the superior mechanical properties of MA silks. Spiders may adjust post secretion processing then alter the mechanical properties of MA silks. In this study, I subjected *Cyclosa mulmeinensis* spiders to different wind disturbance level in the laboratory and then compared the microstructure characters of spiders' MA silk. Previous studies showed that when MA silk was subjected to supercontraction the effects of post secretion processing on silk can be eliminated. Therefore, I compared the mechanical properties of normal MA silks to those of silks under saturated humidity condition (to induce supercontraction) to estimate whether *C. mulmeinensis* spiders were able to adjust their mechanical properties of MA silks without altering the chemical properties. The results showed that most of tensile properties of supercontracted silks were not significantly different, except for extensibility. To determine the degree of alignment and geometry as well as distribution pattern of secondary structures of MA silk, X-ray diffraction was applied. The results show that crystal size of beta-sheet of seems smaller when spider received wind disturbance.

### **Can BAF reflect spider diversity of landscape mosaics? A case study on city parks in central Taiwan**

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In all the human activities which cause natural habitat loss, urbanization produces the greatest local extinct and its detrimental effect lasts longer. Besides, it would replace the native species with widely-distributed nonnative ones and result in the loss of biotic uniqueness of local ecosystem. In recent years, urbanization is still a growing global

trend so the application of biodiversity-enhancing managements during urban development is urgent and important. One popularly-used management conduct is the BAF (biotope area factor) system, which represents the ratio of ecological effective area of a landscape mosaic. However, currently BAF values are generated by expert questionnaire methods using aerial photos. It is not clear whether BAF values can actually reflect the biodiversity of a local area. Because of the high vegetation coverage urban parks often the biodiversity hot spots in cities. Therefore, how to manage city parks to increase diversity and abundance of organisms is vital in enhancing the biodiversity of urban area. In this study, we established sampling plots in various types of parks in central Taiwan to evaluate the congruency between BAF values and in situ biodiversity and to realize what environmental attributes are responsible for high biodiversity in urban parks. We will use expert questionnaire methods to designate BAF value of various landscape homogenous units in these parks. In addition, in all sampling plots we will systematically survey the diversity of spiders and measure the environmental factors. At the completion of data collection we will use multivariate analyses to evaluate whether BAF values are congruent with in situ biodiversity and what landscape attributes are most relevant with a high local biodiversity.

### **Araneae family diversity in a contiguous series of eastern Costa Rican tropical rainforest ecosystems**

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This work reports on the Araneae diversity present in a series of damaged and recovering ecosystems as well as contiguous transitional forests in Limon, Costa Rica. During a three-week collecting trip, we assessed 1200+ individuals among 4 distinct ecosystems and identified them to the family level. Samples were taken using transect hand sampling (~50m intervals), leaf litter collecting in randomly selected one square meter plots, and sweep netting. We observed that primary forest had 21 families of Araneae, secondary forests 33 families, fringe (a reclaimed pasture) 15, and a maintained pasture 11. We used Shannon-Weaver and evenness scores to report our findings to be able to compare our results to previous work. We also provide Simpson and Brillouin indices for further comparisons in respect of previous authors' recommendations. We conclude that secondary forest offers the most diversity followed by primary forest types. However, primary forest offers the most evenness and diversity followed by pasture which exhibits extremely low familial diversity. The impacts of singletons and sample size are also discussed with regard to the impacts on the indices and estimations.

### **The effect of the errant scorpion, *Centruroides vittatus* (Scorpiones: Buthidae), on the activity of the burrowing scorpion, *Vaejovis waueri* (Scorpiones: Vaejovidae)**

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The scorpion, *Vaejovis waueri*, is abundant on loose sandy soils suitable for burrowing. The widely distributed errant scorpion, *Centruroides vittatus* is an intraguild predator of *V. waueri*. Does the activity of *C. vittatus* have an effect on the activity of *V. waueri*? A preliminary study was done in a habitat with large mesquites, shrubs and grass and loose sandy soil at the La Union Ranch near San Ygancio, Texas from June 20, 2013 to October 31, 2013. The activity of the largest size class of *C. vittatus* was high during nights with higher temperatures. *Vaejovis waueri* activity increased as the temperature decreased. All size classes of *C. vittatus* climbed in vegetation more frequently than *V. waueri* with *V. waueri* on the ground frequently and rarely in vegetation. However, the microhabitat use for *C. vittatus* did depend on temperature with the scorpions frequently on the ground at higher temperatures with a higher frequency on the ground for the largest size class. The risk of intraguild predation (IGP) is present because three *C. vittatus* were observed feeding on *V. waueri* of the eighteen *C. vittatus* observed feeding during the study. These results suggest how *V. waueri* can avoid intraguild predation by *C. vittatus* by

reducing their activity when the larger *C. vittatus* are active on the ground. Further research is needed to confirm this pattern, determine the risk of intraguild predation and describe the response of *V. waueri* to the risk of IGP.

**\*\*Diversity of Pseudoscorpions (Arachnida, Pseudoscorpionida) in an oak tree forest of the National Park Pico de Orizaba, México**

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Pseudoscorpionida is an order of small arachnids (0.7 to 12 mm) that live mainly in tropical and subtropical areas. They inhabit mainly in leaf litter, soil or under tree bark. Pseudoscorpionida currently includes 3,380 species distributed in 439 genera and 25 families, but their numbers could range between 3,500 and 5,000 species. In Mexico 161 species grouped into 18 families have been reported, which represent only 4.7% of the world fauna. In the present study we conducted a faunistic inventory inside an oak forest (*Quercus* spp.) near the National Park Pico de Orizaba. This inventory consisted of three systematic samplings during one year in two plots of one hectare each. Several collecting methods were applied, with Berlese funnels and direct collecting being the most important for this group. A total of 733 specimens were collected, 362 were adults representing four families: Chernetidae was the most diverse and abundant with six morphospecies, Chthoniidae with two, plus Olpiidae and Cheliferidae represented by one morphospecies each. Our diversity analysis includes estimates of species richness and similarity comparisons between the two plots. Finally, each species will be documented with standardized compound digital images available at the Morphbank website, a dichotomous identification key and their corresponding diagnoses.

**\*\*Neurochemical correlates of behavior in local docile and aggressive variants of the subsocial spider, *Anelosimus studiosus*, as related to nutritional state, reproductive state, and time of day**

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In temperate zones, spiders are typically solitary, but in east Tennessee, populations of *Anelosimus studiosus* consist of both social and solitary individuals. Neurochemical levels are strongly correlated with docile and aggressive behaviors in *A. studiosus*. Prior studies have shown that brooding female *A. studiosus* (those protecting egg cases) are more aggressive in the evening than in the morning, and they are generally more aggressive than their non-brooding counterparts. It was hypothesized that (1) nutritional state would affect both behavior and neurochemistry, (2) brooding females would have higher levels of aggression-related amines than non-brooding females, and (3) levels would be higher in the evening than in the morning. Female *A. studiosus* were collected from colonies in northeast Tennessee and subsequently maintained in the lab for a minimum of two weeks. A subset was food-deprived to determine effect on behavior and neurochemistry. Neurochemicals were extracted from homogenized whole spiders. Samples were analyzed for biogenic amine content using high-performance liquid chromatography with electrochemical detection (HPLC-ECD). Starved spiders were significantly more aggressive than well-fed spiders after a period of fifteen days, and a significant difference in an unidentified compound was detected. Brooding spiders showed higher levels of another unidentified compound than non-brooders, and the compound was found to be higher at dusk than at dawn. These results indicate that specific neurochemical differences may be correlated with changes in nutritional state, reproductive status, and diel patterns of aggression. This research represents the early stages of physiological investigation into a unique ecological, evolutionary, and behavioral system.

## **Morphology, function and evolution of spider silk glands – a review**

**Řezáč (1,2) M**, TA Blackledge (1), & P Michalik (3)

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All spiders possess silk glands which open through modified setae, called spigots, on their spinnerets. The spinnerets are special appendages on ventral abdomen that are present only in spiders. Spiders are unique in maintaining an amazing battery of up to nine gland types. Each type of gland produces silk with unique material properties that have adapted for different functions. Spiders use silk in almost all aspects of their life, including locomotion, creating shelter, ballooning, obtaining prey and reproducing. Current research has been focused predominantly on the silk glands of two model genera *Araneus* and *Nephila*, and on their major ampullate glands in particular. Our current knowledge about other spider silk glands and about silk glands of non-orb weaving spiders is fragmented. The collective knowledge about spider silk glands was reviewed and summarized by Jacqueline Kooor (1972, 1977). Since then, many published papers have contained sparse information about silk gland histology, the morphology of the external spinning apparatus, spider spinning behavior and the properties of different silks. We present a synthesis of this newly accumulated information. We describe the morphology of spider silk gland and the process of silk spinning. Other topics covered include the ontogeny of silk glands, an overview of spider silk gland types in the major spider groups and evolution of the spider silk glands.

## **\*\*Spider community succession in a post wildfire Jack Pine forest**

**Rose SJ & PC Goebel**

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Ecosystem restoration practices that emulate natural disturbances and their legacies are thought to be more successful than those that do not. In many cases, however, we do not have a clear understanding of the impacts of natural disturbances on ecosystems. This lack of understanding limits the tools that restoration professionals have to effectively restore the structure and function of managed ecosystems. The jack pine forests of northern Lower Michigan are the focus of attention as they are the breeding ground for the endangered Kirtland's Warbler. Current management practices have been shown to simplify the landscape, and without an understanding of how the natural systems respond to fire we do not have the tools to measure the success of restoration efforts that emulate fire and natural post-fire succession. Spiders have been shown to be good bioindicators of ecosystem function; they are abundant, can be easily sampled, and are sensitive to environmental changes. For this study, spiders were sampled in twelve study sites post natural wildfire in northern Lower Michigan, ranging in age from 2-41 years. We also collected environmental and meteorological data. Our preliminary results show that site age, date, temperature, litter mass, litter volume, and understory vegetation density are important drivers of overall spider abundance. These data have shown that there are trends in spider abundance associated with forest succession following wildfire. Spider identification is in progress, and will lead to a greater understanding of the role of natural disturbance in shaping these systems, leading to improved strategies for restoration.

## **Answering arachnoquestions: A service provided by AAS**

**Rovner J**

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Since my 2001 presentation on the subject, the tremendous growth in resources available on the Internet has enabled me to improve my responses to questions submitted to AAS by members of the public. Now, for spider ID requests, I provide not only a name but also a link to a web page and occasionally to a video in order to inform the



questioner about the spider. For arachnids other than spiders, I identify the order and offer a link to a web page and a video. Inquiries seeking information about spiders (rather than IDs) are extremely diverse and include questions about behavior, life cycles, and various other aspects of spider biology. There also are inquiries from people who want to know how to keep spiders out of their car or home, a surprising number of them wishing to do so without harming the spiders. Occasionally, one or more additional Q & A's that relate to the original Q & A are exchanged between the questioner and me.

**\*\*Behavioral responses of male and female *Gladicosa gulosa* (Araneae: Lycosidae) to conspecific acoustic cues.**

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Vibration is an important part of the sensory world in spiders, and many species have adapted vibration as a major part of their conspecific communication. While nearly all male wolf spiders produce vibrations during courtship, the "purring" wolf spider, *Gladicosa gulosa* (Walckenaer 1837), also produces an airborne acoustic signal in conjunction with its vibratory display. However, with limited previous research on this species, the evolutionary and behavioral significance of this component remains unknown. Given that spiders are not known to possess sensory structures for directly perceiving airborne sound, this raises a key question - do males or females of this species respond to conspecific acoustic cues? We measured responses of male and female *G. gulosa* to isolated acoustic signals under various conditions. Individuals were placed in an anechoic chamber on either a vibrating (paper) or non-vibrating (granite) substrate and presented with one of three stimuli- no stimulus, a neutral acoustic stimulus (white noise), or the airborne component of a male conspecific signal. We then measured individual movement patterns and relevant behaviors. We found significant differences in phonotaxis, movement patterns, and association with the stimulus based on the type of stimulus presented. Responses also varied by sex and the vibratory capacity of the substrate. While the mechanism through which these signals may be perceived remains unknown, these results suggest that acoustic signaling may have a role in the communication network in this species.

**\*\*Determination of in-lab homing behavior and movement patterns of *Paruroctonus utahensis***

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Many animals build homes to which they return after excursions. However, the sensory and motor mechanisms that animals use to return home are poorly understood. Sand scorpions, including *Paruroctonus utahensis*, make burrows from which they emerge to hunt at night. These scorpions spend most of their surface time within about a half-meter of their burrow. Our goal was to create a laboratory environment conducive to scorpion homing behavior. Specifically, our objectives were to verify homing behavior and to characterize scorpion movements in these artificial environments. Tests occurred in circular, sand-filled arenas (65 cm diam), in the center of each was a "burrow" (a small jar lid with openings for the scorpions to enter). We filmed all trials from above, under IR light, in a room with a 14:10 hour light-dark cycle. Animals were tested over a 7-day period for their tendency to establish and return to their burrows on a normal day/night cycle. Time-in-burrow percentages showed significant evidence of homing behavior, consistent with their normal field behavior. In the second experiment, we used a MATLAB program to automatically track several hours of videotaped scorpion nocturnal movements. Animals spent most of their time along the arena walls but made intermittent forays across the arena center. When they returned to their burrows, their movements appeared to be direct and deliberate. This behavioral set-up will be useful in future attempts to deduce the sensory information these animals use to return to their burrows.

**\*\*The costs and benefits of sibling cannibalism in the wolf spider *Tigrosa helluo*: a mother's perspective****Wilson D, O Grunmeier, J Case, A Abrams, A Mobley, & M Persons**

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Sibling cannibalism occurs among wolf spiders but its frequency varies considerably among clutches. Consuming siblings may be costly since it putatively reduces both the direct fitness of the mother as well as the indirect fitness of the cannibalistic spiderling. Consequently this behavior is often modeled as a maladaptive by-product of selection for rapacity and a form of parent-offspring conflict. However, if cannibalistic spiderlings are feeding primarily on timid or weak siblings and/or have significantly higher survival than non-cannibalistic siblings, females with more cannibalistic young may not necessarily have reduced fitness. We measured sibling cannibalism frequency among eighteen eggsacs of the wolf spider *Tigrosa helluo*. We also measured differences in survival and growth among separated cannibalistic and non-cannibalistic siblings. After eggsac eclosion, sibling spiderlings were randomly paired for 16 days, noting cannibalism across all pairs (N = 510). Spiderlings were then individually housed, labeled as cannibals or non-cannibals and fed crickets *ad libitum* every two days over the next 110 days. Spiderling mortality, molt timing, and weight after each molt were recorded. Cannibalism frequency varied from 0 to 37% among eggsacs. After separation, significantly more cannibals survived than non-cannibals (82.4% vs 54.3%) Cannibals were also significantly heavier and molted earlier compared to non-cannibals. After 110 days, the proportion of offspring that survived was unrelated to the number of cannibals in the clutch, suggesting that cannibalistic and non-cannibalistic strategies have similar fitness outcomes for the mother and that the fitness costs of sibling cannibalism may be compensated by higher cannibal survival.