AAS Virtual Summer Symposium
Oral Presentation Abstracts
June 24 - July 1, 2021

Arranged by first author's last name
Asterisk (*) indicates contestant in student competition
Presenter underlined

Effect of temperature and humidity on web structure of web building spider *Neoscona theisi*

Imtiaz Alam, Abida Butt

imtiazalam8522@gmail.com

Temperature levels and humidity ranges affect the web building behavior of spiders. The present study is conducted to investigate the effect of temperature and humidity on web structure (mesh height, web size, capture area, capture thread length and number of radii) of *Neoscona theisi*. For experiment, the adult female spiders after satiation period were treated by 11^{o}C, 32^{o}C and 37^{o}C. After the treatment of 72 hours they were shifted into wooden frames to construct their webs. In the same way other spiders after satiation were placed in the chambers for treatment of different humidity ranges i.e. 20%, 60% and 80%. Results were analyzed by ANOVA using Minitab16 and statistica 6.0. Results of temperature treated spiders showed a significant increase in web size, capture area, capture thread length and number of radii at 32^{o}C followed by 37^{o}C and 11^{o}C. Results of humidity treated spiders showed a significant increase in web size, capture area, capture thread length and number of radii at 60% followed by 20% and 80%. However, mesh height was not affected by changes in temperature and humidity.

Habitat, Life History, Phenology, and Behavior of a Non-Native Ant-Mimicking Spider, *Myrmarachne formicaria*

Jennifer L. Apple, Alice Dipzinski, Daniel Fleischman, Cassidy Mills, Julia Ophals, Alanna Richman, Niaomi VanAlstine, Jacqueline Zhou

Department of Biology, SUNY Geneseo, Geneseo, New York, USA
applej@geneseo.edu

The ant-mimicking spider *Myrmarachne formicaria* (Araneae: Salticidae) is a recent arrival to North America from Eurasia, but little is known about its natural history in its native or invaded range. To determine if these spiders are associated with ant density or specific habitats, grids of pin flags (a commonly used substrate for their silken shelters) were employed as a sampling method at 18 sites that were visited weekly over summers 2019-20 to check for the presence of *M. formicaria*. Surveys of ant abundance at sites in 2019 revealed no significant association with these spiders, which were rare in older forest with a sparse understory, but frequently found in younger forest, forest edges, and fields. Egg masses were noted in early June, while spiderlings appeared in early July. Females or juveniles were much more common in surveyed sites than mature males, which were not apparent in shelters until August. Staged encounters between ant-mimicking spiders, ants, and potential predators (other salticids) were used to assess the benefits that *M. formicaria* might gain from its ant mimicry. These findings expand our knowledge of the natural history of this recently introduced species, which is critical to predicting its impact on the native arthropod community.

Population genomics of *Charinus* whip spiders (Amblypygi: Charinidae) from Israel

Caitlin M. Baker, Shlomi Aharon, Jesús A. Ballesteros, Guilherme Gainett, Zeana Ganem, Efrat Gavish-Regev, Prashant Sharma

Department of Integrative Biology, University of Wisconsin-Madison, Madison, Wisconsin, USA
cmbaker6@wisc.edu

Caves are well known arenas of adaptive speciation, where inhabitants often lose visual acuity and pigmentation, or develop enlarged sensory structures. Recently, the amblypygid *Charinus israelensis* was described from two caves in northern Israel based on morphology, where it is readily diagnosed by its vestigial eyes. The other species of amblypygid in Israel, *C. ioanniticus*, is eye-bearing, parthenogenetic, and synanthropic, found across the eastern Mediterranean predominantly in man-made caves. Given that speciation and morphological adaptation to caves is known to be a fast process, we set out to test the validity of these two morphospecies using population genomic data. We sequenced genotyping-by-sequencing (GBS) libraries from 40 *Charinus* specimens spanning 5 caves in Israel. Phylogenetic analysis of the GBS data recovered two highly differentiated and well-supported clades, one corresponding to *C. ioanniticus* and the other to *C. israelensis*. Interestingly, the two species were found to co-occur in one locality, where they showed no habitat differentiation despite their morphological differences. STRUCTURE analysis and population genomic statistics corroborated the phylogeny, identifying two panmictic clusters with almost no admixture between them. Our results therefore support the hypothesis that *C. ioanniticus* and *C. israelensis* constitute two valid species, both of which are likely parthenogenetic.

The developmental origins of scorpion pectines revealed by differential gene expression analyses

Jesús A. Ballesteros, Alison I. Gregorian, Carlos E. Santibañez-López, Prashant P. Sharma

Department of Integrative Biology, University of Wisconsin-Madison, Madison, Wisconsin, USA
ballesterosc@wisc.edu

The appendages of arthropods have evolved in a diversity of forms and are adapted for varied and specialized functions. In the arachnid bauplan, the prosoma is a broadly conserved tagma, with appendages used for food manipulation (chelicerae), sensory/prey capture functions (pedipalps) and four locomotor appendage pairs. Opisthosomal appendages are functionally more diverse and their homology often remains uncertain. Such is the case of the pectines, the enigmatic appendages of the third opisthosomal segment in scorpions. To investigate the developmental genetic basis of this evolutionary novelty, we dissected and sequenced appendage primordia from developing embryos of *Centruroides sculpturatus*. Samples corresponding to the labrum, chelicerae, pedipalp, leg I, pectine and book lung were separated and total RNA sequenced in three biological replicates. Mapping and quantification of genes leveraged the reference genome of *C. sculpturatus*. Differential gene expression analyses were performed using edgeR and DESeq2. Our results show surprising overlap in gene expression of book lungs and pectines. Additionally, we identified 73 genes in the pectines with significantly different gene expression compared to all other appendages. Our results suggest that the pectine represents an ancestral book gill/lung-like structure that became coopted for chemo- and mechanosensory function.

Sequence determinants of substrate specificity in brown recluse venom toxins

Salma Bashir*, Greta Binford, Pamela Zobel-Thropp, Matthew Cordes

Department of Biology, Lewis and Clark College, Portland, Oregon, USA
salma@ibashir.com

Sicariidae toxins (*SicTox*) are an abundant component in the venom of brown recluse spiders, where they are primarily responsible for venom toxicity and prey immobilization. They are also known to cause dermonecrosis in mammals. *SicTox* show variable substrate preference based on their phylogenetic categorization into the beta (β) and alpha (α) clades—*SicTox* of the α clade act primarily on common sphingolipid sphingomyelin (SM), while *SicTox* of the β clade show variable preference towards both sphingomyelin (SM) and ceramide phosphoethanolamine (CPE). The sequence determinants of substrate preference in the α clade have been hypothesized to involve a conserved aromatic cage motif. The variable presence of this aromatic cage in the β clade may also explain the lack of SM-specificity in many β clade proteins. This work has tested the influence of the aromatic cage on specificity towards SM using site-directed mutagenesis to eliminate the cage in α clade protein L1-αIII1i from the spider *Loxosceles laeta*. Mutant L1-αIII1i has demonstrated considerable lack of activity on SM as compared to wild-type L1-αIII1i. Further research is in process to determine if

the mutant remains able to bind membranes, and whether the observed loss of function is complete.

Invisible signals: Insights into chemical communication in the brush legged wolf-spider

Olivia Bauer-Nilsen*, George W. Uetz

Department of Biology, University of Cincinnati, Cincinnati, Ohio, USA
bauernoa@mail.uc.edu

The wolf spider *Schizocosa ocreata* (Hentz, 1844) is known for using of multimodal communication (visual and vibratory signals) in male courtship, but the role of chemical signaling is less obvious. Previous studies have shown that males recognize female chemical cues on dragline silk and, upon encounter will subsequently begin courting. Males can detect female mating status and feeding history based on chemical cues alone and will alter courtship effort as a result. We tested whether *S. ocreata* can detect immune-compromised individuals using chemical cues alone and found divergent results depending on sex. Males performed fewer courtship displays in the presence of silk from pathogen-infected females, and more with silk of controls. When presented unimodally, females showed attraction to male silk in general, but no difference in behavior toward silk from infected or uninfected males was observed. However, when male chemical cues are paired with video playback of visual male courtship, females show more receptivity towards stimuli paired with control silk than infected silk. Results show both males and females use chemical cues in mate choice, but without associated male courting stimuli, immune status of silk does not affect female behavior.

Altered gene expression in response to predator stress in a wolf spider *Pardosa milvina* (Araneae: Lycosidae)

Alexander Berry*, Ann L. Rypstra

Department of Biology, Miami University, Oxford, Ohio, USA
berryad2@miamioh.edu

Predator exposure has a wide variety of impacts on animals, including behavioral and developmental changes and can alter phenotypes in the next generation. One possible explanation for these changes is altered gene expression between exposed and unexposed individuals and their offspring. We used *Pardosa milvina*, a small, generalist wolf spider to examine if exposure to predator stress would cause changes in gene expression in exposed females and their offspring. Females were exposed to predator cues throughout their juvenile development and upon reaching adulthood were used for transcriptome analysis. Other exposed or control females were allowed to produce young, which were used in transcriptome analysis upon reaching their third instar phase. Over 909 differentially expressed genes were

identified in adults and nearly 289 were identified in juveniles. Unexpectedly, the 289 genes differentially expressed in offspring did not represent a subset of those differentially expressed in their parents. Several of these genes were linked with stress response pathways at both stages and several cellular pathways were found to be altered by predator exposure.

Bioinformatic and Evolutionary Approaches Identify Non-Spidroin Proteins with Proposed Functional Importance in Spider Silk

David Blumsack*, Molly Dawson, Alberto Chavez, Jessica Garb

Biological Sciences, University of Massachusetts Lowell, Lowell, Massachusetts, USA
david_blumsack@student.uml.edu

Spider silk is one of the toughest known biomaterials and for that reason, it has been highly studied by researchers looking to unlock its unique properties. This has led to extensive research on spidroins, the major proteins that give spider silk its toughness. There are however other proteins present in spider silk that may serve additional functions such as giving silk anti-microbial properties, preventing oxidation, or assisting spidroins in forming silk structure. To our knowledge, these other silk proteins have not been collectively surveyed to identify conserved proteins likely to serve in such essential functional roles. To identify these proteins, we surveyed publications reporting mass spectrometry analyses of spider silk and created a database of detected proteins. We also used available gene expression data to determine if the transcripts of these proteins had biased expression in silk glands relative to non-silk tissues. The presence of these proteins across distantly related species along with silk gland biased expression supports the hypothesis that non-spidroin proteins serve an important role in spider silk. Here we present the results of this work and consider the evolution of non-spidroin silk proteins in the context of whole proteomes predicted from genomes or de novo transcriptomes.

Dynamics of hybridization in a complex unimodal hybrid zone between members of the *Habronattus americanus* subgroup (F. Salticidae)

Tierney Bougie*, Marshal Hedin

Department of Biology, San Diego State University, San Diego, California, USA
tcbougie@gmail.com

Active hybrid zones offer unique opportunities to study the permeability of isolating barriers between diverging lineages. Hybrid zones with frequent introgression events especially challenge our understanding of the nature of species, suggesting that distinct species may be evolutionarily coupled by hybridization. Unimodal hybrid zones, defined as zones predominated by admixed individuals, indicate ongoing admixture where reproductive barriers are weak or absent. As such, exploring dynamics within unimodal hybrid zones may shed light on the

process of speciation and how species boundaries behave when contemporary rampant hybridization takes place. The *Habronattus americanus* subgroup consists of several closely related jumping spider species with substantial evidence of hybridization and introgression. We explored the above concepts in a unimodal hybrid zone involving *Habronattus americanus* and *H. kubai* near Mt. Shasta, CA. We collected ddRADseq data to perform population genomics analyses to estimate key measures of hybridity and characterize the genomic architecture of the hybrid zone. We also assessed the morphological diversity within the hybrid zone. Our results contribute to an overall better understanding of how genetic and morphological traits may behave in complex unimodal hybrid zones and enrich our understanding of the nature of species in the context of introgression.

Understanding the evolutionary history of the *Aphonopelma marxi* species group across the Madrean Archipelago "Sky Islands" biodiversity hotspot

Karina Silvestre Bringas*, Chris A. Hamilton

Department of Entomology, Plant Pathology, and Nematology, University of Idaho, Moscow, Idaho, USA
karinas@uidaho.edu

The Madrean Sky Islands are an important biodiversity hotspot of the southwestern United States and northern México, home to a vast amount of endemic diversity. These isolated mountain ranges are characterized by the stacking of biomes, from the desert "sea" below, to grasslands, to the classic Madrean oak habitat, to coniferous forests up high. Since the last glaciation, these mountain habitats have become increasingly isolated from each other, with limiting genetic interchange between populations, creating the perfect conditions for diversification. *Aphonopelma* is the only tarantula genus residing within the United States and includes 59 described species across the US and México. Here, we use 1450 UCE loci from a preliminary set of samples across 9 different mountain ranges, mostly ranges sampled for the first time, of the Madrean Sky Islands. We infer a phylogeny of the *Aphonopelma marxi* species group using a concatenated supermatrix and a coalescent-based species tree approach. Relationships between species agree across analysis methods and confirm previous hypothesis, including that there are a number of undescribed species. With an increase in sampling and the inclusion of tarantulas from mountain ranges in México we will gain a better understanding of the phylogenetic relationships between these Sky Island tarantulas and the importance they play in the evolutionary history of the genus.

Island-to-island vicariance, founder-event and within-area speciation: the biogeographic history of the *Antillattus* clade (Salticidae: Euophryini)

Franklyn Cala-Riquelme, Patrick Wiencek, Eduardo Flores-Daza, Greta Binford, Ingi Agnarsson

Grupo de estudios de Arácnidos & Miriápodos, Instituto de Ciencias Naturales, Universidad Nacional de Colombia, Bogotá, Colombia
fcalar@unal.edu.co

The Caribbean Archipelago is a biodiversity hotspot that plays a key role in developing our understanding of how dispersal ability affects species formation. In island systems, species with intermediate dispersal abilities tend to exhibit greater diversity, as may be the case for many of the salticid lineages of the insular Caribbean. Here, we examine patterns of diversification in the *Antillattus* clade and their diversification within and among islands of the Caribbean Archipelago. We used three markers (COI, 16S and 28S) and Bayesian approaches (Mr. Bayes, BEAST, BioGeoBEARS) to infer phylogenetic relationships and biogeographic history of the *Antillattus* clade. To understand the origin and the timing of salticids colonizing the Caribbean, we tested the hypotheses that connections via a landbridge (GAARlandia) and post-GAARlandia overwater dispersal events explain the *Antillattus* clade's diversity in the Greater Antilles. Estimated divergence dates are consistent with the ancestor of the *Antillattus* clade dispersing to the Caribbean via GAARlandia, while divergences between taxa from Cuba, Hispaniola and Puerto Rico appears to have originated by vicariance, founder-events and within-island speciation. Hispaniola was colonized from Northern South America, and in turn seems to be the nucleus from which Cuba and Puerto Rico were colonized. Time tree analysis and model-based BioGeoBEARS analyses of ancestral ranges estimated that the clade diverged c. 27 Mya, probably from the Hispaniola ancestor that subsequently colonized Cuba via the Windward Passage. Finally, multiple dispersal events (founder-events) between Cuba and Hispaniola during the Middle-Miocene and the Late-Miocene occurred in *Antillattus* and *Truncattus*.

Spatial and seasonal patterns of the RTA clade ground-dwelling spiders in two pine-oak forest remnants from Mexico

Emmanuel F. Campuzano, Jorge R. Padilla-Ramírez

Grupo de Sustentabilidad de los Recursos Naturales y Energía, CINVESTAV, Saltillo, Coahuila de Zaragoza, Mexico
efcampuzano@gmail.com

We analyzed the spatial-seasonal patterns on the abundance, composition, structure (i.e. abundance distribution among species), and diversity of the ground-dwelling spiders belonging to the retrolateral tibial apophysis (RTA) clade in two pine-oak forest remnants from Mexico. Additionally, a short review to compare the RTA ground-dwelling communities from Mexican habitats was carried out. Spiders were collected monthly, from July 2010 to June 2011, using pitfall-traps at each site. Species composition was seasonally, but not spatially, different. Estimated diversity for the Hill number 1 was influenced by the sites, and a site-season interaction effect was yielded for the Hill number 2. Abundance and community structure were strongly influenced by both sites and seasons. Six species exhibited strong associations with spatial and seasonal-specific conditions (possible bioindicators). Bibliographic analysis showed

the highest richness and the lowest number of undescribed species in desert habitats of northern Mexico, pointing those as possible species repositories for the RTA clade. Our results showed a heterogenous spatial-seasonal response in the RTA ground-dwelling spiders, together with a weak influence of the regional variation in temperature and precipitation on the abundance and species richness, suggesting a stronger influence of ecological drivers at the microhabitat scale.

A Song of Fire and Water: Evaluating the Dispersal Potential of the Cave-obligate Pseudoscorpion *Hesperochernes mirabilis*

Emma Canaday, David R. Nelsen, Aaron G. Corbit, Charles D. R. Stephen

Biology Department, Southern Adventist University, Collegedale, Tennessee, USA
ec001221@ohio.edu

Caves are not necessarily isolated environments. Genetic connections have been identified between geographically distant populations of the cave-obligate pseudoscorpion *Hesperochernes mirabilis* (Banks, 1895). This suggests the species can survive non-cave conditions while dispersing, but the physiological restraints limiting possible dispersal mechanisms remain unknown. We tested the ability of this species to survive two potential dispersal mechanisms: temperature (23-33 °C) and light (10 h dark and 14 h light) fluctuation they would encounter through phoresy on a flying host between caves; and submersion in water (12 °C with no light) they would need to endure if they could disperse passively through aquifers during cave flooding events. We found that *H. mirabilis* survive on average 27 days in epigean conditions and four days submerged in water. Our results suggest that dispersal via phoresy with a flying vector is better able to explain gene flow between distantly separated caves than dispersal via aquifers. We used our results (predicted days of survival under superterranean conditions) and the migration speed of Indiana Grey Bat to map caves where *H. mirabilis* may be present if they used this species as a dispersal vector.

Diversity and evolution of a new genus of tiger rump tarantulas of southern Mexico and Central America (Araneae: Theraphosidae: Theraphosinae)

Daniela T. Candia-Ramirez*, O. Francke

National Collection of Arachnids (CNAN), Institute of Biology, National Autonomous University of Mexico, Mexico City, Mexico
dcandia04@ciencias.unam.mx

In the last taxonomic revision of the genus *Davus*, it was reported that the species *D. pentaloris* has a great morphological variation and a widespread distribution. In our last contribution, we discovered that this variation represented different species and based on molecular and

morphological data we delimited 13 species, 12 of them new to science. By comparing the interspecific morphological variation of the *D. pentaloris* complex with the rest of the species of *Davus*, we found great morphological differences indicating that they do not belong to this genus. Thus, the main objective of this work is to make the systematic revision of the genus *Davus* based on molecular and morphological data by reconstructing the phylogenetic relationships and making the taxonomic revision based on the results of the species delimitation and the phylogenetic hypotheses obtained. Here we present the preliminary phylogeny of the genus *Davus* based on three molecular markers, one mitochondrial (COI) and two nuclear (EF1g, MID1IP1), showing that the genus *Davus* is not monophyletic and that the *Davus pentaloris* species complex belong to a new genus, as well as the preliminary results of the taxonomic revision. This work shows the importance of integrative taxonomy in the study morphologically conserved groups.

A Tale of Two Morphs: Phylogeography of *Neopurcellia salmoni*, with the first report of male polymorphism in the harvestman suborder Cyphophthalmi

Pietro Tardelli Canedo, Caitlin M. Baker, Rina Morisawa, Eliza J. Pessereau, Sarah L. Boyer

Biology Department, Macalester College, Saint Paul, Minnesota, USA
ptcanedo@gmail.com

Neopurcellia salmoni is a mite harvestman found throughout the forests of the west coast of New Zealand's South Island. This species range is unusually large for the notoriously dispersal-limited Cyphophthalmi, raising the possibility of multiple cryptic species within the lineage. In order to test this hypothesis, we used scanning electron microscopy to examine a large number of individuals from throughout its range, and discovered two distinct male morphotypes distinguished by the presence or absence of dorsal glandular pores. We performed phylogeographic and population genetic analyses using DNA sequence data from the fast-evolving mitochondrial locus COI. Tree topologies revealed two well-supported clades within *Neopurcellia* occupying non-overlapping geographical regions of the west coast. The strong correlation between the evolutionary relationships of lineages within *Neopurcellia* and the geographic distribution of its populations indicates isolation by distance, as expected with dispersal-limited organisms; population genetic analyses confirm strong isolation of populations. However, we discovered that the distribution of male morphotypes does not follow any geographic or phylogenetic pattern. While the presence of two different morphotypes initially suggested multiple *Neopurcellia* species, phylogeographic analysis allowed us to reject this hypothesis. We therefore report here the first known case of male polymorphism in the suborder Cyphophthalmi.

Revisión taxonómica y delimitación de especies mexicanas de *Pelegrina* Franganillo, 1930 (grupo furcata) (Araneae: Salticidae)

Daniela Ble Carrasco, Oscar Francke Ballvé

National Collection of Arachnids (CNAN), Institute of Biology, National Autonomous University of Mexico, Mexico City, Mexico
daniela_ble@hotmail.com

El género de arañas *Pelegrina*, grupo furcata, está conformado actualmente por seis especies. Las hembras de este grupo presentan una amplia variación morfológica intraespecífica, lo que complica su identificación con base en taxonomía tradicional. El objetivo de este estudio fue realizar la delimitación de las especies putativas con base en un criterio de taxonomía integradora (morfología y evidencia molecular). Se llevó a cabo la revisión morfológica principalmente de los caracteres sexuales, como son los pedipalpos en machos y epiginios en hembras, en donde, el carácter que proporcionó mayor información fue la forma de los émbolos presentes en los pedipalpos de machos, identificando tres especies candidatas (JALNAY, EDOMEX y JAL-ZAPOPAN). Para los análisis moleculares, se utilizó el gen mitocondrial CO1, y el análisis de cuatro métodos de delimitación (ABGD, HB, GMYC, bPTP). Bajo el criterio de congruencia entre métodos moleculares de delimitación y la evidencia morfológica se delimitó como especie candidata no confirmada a JAL-ZAPOPAN de la cual no se incluyeron datos moleculares, mientras que como especies candidatas confirmadas se recuperó a JALNAY y EDOMEX. Concluimos que la evidencia morfológica y molecular, dentro de un contexto de taxonomía integradora, son evidencias suficientes para la delimitación de especies del género *Pelegrina*.

Spiders in the spotlight: a global assessment of news coverage on spiders and spider bites

Angela Chuang, Catherine Scott, Jagoba Malumbres-Olarte, Ingi Agnarsson, Valeria Arabesky, Diego Alejandro Barrales-Alcalá, Aimee Lynn Barrion-Dupo, Marco Antonio Benamú, Tharina Bird, Maria Bogolomova, Pedro Cardoso, Maria Chatzaki, Ren-Chung Cheng, Tien-Ai Chu, Naufal Urfi Dhiya'Ulhaq, André-Philippe Drapeau Picard, Hisham K. El-Hennawy, Mert Elverici, Caroline S. Fukushima, Zeana Ganem, Efrat Gavish-Regev, Naledi Gonnye, Axel Hacala, Charles Haddad, Thomas Hesselberg, Tammy A. T. Ho, Thanakorn Into, Marco Isaia, Dharmaraj Jayaraman, Nanguei Karuaera, Rajashree Khalap, Kiran Khalap, Dongyoung Kim, Tuuli Korhonen, Simona Kralj-Fišer, Heidi Land, Shou-Wang Li, Sarah Loboda, Elizabeth Lowe, Yael Lubin, Marija Miličić, Alejandro Martínez, Zingisile Mbo, Grace Mwende Kioko, Veronica Nanni, Yusoff Norma-Rashid, Daniel Nwankwo, Christina Painting, Aleck Pang, Paolo Pantini, Martina Pavlek, Richard Pearce, Booppa Petcharad, Julien Pétillon, Onjaherizo Christian Raberahona, Joni A. Saarinen, Laura Segura-Hernández, Lenka Sentenská, Gabriel Uhl, Leilani Walker, Charles M. Warui, Konrad Wiśniewski, Alireza Zamani, Stefano Mammola

Entomology and Nematology, University of Florida, Lake Alfred, Florida, USA
angelachuang@ufl.edu

Rampant arachnophobia and risk perceptions of spider bites contribute towards a negative public image of spiders. This can be exacerbated by sensationalist or inaccurate media representations of human-spider encounters. We examined online news from the last decade on spiders and spider bites in 40 languages across 6 continents to understand global trends of the 1) news frequency over time, 2) geographical distribution of news and sensationalism, 3) frequency of expert consultation, and 4) error rates in reporting spider taxonomy, anatomy, venom, and photographic use. Spider news coverage increased over the decade, with seasonal peaks in northern hemisphere countries. Spiders from medically important genera (*Loxosceles*, *Latrodectus*, and *Phoneutria*) were among the most covered taxa, but so were false black widows (*Steatoda*) and other species of minor concern. Reports originating from Europe and the Americas were less likely to ask arachnologists, doctors, or other experts to comment on spider news than those from Asia, Africa, and Oceania. Sensationalism and errors were common, occurring in nearly half the articles from the Americas, Asia, and Europe. These trends suggest spiders are readily thrust in the media spotlight but are often inaccurately and unobjectively portrayed, which may heighten public misinformation and exacerbate arachnophobic sentiments.

Cryptic diversity and the importance of biogeography: preliminary results in a genus of a mygalomorph spider (Antrodiaetus, Antrodiaetidae) from the Pacific Northwest

Erik Ciaccio*, Chris Hamilton

Department of Entomology, Plant Pathology, and Nematology, University of Idaho, Moscow, Idaho, USA
ciac1074@vandals.uidaho.edu

Patterns of diversification among many taxa in the Pacific Northwest are a reflection of the complex geographic history in the region. Understanding these patterns provides important insight into how lineages have responded to climatic and geographic shifts. Complicating the understanding of these patterns are lineages with cryptic diversity, a phenomenon where morphological conservatism confounds taxonomy and underrepresents alpha taxonomy. As much evolutionary research replies upon a complete picture of biodiversity, cryptic lineages can represent a source of systemic bias. Folding trapdoor spiders (the genus *Antrodiaetus*) are poorly dispersing habitat specialists that previous research has shown to follow a trend of diversification that reflects the geographic history of where they live. Additionally, *Antrodiaetus* are suspected of containing an unknown amount of undescribed diversity. We present preliminary results of research to characterize the true diversity of *Antrodiaetus* in the Pacific Northwest, relationships among said lineages, and the geographic forces that have shaped them.

Molecular evolution of Inhibitor Cystine Knot toxins in wandering spiders (Araneae: Ctenidae)

T. Jeffrey Cole, Michael S. Brewer

Department of Biology, East Carolina University, Greenville, North Carolina, USA
jffcole7@gmail.com

Venom expressed by the nearly 50,000 species of spiders on Earth largely remains an untapped reservoir of a diverse array of biomolecules with potential for pharmacological and agricultural applications. A large fraction of the noxious components of spider venoms are a functionally diverse family of structurally related polypeptides with an inhibitor cystine knot (ICK) motif. The cysteine-rich nature of these toxins makes structural elucidation difficult, and most studies have focused on venom components from the small handful of medically relevant spider species such as the highly aggressive Brazilian wandering spider *Phoneutria nigriventer*. To alleviate difficulties associated with the study of ICK toxins in spiders, we devised a comprehensive approach to explore the evolutionary patterns that have shaped ICK functional diversification using venom gland transcriptomes and proteomes from phylogenetically distinct lineages of wandering spiders and their close relatives. We identified 626 unique ICK toxins belonging to seven topological elaborations. Phylogenetic tests of episodic diversification revealed distinct regions between cysteine residues that demonstrated differential evidence of positive and negative selection, which may have structural implications towards the specificity and efficacy of these toxins. Increased taxon sampling and whole genome sequencing will provide invaluable insights to further understand the evolutionary processes that have given rise to this diverse class of toxins.

The complex evolutionary history of cribellate orb-weaver capture thread spidroins

Sandra M. Correa-Garhwal, Richard Baker, Thomas H. Clarke, Nadia A. Ayoub, Cheryl Y. Hayashi

American Museum of Natural History, New York, New York, USA
scorrea-garhwal@amnh.org

Spiders have evolved two types of capture threads, one with a wet adhesive spun by ecribellate orb-weavers and another with a dry adhesive spun by cribellate spiders. Cribellar capture thread is a composite of pseudoflagelliform, paracribellar, and cribellar silk fibers. The genetics and evolution of cribellar capture threads are not fully known. Using genomic and transcriptomic approaches we assembled a comprehensive spidroin set for the cribellate spider *Uloborus diversus*. We examine in detail the silk genes associated with cribellar threads and compare them across cribellate taxa. We show that the cribellar spidroin (CrSp) has three distinct repeat units and some are conserved across species. We propose two spidroins, *U. diversus* Sp_vA and Sp_vB, as components of paracribellar silk. Moreover, we find that pseudoflagelliform spidroin (Pflag) has 48 repeats that cluster into four repeat types. Each Pflag repeat has a spacer region followed by a proline, serine, glycine, and glutamic acid reach region arranged in

the amino acid motifs GPS(X), KPS(X), and QPS(X) that could contribute to the fiber elasticity. Spidroin gene tree analyses show that Pflag is in clade with Sp5801 and share a monophyletic origin with Flag suggesting they evolved before the split of orb-web weavers and RTA spiders.

Towards a computational ethology of web-making: quantifying movement sequences underlying stages of web-building in Uloborus diversus

Abel Corver* Nicholas Wilkerson, Jeremiah Miller, Andrew Gordus

Solomon H. Snyder Department of Neuroscience, Johns Hopkins School of Medicine, Baltimore, Maryland, USA
abel.corver@gmail.com

The geometric complexity and stereotypy of spider webs have long generated interest in their algorithmic origin. Like other examples of animal architecture, web construction is the result of several assembly phases that reflect different behavioral stages that must be properly coordinated to build a successful structure. Manual observations have revealed a range of sensory cues and movement patterns used during web construction, but methods to systematically quantify the dynamics of these sensorimotor patterns are lacking. Here, we apply an analytical pipeline to the web-making behavior of the orb weaver Uloborus diversus. Using an unsupervised clustering approach, we identify stereotyped leg movements both specific to and shared across stages of construction. A Hierarchical Hidden Markov Model reveals that stages of web-building are characterized by distinct and stereotyped sequences of actions largely shared across individuals. We will also share progress on ongoing work using semi-automated annotation of dynamic web geometry to model the spider's tactile sensory experience during web-making, and our progress towards developing two-photon calcium imaging in this spider.

Trophic specialization and chemical integration of a newly described spider ant symbiont

Paula E. Cushing, Norman V. Horner

Denver Museum of Nature and Science, Denver, Colorado, USA
Paula.Cushing@dmns.org

The spider *Myrmecicultor chihuahuensis* (Myrmecicultoridae) was described in 2019 and hypothesized to be a myrmecophile, living inside ant nests. The defensive behavior of ants is mainly influenced by species-specific cuticular hydrocarbons (CHCs) and ant symbionts often evolve strategies allowing them to either bypass or mimic the host’s chemical communication code in order to infiltrate colonies. These strategies can also include behavioral and mechanical adaptations. To test the hypothesis that *M. chihuahuensis* are chemical mimics of their host ants, we 1) carried out behavioral bioassays, including labeling ants with deuterated CHCs, to

determine the level of behavioral interaction between spiders and ants and 2) analyzed the cuticular hydrocarbons of spiders and potential host ants using gas chromatography-mass spectrometry (GC-MS). We discovered that this new species of spider is a myrmecophage, displaying hunting strategies similar to other myrmecophagous spiders, particularly those in the genus *Zodarion* (Zodariidae). The CHC profile of *M. chihuahuensis* bore a close resemblance to the CHCs of the ants and are within the range of host perception, thus excluding chemical insignificance. Deuterium-labeling experiments suggest that the spiders did not steal their CHCs from the ants. The integration mechanism as well as the level of colony integration remains unknown.

Immunostimulation of the model spider species *Parasteatoda tepidariorum*

Agnieszka Czerwonka, Marta Sawadro, Weronika Porc, Mateusz Glenszczyk, Agnieszka Babczynska

University of Silesia in Katowice, Silesia, Katowice, Poland
aczerwonka@us.edu.pl

The immune system of spiders is innate, non-specific and consists mainly of hemolymph cells and antibacterial proteins. The defensive response of hemocytes is based on hemolymph coagulation, phagocytosis of microorganisms, and melanotic encapsulation of pathogens. To learn more about the immune responses of spiders, we performed studies on the cosmopolitan, synanthropic species *Parasteatoda tepidariorum* (Theridiidae). Our research team has got a laboratory culture of this species since 2014. We checked the immune response of *P. tepidariorum* to injury, insertion of a foreign body, and infection with bacteria. Furthermore, we checked what immune system-related proteins might be present in tested spiders' hemolymph. Reactions were studied in selected developmental stages of *P. tepidariorum*: embryos, juveniles, subadults, and adults. Our results indicate that (i) the immune system's reactions to injury and infection are rapid and consist of coagulation of the hemolymph, the release of lysozyme and melanization of the foreign body, (ii) bacterial infection increases the level of lysozyme and HSP70 protein in spiders, (iii) in immunostimulated spiders, 2 hours after infection with *Micrococcus luteus* bacteria, the number of dead hemocytes is higher than in uninfected individuals.

Microendemics of Madagascar: diversity and systematics of Madagascan Schizomida

Gustavo de Miranda, Rowan French, Robert Kallal, Hannah Wood

Entomology Department, Smithsonian National Museum of Natural History, Washington D.C., USA
smiranda.gustavo@gmail.com

Schizomids are small arachnids that live in the leaf litter and inside caves of tropical and subtropical forests. They are short-range endemics with low dispersal abilities, making them excellent candidate models for biogeography studies. Little is known about schizomid biogeography, diversity, and evolution, and no previous molecular work has been done on Madagascan schizomids. We bridge this gap by investigating the taxonomy and systematics of schizomids from Madagascar using genomic ultraconserved elements from museum-preserved and newly collected material. Specifically, we reconstruct their phylogenetic histories, analyze morphological variability, and species diversification in a phylogenetic context. Results show high diversity of this micro-endemic group, an in situ origin of most Madagascan species, and a distant relationship with groups from Australia, which were thought to be their sister lineage. Phylogenetic results will also inform future taxonomic revision, including the description of new species and genera. The findings of our project have the potential to provide valuable insight into the systematics of a little-studied arachnid group from an under-sampled region of the world.

The challenge of delimiting cryptic species, and a supervised machine learning solution

Shahan Derkarabetian, James Starrett, Marshal Hedin

Organismal and Evolutionary Biology, Harvard University, Cambridge, Massachusetts, USA
sderkarabetian@gmail.com

The diversity of biological and ecological characteristics of organisms, and the underlying genetic patterns and processes of speciation, makes the development of universally applicable genetic species delimitation methods challenging. Many approaches sometimes delimit populations and overestimate species numbers, an issue exacerbated in taxa with inherently high population structure due to low dispersal ability, and in cryptic species. These taxa present a conundrum when delimiting species: analyses rely heavily, if not entirely, on genetic data which over split species, while other lines of evidence lump. We showcase this conundrum in the harvester *Theromaster brunneus*, a low dispersal taxon with a wide geographic distribution and high potential for cryptic species. Integrating morphology, mitochondrial, and genome-scale data, we find high discordance across analyses and data types in species number, with further evidence that multispecies coalescent approaches over split. We demonstrate a supervised machine learning approach that effectively delimits cryptic species using a custom training dataset derived from a well-studied lineage with similar biological characteristics as *Theromaster*. This novel approach uses known species with particular biological characteristics to inform unknown species with similar characteristics. In principle, this approach is universally applicable for species delimitation of any taxon with genetic data, particularly for cryptic species.

First time DNA barcoding of spiders from The Nilgiris, Tamilnadu, India

Jayaraman Dharmaraj, Chinnappan Gunasekaran, Vallavan Rajkumar

Sri Vijay Vidyalaya College of Arts and Science, Dharmapuri, Tamilnadu, India
dharmaraj590@gmail.com

Spiders are very unique biological control agents. In the present study, DNA barcoding was used to the accuracy of molecular identification with documentation of spiders from the selected areas of The Nilgiris, Tamilnadu, India. A total of four selected spider species were captured. On the basis of molecular results, all the specimens were allowed the correct taxon. It is concluded from the present study that morphological investigations to identify a spider are satisfactory, but to enhance the accuracy, pace and credibility of results, molecular techniques like DNA barcoding is considerable. Furthermore, to magnify authenticity of evaluation of spiders, integrated barcoding - combination of molecular methods and conventional taxonomy is compulsory. Spider species are satisfactory, but to enlarge the pace and credibility of the results, combination of DNA barcoding is beneficial.

Motley views: evolutionary impact of audience perception on morphology in the jumping spider, *Synemosyna formica*

Alexis Dodson, David Outomuro Priede, Ana Wiatr, Nathan Morehouse

Department of Biological Sciences, University of Cincinnati, Cincinnati, Ohio, USA
dodsonas@mail.uc.edu

How do you mate if you and your potential partner are both in disguise? Mimicry can evolve to reduce predation risk but might reduce mating opportunities due to misidentification of conspecifics as their models. This raises some interesting questions: How do animals manage these conflicting contexts? One solution may be to tailor one's appearance to account for differences in the typical vantage point of distinct audiences. Conspecifics typically view mates at eye level while aerial and/or large predators often look at prey from above. Using analyses of the coloration and morphology of *Synemosyna formica*, an ant-mimicking salticid, we compared myrmecomorph color and shape to ant models from dorsal and lateral views. Analysis of dorsal morphology showed juvenile and adult *S. formica* were closer in shape to ants when viewed from a top-down perspective but more closely resemble spiders when viewed laterally. Likewise, we found their dorsal coloration was less discriminable from ants than their lateral coloration when viewed through predator visual systems. Our results indicate that *S. formica* may use vantage-point-specific appearances to overcome the challenges mimics face when balancing predator avoidance with conspecific recognition.

Spatial Distribution of a Tree Trunk Specialist Spider (Linyphiidae: *Drapetisca alteranda*): Landscape Versus Microhabitat Drivers

Michael L. Draney, Jason C. Doll, Lydia R. Doerr, Christopher J. Houghton, Patrick S. Forsythe

Department of Natural & Applied Sciences, University of Wisconsin-Green Bay, Green Bay, Wisconsin, USA
draneym@uwgb.edu

By completely censusing a 1 ha forest dynamics plot it was possible to identify variables (spider mass, size, sex and tree species, size, and bark roughness) that influenced the spatial distribution of adult *Drapetisca alteranda*, a linyphiid spider that specializes in lower tree trunks in North American forests. To account for spatial autocorrelation, a conditional autoregressive random effect was included in the zero inflated Poisson generalized linear mixed model. Parameters estimated were produced by Bayesian inference with vague prior probability distributions and the best of 16 models were selected using Watanabe-Akaike Information Criterion. The best model showed that larger diameter trees located at higher plot elevations were more likely to have *D. alteranda* present. Smooth bark tree species such as paper birch and American basswood tended to have the most spiders while rough bark species had the least. The relationship between tree diameter and *D. alteranda* abundance also varied by tree species. Spider sex and size were not associated with microhabitat variables such as height on the trunk, tree species, or bark furrow depth. Landscape-level factors largely predict *D. alteranda* abundance and distribution, suggesting that spatial autocorrelation should be considered when modeling the abundance of even small animals like spiders.

Possible self-assembly in linyphiid sheet webs

William Eberhard

Smithsonian Tropical Research Institute, Panama City, Panama
william.eberhard@gmail.com

Many lines in the sheets of four linyphiid species bore numerous small droplets. Droplet-bearing lines of *Linyphia simplicata* (F.O. Pickard-Cambridge, 1902) and *Nereine coosa* (Gertsch, 1951) adhered weakly to smooth, dry surfaces, contradicting previous statements that such lines in linyphiid webs are not sticky. Droplets at the intersections of lines tended to be larger than nearby droplets on the same lines, and showed wider separations from adjacent droplets than did other, nearby droplets on the same lines. A “self-assembly” hypothesis to explain these findings, that larger droplets accumulated at intersections as a result of lines in the sheet scraping against each other, was supported by confirming that larger intersection droplets were more widely separated from adjacent droplets than were smaller intersection droplets. These observations suggest a dynamic view of linyphiid sheet webs, in which the distribution of sticky material is adjusted advantageously immediately after lines are produced, due to upward dabbing movements of the spider’s abdomen that press the sheet lines against each other, and to movements of web lines against each other during or soon after web construction. Larger droplets may be advantageous in binding lines together more strongly, and in adhering more strongly to prey.

Scorpions of the Caucasus: current advances and perspectives

Victor Fet

Department of Biological Sciences, Marshall University, Huntington, West Virginia, USA
fet@marshall.edu

The worldwide fauna of scorpions includes about 2600 species, over 200 genera, and 23 families. The list of the Caucasus scorpions (in Armenia, Azerbaijan, Georgia, and Russia, with bordering provinces of Turkey and Iran) currently includes 16 species, 11 genera, and 5 families. Some of these were described and well-observed in the 19th century, such as highly toxic *Androctonus crassicauda*, *Mesobuthus eupeus*, and *Olivierus caucasicus* (Buthidae), as well as much less toxic *Alpiscorpius mingrelicus* and *Euscorpius italicus* (Euscorpiidae). A list of all known records until 1988 (including full Birula's collection preserved in the Zoological Institute, St.-Petersburg, Russia) was published by Fet (1989). A relict, basal *Calchas nordmanni* (belonging to the relict Anatolian-Aegean family Iuridae) is common in the Artvin Province (Turkey, Çoruh River watershed); it could be found in the neighboring Georgia (Adjaritskhali Valley). Distribution of scorpions in the Caucasus needs further evaluation, especially disjunctions between Transcaucasia and Northern Caucasus. Detailed DNA barcoding is required for most of Caucasian taxa; more data are available from Turkey and Iran than from the rest of the Caucasus. Some species are likely to represent complexes, as type populations of *M. eupeus* and *O. caucasicus* are restricted to the Caucasus. Formerly "widespread polymorphic species with numerous subspecies" today become widely ranging complexes of allopatric species, with estimated divergence in Miocene or earlier.

Sexual conflict in false black widow spiders – Aging females manipulate mate choice by males

Andreas Fischer*, Camilla A. Roman-Torres, Beatrice Chee, Gerhard Gries

Biological Sciences, Simon Fraser University, Burnaby, British Columbia, Canada
afischer@sfu.ca

Across spider taxa, older females are generally more 'appealing' to males than younger females, but the underlying mechanisms are not known. Here, we investigated how aging of female false black widow spiders, *Steatoda grossa* (Theridiidae), affects their sexual signalling and reproductive output. Age-dependently, the reproductive output of females declined dramatically. Older females also produced lower dense webs and deposited less courtship-inducing contact pheromone on their webs than younger females, as determined by high performance liquid chromatography – mass spectrometry. However, in y-tube olfactometers the webs of old females remained as attractive to mate-seeking males as the webs of young

females. It follows that old females manipulate the mate choice of males that would attain higher reproductive fitness by mating with younger females.

Effect of insecticide-history applications on spider-fauna present in Uruguayan rice crops

Viviana Franco, Sebastian Martinez, Carmen Viera, Luis Garcia

Universidad de la República and INIA-Uruguay, Montevideo, Uruguay
vfranco@fcien.edu.uy

Rice production in Uruguay has been traditionally characterized by a low insecticide use. Nevertheless, in recent years there has been an increase on the use of insecticides in some regions of the country, however, the effect of these practices on the local fauna are unknown. We evaluated the effects of insecticide applications on the local fauna found in rice crops using spiders as a model. We compared the spider-fauna richness and abundance in rice crops with more than two years of insecticide applications, against rice crops with no insecticide applications. Samples were taken using a sweep net between the panicle formation and harvesting stages. Once collected, specimens were identified to the lowest taxonomic level possible, abundance and diversity were compared for both insecticide and non-insecticide treated rice fields, using a Generalized linear model and the Shannon-Wiener index, respectively. Abundance and richness were higher in non-insecticide treated rice crops, suggesting negative effects of insecticide use on the local spider populations. These results suggest that the traditional rice production has more benefits on local fauna, when compared to new models, which promote the insecticide use. Further studies will evaluate the effect of spiders on local rice pests.

Evidence of learning walks related to scorpion home burrow navigation

Douglas D. Gaffin, Maria G. Munoz

Department of Biology, University of Oklahoma, Norman, Oklahoma, USA
ddgaffin@ou.edu

The Navigation by Chemotextural Familiarity Hypothesis (NCFH) suggests that scorpions use their midventral pectines to gather chemical and textural information near their burrows and use this information as they subsequently return home. For NCFH to be viable, animals must somehow acquire home-directed “tastes” of the substrate, such as through path integration (PI) and/or learning walks. We conducted behavioral trials in a laboratory, using desert grassland scorpions (*Paruroctonus utahensis*) collected from a nearby dune. Animals reliably formed burrows in small mounds of sand we provided in the middle of circular, sand-lined behavioral arenas (76 cm diameter). We processed overnight infrared video recordings with a MATLAB

script that tracked animal movements at 1-2 s intervals. In all, we analyzed the movements of 23 animals, representing nearly 1500 hours of video recording. We found that once animals established their home burrows, they immediately made one to several short looping excursions away from and back to their burrows before moving greater distances. These putative learning walks, together with recently reported PI in scorpions, may provide the crucial home-directed information requisite for NCFH.

Synaptic interactions in scorpion peg sensilla appear to maintain chemosensory neurons within dynamic firing range

Douglas D. Gaffin, Safra F. Shakir

Department of Biology, University of Oklahoma, Norman, Oklahoma, USA
ddgaffin@ou.edu

Scorpions have elaborate chemo-tactile organs called pectines on their ventral mesosoma. The teeth of the comb-like pectines support thousands of minute projections called peg sensilla (aka “pegs”), each containing approximately 10 chemosensory neurons. Males use pectines to detect pheromones released by females, and both sexes apparently use pectines to find prey and navigate to home retreats. Electrophysiological recordings from pegs of *Paruroctonus utahensis* reveal three spontaneously active cells (A_1, A_2, and B), which appear to interact synaptically. We made long-term extracellular recordings from the bases of peg sensilla and used a combination of conditional cross-interval and conditional interspike-interval analyses to assess the temporal dynamics of the A and B spike trains. Like previous researchers, we found that A cells are inhibited by B cells for tens of milliseconds. In addition, after normalizing our records, we found clear evidence that the A cells excite the B cells. This simple local circuit appears to maintain the A cells in a dynamic firing range and may have important implications for tracking pheromonal trails and sensing substrate chemistry for navigation.

Assessment of the biocontrol potential of natural enemies against psyllid populations in a pear tree orchard during spring

Domagoj Gajski, Stano Pekar

Department of Botany and Zoology, Faculty of Science, Masaryk University, Brno, Czech Republic
molekularac2013@gmail.com

Modern pest control management systems are based on the support of naturally occurring arthropod predators, as it has been shown that such predators offer an important ecosystem service. However, most naturally occurring arthropod predators are generalists (euryphagous). Their role in the biological control of specific pests has been recognized but remains poorly

studied. Here, we focused on the naturally occurring arthropod predators of psyllids – the main insect pest of pear trees. We investigated the abundance of psyllids and all their potential enemies in an abandoned pear orchard on a weekly basis from early spring to early summer. In addition, employing PCR diagnostics and specific primers, we investigated the predation rate on psyllids in all predators collected. We found four predatory groups: spiders were the most abundant, followed by coccinellid beetles, anthocorid bugs and cantharid beetles. Anthocorids and spiders had the highest predation rates among the predatory groups. Among spiders, >50% of foliage-dwelling spiders were positive for psyllids and showed a numerical response to the abundance of psyllids. We conclude that foliage-dwelling spiders are, of the four groups, the most important natural enemies of psyllids on pear trees during spring in Central Europe, as they outnumber specialized Anthocoris bugs.

Transcriptomic and genomic views of dragline silk diversity across the bark spider genus *Caerostris* and beyond

Jessica Garb, Molly Dawson, Alberto Chavez, Matjaž Gregorič, Matjaž Kuntner, Ingi Agnarsson, Todd Blackledge, Robert Haney

Department of Biological Sciences, University of Massachusetts Lowell, Lowell, Massachusetts, USA
Jessica_Garb@uml.edu

Spider silks are composed of different spidroin proteins exhibiting silk gland-specific patterns of expression that vary within and across species, leading to enormous functional diversity in silk fibers and constructions. Despite immense effort to determine the molecular make-up of silks, the highly repetitive nature of spidroins, along with limited genomic resources has led to a restricted view of silk composition. A prime example is dragline silk from major ampullate glands that is used by orb-weavers in the frame and radii of webs, which was thought to be predominately composed of two MaSp spidroins. The availability of recent transcriptomes and genomes has revealed a greater diversity of MaSp spidroins, yet how these spidroins are contributing to fiber performance is often unclear. Here we present dragline spidroin sequence and expression diversity in the bark spider genus *Caerostris*, noted for its particularly tough dragline and large orbwebs. Based on long and short-read deep sequencing, our results reinforce the largely silk gland biased nature of spidroin expression and that MaSps exhibit greater diversity in comparison to other spidroins. We consider the phylogenetic distribution of MaSp diversity outside of *Caerostris* and the mechanisms by which this diversity might contribute to variation in dragline performance.

The examination of cheliceral shape morphology in camel spiders (Eremobatidae: Therobatinae) using Elliptical Fourier analysis

Erika L. Garcia, Paula E. Cushing

Department of Zoology, Denver Museum of Nature & Science, Denver, Colorado, USA
erika.garcia@ucdenver.edu

Male cheliceral morphology is the leading diagnostic character in camel spider systematics and is the basis for current solifuge taxonomy. Male chelicerae vary in dentition, shape, seta types, and shape of the flagella or flagellar groove across multiple taxonomic levels. However, taxonomic descriptions are often restricted to qualitative descriptions of size and complex shapes. Limiting shape descriptions to a single qualitative descriptor excludes the consideration for variation that may exist within genera, or between populations of the same species. As part of an in progress taxonomic revision of Therobatinae (Eremobatidae, Krapelin 1901), here we present a 2-dimenstional (2D) morphological analysis of male therobatine cheliceral morphology using an Elliptical Fourier (EF) approach for closed outlines. In addition to multivariate approaches, we implement maximum likelihood and Bayesian model-based clustering methods to determine the optimal number of clusters from harmonic coefficients. Investigation into ubiquitously used character sets within Therobatinae will be used to better inform taxonomic boundaries and inter- and intraspecific variation.

Taxonomic revision of the spider genus *Falconina* Brignoli, 1985 (Araneae: Corinnidae: Corinninae): preliminary results

Fabián García, Alexandre Bonaldo Bragio

Laboratório de Aracnologia, Museu Paraense Emílio Goeldi, Belém, Pará, Brasil
Falgaroo97515@gmail.com

The Corinnidae genus *Falconina* Brignoli, 1985 currently includes four valid species: *F. melloi* (Schenkel, 1953), the type species, from Venezuela and northern Colombia; *F. gracilis* (Keyserling, 1981) from Argentina, Brazil, Paraguay, and south-western USA (possibly introduced); *F. albomaculosa* (Schmidt, 1971) from Ecuador; and *F. crassipalpis* (Checkering, 1937) from Panama and Cuba. Besides, there are many specimens of *Falconina* deposited in various museum collections, which represent several undescribed species. This study aims to perform a taxonomic revision of *Falconina*, generating a much more comprehensive taxonomic knowledge of the genus. So far, 72 vials coming from Brazilian and international institutions have been examined, corresponding to 49 males, 32 females, and 12 immatures, which were preliminarily assigned to ten morphospecies. Photographs of the type material of *F. albomaculosa* and *F. crassipalpis* were obtained for redescription. We identified some specimens of *F. aff. gracilis* presenting several diagnostic features for *F. gracilis* but with several differences in genitalia structures. Our results are still preliminary, therefore two scenarios with *F. gracilis* are possible: intraspecific variation within a single species or a species complex. Additionally, at least seven *Falconina* species new to science will be described.

The effects of resmethrin and methoprene on the salt-marsh wolf spider *Pardosa littoralis*

Mikayla Glick*, Matthias Foellmer

Department of Biology, Adelphi University, Garden City, New York, USA
mikaylee2000@aol.com

Salt marshes provide crucial ecological services; they absorb wave energy, protecting coastal communities from floods, and sequester carbon, decelerating climate change. Salt marshes are continuously degraded by anthropogenic forces such as rising sea levels and pollution. Pesticides such as methoprene and resmethrin are commonly sprayed in salt marshes to control mosquito populations, but their combined effects on non-target organisms are unknown. In addition to inducing direct mortality, pesticides can alter the performance of organisms due to more subtle, non-lethal effects, which can scale up to impact communities. Here we test the combined effects of methoprene, a larvicide, and resmethrin, an adulticide, on prey-capture behavior in an abundant salt marsh predator, *Pardosa littoralis*, using residual concentrations commonly found in coastal wetlands. We found that the exposure to resmethrin greatly reduces prey capture success. Surprisingly, this effect disappeared when resmethrin and methoprene were applied in combination. We discuss possible reasons for the unexpected interaction and ecological consequences of the detected effects in the light of the current literature.

Microhabitat selection as a function of web type and forest succession stage in spiders

Robin Glover*, Jessica Schmidt, Andrea Haberkern, Robb Bennett, Leticia Avilés

Biodiversity Research Centre, University of British Columbia, Vancouver, British Columbia, Canada
robinglover21@gmail.com

Habitat selection behaviours greatly influence organismal fitness because they determine the environmental pressures an organism is exposed to. Choosing an initial habitat is especially important for web-building spiders, which are uniquely sensitive to the physical structure of their environment. Spider webs can be separated into three categories based on their geometry: orb, tangle, and sheet-and-tangle. Since each web architecture is associated with a unique set of structural requirements, spiders with certain web types may favour environments with particular vegetation structure. While different habitat selection strategies have been observed in spiders with various web types, the factors that influence a spider's choice in web-site location are still largely unknown. In this study, we aimed to determine how forest succession stage influences communities of web-building spiders in terms of the proportion of different web types. We investigated whether the proportion of different web geometries changes along a gradient of succession stages in Pacific Spirit Regional Park, in Vancouver, BC, Canada. We collected web and vegetation data across ten sites throughout the summer of 2020. Contrary to our predictions, we found that leaf size and seasonal phenology, but not succession stage,

significantly influenced the proportional composition of the web-building spider community at PSRP.

Aggressive females might counteract male pace of life tradeoffs

Jake Godfrey*, Ann Rypstra

Department of Biology, Miami University, Oxford, Ohio, USA
godfreja@miamioh.edu

The Pace of Life Syndrome (PoLS) hypothesis describes a spectrum on which individuals develop rapidly at the expense of self-investment, or slowly but invest more in long-term survival. We explored a suite of traits that should accompany the difference in growth in the wolf spider *Tigrosa helluo*. Specifically, we found that faster maturing individuals displayed smaller size, lighter pigmentation, and different behavioral patterns than slower individuals. Intriguingly, faster maturing males had stronger immune responses, and male responses were stronger than females in general. We hypothesized that this deviation from the PoLS hypothesis is a result of female mate choice, predicting females favor more immunocompetent males. We conducted 57 mating trials, after which we performed encapsulation assays and took body condition measurements on all males. We found that more asymmetrical males were at higher risk of female aggression, and less likely to experience successful copulation. However, encapsulation was the strongest predictor of the number of aggressive lunges females made towards males. This behavior likely reduces male success by increasing the probability of sexual cannibalism, which supports our hypothesis that sexual selection counteracts the tradeoffs that were expected under the PoLS hypothesis.

Fast non-stereotyped prey capture and handling in wandering spiders

Julio C. González-Gómez, Yuri. Simone, Lida M. Franco, Arie Van Der Meijden

Grupo de Investigación Biología y Ecología de Artrópodos (BEA), Corporación Huiltur, Neiva, Huila y Universidad del Tolima, Tolima, Colombia
jcesargonzalez@ut.edu.co

Spiders have a crucial role in shaping arthropod communities.They feed on many different types of prey, often adopting different capture strategies. We investigated high-speed videos of predatory events in *Phoneutria depilata*, *Ancylometes bogotensis* and *Trechalea* sp., focusing on prey capture and manipulation before the first bite. *Pavocosa* sp., and *Acheta domesticus* were chosen to represent dangerous and not dangerous prey respectively. All species of predators largely show the same behavioral units, but *Phoneutria* and *Trechalea* each presented a unique behavioral unit. We found a significant effect of prey type ($z=3.244$; $p=0.0012$) and size ($z=-2.11$; $p=0.035$) on the bite location. Specifically, *Pavocosa* sp. was more frequently bitten

ventrally, and more often rotated during handling. Crickets were generally bitten dorsally and less frequently rotated. We thus found that prey manipulation in the tested species is different when spiders or crickets are offered as prey. This may be due to a different level of danger represented by the prey that requires a more complex prey capture strategy including rotation aimed to deliver a ventral bite.

The energetic intake of web building spiders is determined by spider size, not web geometry

Gabriel Greenberg-Pines*, Samantha Straus, Robb Bennett, Leticia Avilés

Biodiversity Research Centre, University of British Columbia, Vancouver, British Columbia, Canada
pinesgabe@zoology.ubc.ca

Web building spiders use traps composed of silk to capture insect prey. Metabolic theory predicts organisms should need less food per-unit-mass as they increase in size. Spider webs, therefore, need not grow isometrically with spider size. It is unclear, however, how the allometric relationships between spiders, their webs, and the prey they capture, are affected by web geometry. We found that silk content per-unit-spider mass of orb, tangle, and sheet-and-tangle webs indeed declined as spider mass increased. Sheet-and-tangle webs, however, contained two orders of magnitude more silk than the two other web types. Prey capture surface area per-unit-spider mass, however, was constant as spider size increased in sheet-and-tangle webs –perhaps as a mechanism to recover the high cost of their webs– whereas it declined in both orb and tangle building spiders. As a result, prey biomass per hour per-unit-spider mass declined as spider mass increased with identical slopes and intercepts for all three web types. Our findings suggest that, despite striking differences in their web geometry, spiders build webs that are big enough to supply them the energy they need, and no bigger.

Contribution to the life history of jumping spider *Paraphidippus aurantius* (Araneae: Salticidae) of the Ecological Reserve of Pedregal de San Ángel, Ciudad de México

Dariana Guerrero, Mariana Vargas, Jonathan Arreguin, Oscar Francke

Colección Nacional de Arácnidos (CNAN), Instituto de Biología de la Universidad Nacional Autónoma de México (UNAM), Ciudad de México, México
darguerrero03@gmail.com

The knowledge of the life cycles of species and the phenological patterns of populations are important aspects to known about their life history. The present study analyzes the phenology and describes a few aspects about the life cycle of a population of *Paraphidippus aurantius* Lucas, 1833 in a xeric habitat. After a year and a half of observations in the field, rearing

individuals in captivity and analyzing data with statistical tools; the results showed that the population is stenochronus with the period of reproduction in summer, and their life cycle was complete in a year. The abundance had an exponential growth correlated with the increase of temperature in the habitat, and itself maintained stability between stations. The data showed that developmental instars of the species were dependent on the station. The juvenile individuals were recorded from the dry season whereas subadults and adults, especially males, were recorded from the rainy season. Also describes some details about the maternal care of species. In addition, this is the first study to report the four morphotypes of females described in the literature for the same population.

Molecular phylogeny of the tropical wandering spiders (Ctenidae) and the evolution of the eye conformation in the RTA Clade

Nicolas A. Hazzi, Gustavo Hormiga

Department of Biological Sciences, George Washington University, Washington, D.C., USA
nicolashazzi@gwu.edu

Tropical wandering spiders (Ctenidae) are a diverse family within the RTA Clade, reaching their highest species richness in the tropics. We present a molecular phylogeny of Ctenidae, including for the first time representatives of all subfamilies. The molecular phylogeny was inferred using five nuclear (H3, 28S, 18S, Actin and ITS-2) and four mitochondrial (NADH, COI, 12S, 16S) markers. The matrix comprises 90 ctenid species and a total of 250 terminals, including representatives of other RTA families. The monophyly of Ctenidae was recovered with low support, and in some analyses the genus Ancylometes was placed as a sister group of Thomisidae. The subfamily Acantheinae is not monophyletic in most analyses and *Asthenoctenus borelli*, considered in morphological phylogenies as Viridasiinae (now Viridasinidae), belongs to the family Ctenidae. The ancestral reconstruction of the ocular conformation in the RTA clade suggests that the ocular pattern of Ctenidae has evolved convergently at least four times and it has originated from ocular conformations of two rows of four eyes (4-4) and from the ocular pattern of lycosids and pisaurids (4-2-2). Despite the high number of markers and taxa used in this study, the empirical support for the monophyly of Ctenidae remains controversial.

Evidence for concept learning in amblypygids

Eileen Hebets, Fiona Shogren, Daniel Wiegmann, Verner Bingman, Colton Watts

School of Biological Sciences, University of Nebraska-Lincoln, Lincoln, Nebraska, USA
ehebets2@unl.edu

Amblypygids have a documented capacity for multi-sensory guided navigation and learning, and complex mushroom bodies presumed to underlie their cognitive prowess. We used a match-to-sample design to

test whether amblypygids can also learn concepts – e.g. relationships between objects/“sameness”. We first paired individuals with an olfactory stimulus in an entrance refuge attached to a test arena. On either end of the test arena, we placed dark refuges, each associated with one of two distinct chemical stimuli (odors), with one always matching that in the entrance refuge. Once released into the test arena, an overhead light encouraged amblypygids to seek out dark refuges. During training trials, only the entrance to the matched-odor refuge was open. We used each odor as the matched stimulus every day for five consecutive days (i.e. 10 trainings). Following training, we ran a test trial in which we blocked both refuge entrances and scored amblypygid behavior. We then conducted two more days of training trials and ran a “novel” test trial with two unfamiliar odors. In novel test trials, amblypygids were more likely to choose the matched side first, suggesting they may have learned the concept of “sameness”.

The role of historical legacies in shaping spider communities across two mountain ranges in Sulawesi, Indonesia

Anna Holmquist*, Rosemary Gillespie

University of California, Berkeley, Berkeley, California, USA
ajholmqu@berkeley.edu

The relative importance of historical contingencies versus local environmental factors in shaping patterns of species diversity remains unresolved in most systems, largely because the two tend to be intertwined. The island of Sulawesi, a complex juxtaposition of ancient land masses formed in isolation several million years ago, holds insight into the role of contingency versus determinism in dictating species assembly. Much of the highly endemic biota of Sulawesi diversified between paleo-island regions, resulting in defined areas of endemism (AOEs). The processes forming this patchwork are still largely unknown. Spiders (order Araneae) are an excellent candidate for disentangling these processes because they are abundant, diverse, and often first colonizers of newly formed land masses, evolving in conjunction with Sulawesi through periods of geological fluctuation. In this study, we ask: in what way has the paleogeography of Sulawesi shaped spider communities? To address this question, we sequenced a mini-barcode region and additional nuclear markers in spiders collected across two mountain ranges, each located in separate AOEs on Sulawesi. With these data, we assessed community structure and relatedness across elevation gradients and between mountain ranges. Here we present novel findings on how different elements of spider communities reflect historical legacies of Sulawesi.

Home on the range: a pilot study on solifuge (Solifugae: Eremobatidae) site fidelity at Rocky Mountain Arsenal National Wildlife Refuge

R. Ryan Jones, Erika L. Garcia, Diana L. Batista-Perales

Denver Museum of Nature & Science, Denver, Colorado, USA
richjones327@gmail.com

dbatista@ciencias.unam.mx

Many animals, including many arachnids, return to an established “home” after an active period. Although desert-adapted solifuges shelter from the sun in retreats, it is unknown if these solifuges “home” to and re-use the same retreats over multiple consecutive periods. We sought to investigate if individual solifuges exhibit site fidelity (philopatry) and could be found repeatedly within the same small geographic area using a simple mark-and-recapture study design. Over the course of the seven-day study period, nine of 46 solifuges were recaptured once, and two were recaptured a third time, with an average distance of 4.17m between encounters. This rate of recapture is suggestive that solifuges remain in or return to the same geographic area over some period of time – a prerequisite for homing behavior. We discuss the further investigation is warranted to establish if solifuges are repeatedly using the same retreats, and if so, how they are navigating during homing.

Tales of schizomid tails: patterns in schizomid flagellum shape from elliptical Fourier analysis

Robert J. Kallal, Gustavo de Miranda, Hannah M. Wood

Department of Entomology, Smithsonian National Museum of Natural History, Washington, D.C., USA
kallal.research@gmail.com

Schizomids are small, soil-dwelling arachnids termed a neglected cousin in the arachnid tree of life. Due in part to their size and cryptic habitats, they are more rarely collected. Their biology is little known. Much of their morphological taxonomy is based on the flagellum and its setal patterns. In females, it is relatively short and segmented, akin to the better-known flagellum of their sister lineage, the vinegaroons (Thelyphonida). Unlike vinegaroons, males have a paddle-like flagellum that plays a role in courtship and mating, and it's widely illustrated in the literature. We sought to understand the variance in the schizomid flagellum using elliptical Fourier methods of two-dimensional geometric morphometrics. We attained more than 400 images of the flagellum for schizomid species with known males, accounting for all such genera, and analyzed both their dorsal and lateral aspects. Furthermore, we investigate the correlation of shape to size, habitat, and biogeographic realm. We also wanted to understand if the described diversity tracks with the size of the area they inhabit. We found allometric signal but broad overlap in the other variables. This work illustrates the importance of primary taxonomic literature on morphological features that allows comparative analysis as data accumulates through the centuries.

Spiders Got Groove, “What’s Love Got to Do With It?” and Other Perspectives for the Exploration of Spider Venoms

Charles P. Kristensen

Spider Pharm, Yarnell, Arizona, USA
chuck@spiderpharm.com

This talk focuses on the use of anecdotal and more rigorous observations to identify, target and explore important transitions and other changes caused by spider venoms. Spider venoms tend to be complex mixtures of toxins and other components with diverse modes of action adapted for use against diverse predators, competitors and prey and with different anatomies, chemistries and physiologies under a wide range of conditions in many contexts. Modern technology makes it relatively easy to catalogue the composition of venoms and to propose basic modes of action of many of the components, but we still need data from the wild for context and specifics. Without this data, it is difficult to imagine the advantages and disadvantages of changes of evolutionary changes in the venom. Although many of the changes caused by the venoms are not directly observable but some are, and we can also look for transitions and in the behavior of the spider and prey for clues that may be useful. Fortunately, the size and availability of spiders and prey and the relative ease of observing them in captivity and in the wild makes it relatively easy to observe interactions between diverse species under diverse conditions.

Phylogenomics illuminate the evolution of orb webs, tracheal systems and the biogeographic history of the world's smallest orb-weaving spiders

Siddharth Kulkarni, Hannah Wood, Gustavo Hormiga

Department of Biological Sciences, George Washington University, Washington, D.C., USA
sskspider@gmail.com

The miniature orb weaving spiders (< 2 mm body length) are an assemblage of five spider families known as symphytognathoids. One of its families, Anapidae, includes spiders that construct a variety of modified orb webs, sheet webs, cobwebs, and one species (Sofanapis antillanca) is a kleptoparasite. Symphytognathoids are resolved as monophyletic using morphology plus Sanger-based markers, paraphyletic with solely Sanger-based markers, and polyphyletic with transcriptomes. In this study, we capitalized on a large taxon sampling of symphytognathoids focused on Anapidae using newly sequenced ultraconserved elements (UCEs) combined with UCEs recovered from available transcriptomes and genomes. Evaluating various support metrics and topology tests, we found support for the "symphytognathoids" clade, Anterior Tracheal System (ANTS) Clade, and monophyly of the family Anapidae. Anapidae can be divided into three major clades- the Vichitra Clade, subfamily Micropholcommatinae and the Orb-weaving anapids Clade. Biogeographic analyses reconstructed a Gondwanan ancestral area for Anapidae and the divergence of its lineages coincide with the period of Gondwana breakup. In symphytognathoids, the ancestral anterior book lungs system transformed once into tracheal system and multiple times into reduced book

lungs, and the posterior tracheal system was lost and secondarily gained multiple times. The orb web structure was lost four times independently and transformed into sheet web once.

Resource allocation in the development of dimorphic male sexually selected traits in the jumping spider, *Maevia inclemens*

Laurel B. Lietzenmayer*, Lauren M. Goldstein, Josephine M. Pasche, David L. Clark, Lisa A. Taylor

Entomology and Nematology Department, University of Florida, Gainesville, Florida, USA
lblietzenmayer@gmail.com

The genetic male dimorphism of the jumping spider, *Maevia inclemens*, includes both morphological and behavioral differences associated with alternative reproductive tactics that may be affected by an individual's nutrition throughout development. The alternative reproductive tactics we have proposed are that: 1) the tufted morph uses conspicuous tufts of setae above the AMEs to honestly signal their quality as a mate, and 2) the striped morph uses black-and-white striped patterns on their legs to deter aggression and predation from females. Depending on the diet individuals receive during development, and their respective reproductive tactics as adults, each male morph may allocate resources differently to sexually selected traits or overall body size to maximize reproductive success. We raised spiderlings on high and low quality diets until maturity, then tested whether our diet treatments impacted morph-specific sexually selected traits (i.e., tufts and stripes), overall body size, and growth rates. Studying how *M. inclemens* allocates resources to dimorphic traits during development can help us better understand this unique genetic male dimorphism that fails to conform to more widespread, plastic examples.

They mostly come at night: nocturnal marauding by *Enoplognatha ovata*

Sean McCann, Catherine Scott

Biological Sciences, University of Toronto Scarborough, Scarborough, Ontario, Canada
smccann27@gmail.com

Enoplognatha ovata is a medium-sized theridiid spider introduced to North America from Europe, and common on the West Coast. Much-studied because of its striking colour polymorphism, its ecology and natural history has thus far attracted almost no interest. Indeed, we assumed these "candy-striped spiders" to be uninteresting ourselves until we began to observe their remarkably flexible predation behaviour during nocturnal observations of black widow spiders at Island View Beach, on Vancouver Island, BC. During the daylight hours, this spider typifies a fairly ordinary theridiid predation strategy, with a capture web built on vegetation, and killing of insects that come into contact with the web. By night, however, adult

and penultimate-instar candy-striped spiders also engage in araneophagy and kleptoparasitism in neighbouring spiders' webs. Moreover, they leave their webs to climb nearby vegetation and launch sneak attacks on sleeping insects, particularly bees and wasps. This nighttime marauding can be very profitable, with large kills allowing feeding for several days. We speculate that this form of nocturnal hunting allows rapid acquisition of nutrients for egg sac production.

Effects of fire on ground-dwelling spider assemblages in central Indiana forests

Marc A. Milne, Joseph Gonsiorowski, Nathan Tuft, Brodrick Deno, Tyler Ploss, Janise Acosta, Lucas Frandsen, Casey Venable

Department of Biology, University of Indianapolis, Indianapolis, Indiana, USA
milnem@uindy.edu

Fire is a natural disturbance that occurs in many temperate and tropical ecosystems worldwide. As ubiquitous members of these ecosystems, spiders are often affected by fire and their response to this disturbance has been shown to be dependent on taxonomy, functional diversity, seasonality, and a variety of environmental factors. We examined the effect of fire on ground-dwelling spider assemblages in temperate forests in central Indiana over five years and found that spider assemblages were significantly affected by fire disturbance. Overall spider abundance and diversity decreased while species richness remained unaffected. We also found that spider response depended heavily on the family and/or guild to which the spider belonged. Finally, we found that spider assemblages displayed high resilience to fire, becoming similar to unburned sections after 1 year, only when males (which are prone to wandering) were excluded from the analysis. We suspect that altered habitat heterogeneity, the patchy nature of fire's effect on leaf litter, and the high rate of re-colonization by spiders all played important roles in these observed patterns.

Sequencing ultraconserved elements in the New Zealand mite harvestman genus *Rakaia*

Rina Morisawa, Shahan Derkarabetian, Sarah L. Boyer

Department of Biology, Macalester College, Saint Paul, Minnesota, USA
rina.morisawa1@gmail.com

We produced an updated phylogeny of mite harvestman (Arachnida, Opiliones, Cyphophthalmi) genus *Rakaia* based on sequence capture of ultraconserved elements (UCE), highly conserved regions of the genome shared across distant taxa. *Rakaia* is the most speciose and widespread mite harvestman genus in New Zealand; previous efforts to understand phylogenetic relationships within this group have been restricted in terms of taxonomic sampling and number of loci used in standard Sanger sequencing protocol. The DNA degradation associated with

museum collections rules out the option of Sanger sequencing several key specimens. However, UCE target capture can overcome these obstacles by allowing sequencing of hundreds of loci across the genome from specimens collected as early as the 1860s. We sequenced UCEs from 61 *Rakaia* specimens from all except one known species, in a first attempt at using next-generation sequencing techniques for New Zealand mite harvestmen at the species level. Morphological and geographical data were used in tandem with molecular DNA data to describe four new species. Using the UCE-generated phylogeny from this project, we identify future directions for utilizing these high-resolution phylogenies to test long-disputed biogeographical hypotheses in the context of Gondwanan vicariance.

Effect of thiamethoxam and trichlorfon on web building behaviour of *Neoscona theisi* (Araneae; Araneidae)

Muhammad Khalid Mukhtar, Sidra Naeem, Hafiz Muhammad Tahir, Humera Razzaq, Sajida Naseem

Department of Zoology, University of Sargodha, Sargodha, Punjab, Pakistan
mkmukhtar@gmail.com

The field collected spiders were divided into two groups, control and experimental. Spiders of experimental group were exposed to different concentrations of insecticides, thiamethoxam and trichlorfon, while spiders of control group were treated only with distilled water. After that, spiders were shifted to specially designed boxes and were allowed to build their webs under laboratory conditions. Observations were made after 24, 48 and 72 hours of application of insecticides. Pictures of webs constructed by both control and experimental group spiders were taken by digital camera and web parameters (no. of spirals, no. of radii, mesh height, web diameter, radius, capture area and anchoring thread length) were recorded and compared. Results showed that both insecticides effect on web building behaviour. Trichlorfon proved highly lethal as it caused 100% mortality at recommended field rate concentration, while thiamethoxam caused only 20% mortality at field rate. Statistical analysis of web parameters revealed that higher concentrations affected web building more significantly while lower concentration i.e. half field rate did not affect web parameter significantly and normal web building was observed. Trichlorfon caused more lethal effects while thiamethoxam had sub lethal effects on web building.

Arañas del suelo (Araneae) de la Reserva San Pedro (Santa Elena, Medellín): construyendo una línea de base para monitorear los cambios en procesos de restauración

Ana S. Muñoz-Montoya, Juan D. Marín-Uribe, J. Cardona-Duque

Sciences and Biotechnology Faculty, Biology, Universidad CES, Medellín, Antioquia, Colombia

munozm.ana@uces.edu.co

La reserva San Pedro, ubicada en Medellín, es un ecosistema estratégico del municipio, en el que se inició un proceso de restauración en 2010, en el marco del proyecto Más Bosques para Medellín. Para evaluar la eficiencia del proceso, en 2011 se construyeron líneas de base de aves, plantas y algunos grupos de insectos, y en 2019 se realizó el primer monitoreo, y se recolectaron sistemáticamente diversos grupos de artrópodos. Las arañas son buenas indicadoras de calidad ambiental y los estudios con este grupo en Colombia son escasos. Este trabajo busca establecer una línea de base de Araneae en esta reserva utilizando muestras de trampas pitfall en dos estados sucesionales. El material se identificó con claves taxonómicas y literatura especializada, generando el primer listado de arañas de la reserva. Se recolectaron 237 especímenes en las coberturas de Restauración y Bosque, correspondientes a 20 familias y 41 morfoespecies. La riqueza fue mayor en restauración, con 25 morfoespecies, versus 16 morfoespecies en la cobertura de bosque. Se espera comparar las coberturas, identificando especies bioindicadoras de cada estado sucesional. Este trabajo ampliará el conocimiento del uso de arañas en los procesos de restauración.

Comparative sublethal effects of insecticides spiromesifen and thiamethoxam on the functional response of *Oxyopes javanus*

Hina Nazli, Abida Butt, Muhammad Xaaceph Khan

IPM Lab, Department of Zoology, University of the Punjab, Lahore, Pakistan
hina.naz001@gmail.com

Spiders feed on a wide variety of insect pests and play a vital role in keeping the pest populations under threshhold levels in agroecosytems. *Oxyopes javanus* (Oxyopidae) is one of the most influential spider species in the agroecosystem of Punjab, Pakistan. However the sublethal effects of insecticides on this species are poorly explored. In the present study the effects of sublethal concentration of insecticides spiromesifen and thiamethoxam on functional response of *O. javanus* against wheat aphid (*Schizaphis graminum*) were explored. Adult spiders were treated with LC30 concentrations of both insecticides by dipping method. Functional response of *O. javanus* was estimated after 12, 24 and 48 hours against offered densities (3, 5, 10, 15, and 20) of aphids. Untreated and spiromesifen treated spiders showed type II functional response. Thiamethoxam treated spiders showed type II functional response in 12 and 48 hours observation and type III functional response after 24 hours observation. Handling time increased, attack rate and search efficiency decreased in insecticide treated spiders. It was concluded that both of these insecticides have negative sublethal effects on functional response of *O. javanus*. However, negative effects of thiamethoxam on functional response of *O. javanus* were higher than spiromesifen. These insecticides might have negative sublethal effects on other spider species of region too. Further studies should explore the sublethal effects of these insecticides on other native natural enemies and spiders of this area.

Taxonomic sampling and rare genomic change overcome long-branch attraction in the phylogenetic placement of pseudoscorpions

Andrew Z. Ontano, Guilherme Gainett, Shlomi Aharon, Jesús A. Ballesteros, Ligia R. Benavides, Kevin F. Corbett, Efrat Gavish-Regev, Mark S. Harvey, Scott Monsma, Carlos E., Santibáñez-López, Emily V. W. Setton, Jakob T. Zehms, Jeanne A. Zeh, David W. Zeh, Prashant P. Sharma

Department of Integrative Biology, University of Wisconsin-Madison, Madison, Wisconsin, USA
ontano@wisc.edu

The backbone phylogeny of Chelicerata has remained unstable despite continuous progress in the availability of genome-scale data. The placement of several orders has remained problematic due to systematic artifacts caused by long branch attraction. Across various analyses the fast-evolving pseudoscorpions have been recovered clustering with other fast-evolving lineages such as Acariformes and Parasitiformes or clustering with Arachnopulmonata. To overcome long branch attraction, we analyzed supermatrices utilizing a combination of broad taxonomic sampling and various gene occupancy thresholds to investigate the phylogenetic placement of pseudoscorpions. We generated the first high-quality developmental transcriptome and genome for pseudoscorpions to assess the incidence of arachnopulmonate-specfic gene duplications. Our results support the inclusion of pseudoscorpions in Arachnopulmonata as sister group of scorpions.

Humidity mediated performance and material properties of orb weaving spider adhesive

Brent D. Opell, Hannah Mae Elmore, Mary L. Hendricks

Department of Biological Sciences, Virginia Tech, Blacksburg, Virginia, USA
bopell@vt.edu

Capture thread glue droplets retain insects that strike an orb web and are key to the success of over 4,600 described spider species. Each droplet is a self-assembling adhesive system whose emergent biomechanical properties are centered on its viscoelastic, adhesive core. This bioadhesive is dependent on its surrounding hygroscopic aqueous layer for hydration and chemical conditioning. Consequently, a droplet's water content and adhesive performance track environmental humidity. We tested the hypothesis that natural selection has tuned a droplet's adhesive performance and material properties to a species' foraging humidity. When tested over a 70% RH range, droplet extension lengths per adhesive volume peaked at lower humidities in species from exposed, low humidity habitats, and at higher humidities in nocturnal species and those found in humid habitats. However, at the RH's where these species' maximum extension per adhesive volume indices were observed, the stiffness of most species' adhesive did not differ, documenting that selection has tuned elastic modulus by adjusting droplet hygroscopicity.

This inverse relationship between droplet hygroscopicity and a species' foraging humidity ensures optimal adhesive stiffness. By characterizing the environmental responsiveness and properties of orb spider adhesive, our study also profiles its biomimetic potential.

He's compensating for something: Male *Schizocosa ocreata* wolf spiders use increased courtship vigor to compensate for a visual trait indicating poor condition.

Autumn Otto*, Olivia Bauer-Nilsen, George Uetz

Department of Biology, University of Cincinnati, Cincinnati, Ohio, USA
ottoau@mail.uc.edu

Males of the brush-legged wolf spider, *Schizocosa ocreata* (Hentz), court potential mates with visual signals that are static (foreleg tufts) or dynamic (leg-waving displays, vibrations) and reflect male condition. Previous studies have shown female preferences for larger leg tufts and higher courtship vigor (rate of leg waving). The main objective of this study was to test the Courtship Compensation Hypothesis, which predicts that males with smaller tufts can compensate for their deficiency by increasing courtship effort and potentially increase mating success. We tested this hypothesis with digital video playback, where females were presented with video males with manipulated courtship vigor and tuft size. Female responses to altered videos showed that males with reduced tufts but increased courtship vigor were equivalent to those seen with controls (average tuft size and mean vigor levels). Additional video playback studies of female receptivity to all combinations of manipulated tuft size and vigor showed the dynamic trait (vigor) to be equal or more important than the static trait (tuft size). These results suggest male spiders with smaller fixed traits can "level the playing field" and compensate behaviorally for limits of size and morphology, supporting the Courtship Compensation Hypothesis.

Friend and Foe? Ecosystem management and functional diversity of spiders

Guilherme Oyarzabal, Murilo Guimaraes

Departamento de Zoologia, Universidade Federal do Rio Grande do Sul, Porto Alegre, Rio Grande do Sul, Brazil
guilhermeoyarzabal@gmail.com

Historically, spiders' taxonomic diversity has been the main focus in studies of grazing impact, while spiders' guilds, with its intrinsic variation of characteristics, has been neglected. An improper approach to spider under grazing impact may have led us to erroneous conclusions about losses and gains of taxonomic and functional diversities. Here, we systematically reviewed the literature, between 2009 and 2019, to assess and evaluate the effects of grazing on spiders' taxonomic and functional guild diversities on worldwide grasslands. We hypothesize

that spiders are not a functionally homogeneous group and treating them as such, overshadows the effects of grazing on grassland ecosystems. From a taxonomic perspective, we found no evidence of grazing impact on total spider abundance and richness. However, from a functional perspective, high grazing pressure reduced the diversity of orbicular and sensitive web guilds while increased the diversity of ground, sheet, and space web guilds. Our major results suggest that grazing intensity alters the functional composition of grassland's spiders, with each guild responding differently. We suggest that is of utmost importance consider the intrinsic variability of characteristics and habits within Araneae. Therefore, functional diversity is an alternative to understand relationships between spiders and many ecosystems management.

The World Spider Trait database (WST): a centralised global open repository for curated data on spider traits

Stano Pekar, Jonas Wolff, Pedro Cardoso, Ľudmila Černecká, Klaus Birkhofer, Stefano Mammola, Elizabeth Lowe, Caroline Fukushima, Marie Herberstein

Department of Botany and Zoology, Faculty of Science, Masaryk University, Brno, Czechia
pekar@sci.muni.cz

Spiders are a highly diversified group of arthropods which play an important role in terrestrial ecosystems as ubiquitous predators, making them a suitable group to test a variety of eco-evolutionary hypotheses. For this purpose, knowledge of a diverse range of species traits is required. Until now data on spider traits have been scattered across thousands of publications produced for over two centuries and written in diverse languages. To facilitate access to such data we developed an online database for archiving and accessing spider traits at a global scale. The database has been designed to accommodate a great variety of traits (e.g., ecological, behavioural, morphological) measured at individual, species or higher taxonomic levels. Records are accompanied by extensive metadata (e.g., location, method). The database is curated by an expert team, regularly updated and open to any user. A future goal of the growing database is to include all published and unpublished data on spider traits provided by experts worldwide and to facilitate broad cross-taxa assays in functional ecology and comparative biology.

Behavioral manipulation in two Linyphiidae spiders induced by the parasitoid wasp *Eruga unilabiana* Pádua & Sobczak 2018 (Hymenoptera: Ichneumonidae)

Luis Campili Pereira, German Antonio Villanueva-Bonilla, Raul Azevedo, Jober Fernando Sobczak

Programa de Pós-graduação em Ecologia e Recursos Naturais, Departamento de Biologia, Centro de Ciências, Universidade Federal do Ceará, Fortaleza, Ceará, Brazil
luiscampili@alu.ufc.br

Parasitoids wasp of the *Polysphinctas* genus group (Hymenoptera: Ichneumonidae: Pimpliinae) induce their host spiders to build modified webs that offer protection to their pupae against natural enemies and abiotic factors. In present study, we report behavioral manipulation of the host spider *Eurymorium* sp. (Linyphiidae) by the parasitoid wasp *Eruga unilabiana* for the first time. In addition, we quantified the difference between structures of normal and modified web of *Eurymorium* sp. and the other host spider, *Sphecozone* sp. (Linyphiidae). Parasitized and non-parasitized spiders of both species were collected in a semideciduous tropical montane forest, located in Mulungu, Ceará-Brazil from August 2020 to January 2021 and were taken to UNILAB's Ecology and Evolution laboratory for creation and study. Individuals of *Eurymorium* sp. are induce to build a modified web with more protective and stable characteristics than normal web and, these modified webs are structurally similar to those built by individuals of *Sphecozone* sp. when they are also manipulated by the same parasitoid. The areas of the sheets and the length of the interception threads of the modified webs were significantly smaller than normal webs in both species of spiders. These manipulations are adjusted to the natural history of the hosts.

Urbanization increases web aggregation of funnel-web spiders, *Agelenopsis pennsylvanica*

Brandi J. Pessman*, Madison Hays, Earl Agpawa, Eileen Hebets

School of Biological Sciences, University of Nebraska-Lincoln, Lincoln, Nebraska, USA
bpessman2@huskers.unl.edu

Urbanization has the potential to alter habitat quality and consequently the spatial distributions of animals. Funnel-web spiders, *Agelenopsis pennsylvanica*, are prevalent across landscapes in Lincoln, Nebraska. To determine if urbanization affects web placement and spatial distribution of *A. pennsylvanica*, we compared web aggregation and substrate measures across two location-types: a city center (University Campus) and a forested city park. In each location-type, we used random walks to find initial focal spiders. We then measured the distance from the focal web to the nearest webs within ten meters. We observed web placement by measuring web height and noting available and used web substrates. While we found no difference between location-types in the distance walked to the focal webs, the city center had more webs within ten-meter radii of the focal webs. The distances between webs and web heights were shorter in the city center. Forest spiders took advantage of more diverse vegetation by building webs on a greater number of different plant species. Our results suggest that urban conditions increase web aggregation and affect web placement. While the underlying mechanisms for these differences remain unclear, future work will explore microhabitat structure, noise, and the potential for behavioral differences between locations.

The Guardstone Spiders of the genus *Phonotimpus* (Araneae, Phrurolithidae) in North of Mexico

Norman I. Platnick, David Chamé-Vázquez, Guillermo Ibarra-Núñez

Colección de Arácnidos e Insectos, Centro de Investigaciones Biológicas del Noroestes, S. C.
La Paz, Baja California Sur, Mexico
chamevazquez@gmail.com

In North America, Phrurolithidae is a poorly known family of spiders, only the genera *Drassinella* and *Phrurotimpus* (in part) have been reviewed recently. Some North American phrurolithids are misplaced, and some are only known from one sex. Moreover, the males of type species of the American genera *Piabuna*, *Scotinella*, and *Phonotimpus* are unknown. The last genus was erected with two species, *P. eutypus* and *P. separatus*, both from North of Mexico. Currently, the genus has seven species, four were recently described from South and Central Mexico and one species was transferred from *Gosiphrurus*. Nevertheless, many undescribed species are housed in natural history collections pending to be described. This works presents the partial revision of *Phonotimpus* from North of Mexico. Up to this moment, we have identified 25 putative new species and we redescribe *P. eutypus* and *P. separatus*. All species share the distinctive eye pattern, and both sexes have a dorsal opisthosomal scutum, this combination of characters seems unique among the New World genera. However, we describe different conformations of copulatory organs; therefore, we propose several informal groups for all known *Phonotimpus* species.

Juvenile leg autotomy predicts final weapon morph in a New Zealand harvestman

Erin C. Powell, Christina J. Painting, Anthony J. Hickey, Glauco Machado, Gregory I. Holwell

Entomology and Nematology Department, University of Florida, Gainesville, Florida, USA
erin.powell94@gmail.com

Sexual selection drives the evolution of diverse exaggerated structures, including weapons used in male-male competition. Intraspecific weapon polymorphisms that arise via conditional thresholds may be affected by juvenile experience such as interactions with predators, yet this idea has rarely been tested. The New Zealand harvestman, *Forsteropsalis pureora*, uses leg autotomy as a strategy to escape predators. This species has three male morphs (alpha, beta, gamma) that differ in body and weapon size and shape. Alpha and beta males are large-bodied and fight opponents with their large chelicerae, while gamma males are small-bodied with small chelicerae and scramble to find mates. Here we tested whether juvenile experience affects final adult morph using leg autotomy scars as a proxy of predator encounters. We found that gamma males had autotomized more legs as juveniles than alphas or betas. Gamma males autotomized more of leg pair I, II, and III than alphas or betas. Leg II was lost most often by juveniles across all male morphs. Leg loss during development may affect foraging, locomotion,

stress, and future contest success, potentially linking juvenile predator encounters to an individual's final adult morph.

Functional replacement in genital locking led to multiple RTA losses in ghost spiders (Amaurobioidinae, Anyphaenidae)

Dante Poy*, Luis N. Piacentini, Peter Michalik, Martín J. Ramírez

División Aracnología, Museo Argentino de Ciencias Naturales "Bernardino Rivadavia", Buenos Aires, Argentina
dante.poy@gmail.com

The retrolateral tibial apophysis (RTA) is the main synapomorphy of the most diverse group of spiders, the RTA clade. The RTA frequently performs a key function during genital coupling, which is the first and main mechanical engagement between male and female genitalia (i.e., primary locking). However, in several lineages the RTA is lost, raising the question on how genital coupling is achieved in these taxa. To address this, we used the anyphaenid subfamily Amaurobioidinae as a model and studied the copulatory mechanics of five species lacking functional RTA. We reconstructed their genital coupling using μCT scans of cryofixed mating pairs, which revealed that primary locking is always achieved by inserting the conductor into the ipsilateral copulatory opening. Subsequent phylogenetic mapping indicates that the conductor locking is ancestral, and that the RTA has been independently lost or reduced eight times in Amaurobioidinae. We hypothesize that the involvement of the conductor for primary locking relieved the RTA from selective pressure, and led to multiple losses of the RTA. Additionally, we found a high diversity of secondary locking mechanisms between closely related species.

Analysis of differential gene expression in venom glands in *Phoneutria boliviensis*

Diego Sierra Ramirez, Giovany Guevara, Lida Marcela Franco Pérez, Arie van der Meijden, Julio César González-Gómez, Carlos Fernando Prada Quiroga

Universidad del Tolima, Ibagué, Tolima, Colombia
dsierrar@ut.edu.co

The analysis of venoms and especially how their composition changes according to certain conditions has awakened a growing interest in research, given the pharmacological possibilities of better understanding venoms in order to use them as alternatives to existing medical treatments, in this work we present evidence that *P. boliviensis* (a species of medical importance for Colombia) has a differential gene expression in 169 transcripts involved in the production of neurotoxins, endopeptidases and other venom components between males and females; Additionally, by subjecting *P. boliviensis* to strict vertebrate (*Hemidactylus* sp.), invertebrate (*Tenebrio mollitor*) and mixed diets (*Hemidactylus* sp. + *Tenebrio mollitor*) we demonstrated that

70 transcripts produced in the venom glands could be expressed depending on the diet consumed.

An insect's view of orb webs in different light environments

Dinesh Rao, Horacio Tapia-McClung, Dulce Rodriguez-Morales

Inbioteca, Universidad Veracruzana, Xalapa, Veracruz, Mexico
dinrao@gmail.com

When a flying insect is foraging, it may encounter orb webs strung along its path. These webs are often at the limit of perception from the perspective of insect eyes. However, the visibility of webs may change depending on the position of the sun in the sky and allow the insect to detect webs. In this experiment, we filmed hoverflies approaching the webs of *Allocycloa bifurca* (Araneae: Araneidae) in three light conditions: when the sun was behind the web, in front of the web and above the web. We tracked the trajectories of the hoverflies as they approached the webs. Using a full spectrum digital camera, we carried out psychophysical visual modelling simulations to depict the webs as seen by the hoverfly visual system. Our results suggest that hoverflies are capable of detecting webs only at a very close range, but their characteristic ability to control their flight ensures that they can avoid the webs in time. Our study emphasises the need for species-specific evaluation of insect-web encounters and the use of visual ecology techniques for understanding predator-prey interactions.

Pushing the limits of micro-CT visualizations, PTA staining to observe the spider central nervous system

F. Andres Rivera-Quiroz, Jeremy Miller

Understanding Evolution research group, Naturalis Biodiversity Center, Leiden, The Netherlands
andres.riveraquiroz@naturalis.nl

Micro-CT scanning is a powerful and versatile tool for observing and documenting morphology at various levels. Unfortunately, arthropod specimens require a staining process that enhances X-ray absorption to facilitate clear visualization . Recently, research on the internal anatomy of spiders has been supplemented by the inclusion of micro-CT scans. All of these studies have used iodine staining plus critical point drying (CPD) to achieve tissue contrast. However, this method induces shrinkage of the soft tissue which can generate artifacts in the morphology of internal structures. Here we tested the performance of phosphotungstic acid (PTA) in comparison to iodine, testing different staining times and scanning parameters to achieve optimal tissue contrast and detail of the central nervous system. Our results show that PTA provides a contrast that greatly surpasses the resolution of iodine without the need of CPD. This makes PTA less impactful on the long term preservation of specimens and could allow even

rarely collected taxa to be investigated using micro-CT. This fast and less invasive method could facilitate the documentation of internal anatomical features of the central nervous system (and other organs like venom glands, silk glands, digestive and respiratory systems, etc.) in the context of broad phylogenetic studies.

Phenology of wolf spider *Pardosa flavisterna* Caporiacco, 1935 (Araneae: Lycosidae) in agroecosystems of Kashmir, India

Shazia Riyaz, Abdul Ahad Buhroo

Entomology Research Unit, Department of Zoology, University of Kashmir, Hazratbal, Srinagar, Kahmir, India
shaziashah121@gmail.com

In this study phenology of the wolf spider, *P. flavisterna* is studied which is a predominant arthropod predator in the agroecosystems of Kashmir valley. Its distribution is restricted to some parts of India and Pakistan only. The life cycle pattern was deduced via sampling done by manual searching, pitfall trapping in different agricultural fields along with carapace width analysis of field catches and individuals raised in laboratory conditions. It took eight instars for both males and females to mature showing a mean carapace width (±SE) of 2.59mm (±0.029), n=17, and 2.48mm (±0.024), n=14 for female and male at maturity respectively under controlled conditions. Analysis of the monthly catches and outcome of the measurement of their carapace width designates an annual-biennial life cycle to *P. flavisterna* having stenochronous occurrence, reproducing in spring and summer. The female produces two egg sacs, one in early spring and the other in summer. The first brood matures in the upcoming spring and the second grows throughout the subsequent year and matures the next spring. The average clutch size (±SE) is 68.24 (±4.57), n=122, ranges from 41-103. The numbers of individuals caught were affected by weather parameters with the temperature showing positive correlation with the number of catches ($r=0.58$, $p<0.05$). *P. flavisterna* hibernates in juvenile and subadult stage. There are two cohorts present at any time in the population and juveniles can be seen throughout the year.

New distributional records of *Phidippus* species for Mexico and Baja California

Luis C. Hernandez Salgado*, F. Sara Ceccarelli, Luz A. Garduño Villaseñor, Dariana R. Guerrero Fuentes, Eulogio López Reyes

Conservation Biology Department, Ensenada Center for Scientific Research and Higher Education, Enseanda, Baja California, Mexico
luiscarlos@cicese.edu.mx

Due to its heterogeneity in ecoregions and its varied topography, the Mexican peninsula of Baja California appears to be an area of high diversity for many taxa. However, a paucity of studies means that the diversity of Baja California's spiders is generally poorly known. For example, distributional records of the jumping spider genus *Phidippus* show that there are six species found in Baja California. However, considering the distributions of some species in southern California and in the north-western Mexican states of Sonora and Sinaloa, it is possible that in Baja California there could be up to sixteen species. As part of a larger study on the evolution and biogeography of the North American genus *Phidippus*, our first aim was to uncover the diversity of the genus in Baja California. Based on morphological examinations and molecular barcoding (DNA sequences of the first 680 base-pairs of the mitochondrial Cytochrome Oxidase C I gene), until now, nine species have been identified, of which three represent new records for Baja California, and one for Mexico. As this project is still ongoing, it is possible that these numbers will increase in the near future.

Phylogenomic analysis of 100 scorpion venom gland transcriptomes reveals the origins of toxicity

Carlos E. Santibáñez-López, J. Ballesteros, Caitlin M. Baker, Yoram Zvik, Efrat Gavish-Regev, Prashant P. Sharma

Department of Integrative Biology, University of Wisconsin-Madison, Madison, Wisconsin, USA
santibanezlopezc@wcsu.edu

The higher-level systematics of scorpions has been significantly revised in the last decade. While phylogenomic analyses have strongly supported the redefinition of two parvorders ("Buthida and Iurida"), relationships within Iurida have been greatly in flux. Moreover, few phylogenomic works have tackled relationships in the diverse Buthida. The lack of a robust and densely sampled scorpion phylogeny has hindered inference of the evolutionary dynamics of scorpion venoms. Here, we present an updated 100-taxon phylogeny of scorpions, built exclusively using venom gland transcriptomes or whole genome. Specifically, our work makes major advances toward sampling key lineages in the asymmetrically diverse family Buthidae. Our results provide a robust backbone phylogeny of scorpions, with fossil-dating revealing surprisingly young ages for many scorpion clades. The synthesis of our analyses suggests that Buthidae diversified in the Cretaceous, suggesting a contemporaneous diversification of mammal-specific toxins and of the mammal lineages that constitute major scorpion predators.

RADseq reveals patterns of diversification, range expansion, and introgression in the giant camel spiders of genus *Eremocosta* (Solifugae: Eremobatidae)

Carlos E. Santibáñez-López, Paula E. Cushing, Alexsis M. Powell, Matthew R. Graham

Department of Biology, Eastern Connecticut State University, Windham, Connecticut, USA

grahamm@easternct.edu

Species of camel spiders in the family Eremobatidae are an important component of arthropod communities in arid ecosystems throughout North America. Recently, research demonstrated that the evolutionary history and biogeography of the family are poorly understood. We explored the biogeographic history of these arachnids by using genome-wide SNP data, morphology, and distribution modelling to study the eremobatid genus *Eremocosta*, which contains exceptionally large species distributed throughout North American deserts. Relationships among species were resolved with strong support and they appear to have diversified within distinct desert regions along an east-to-west progression beginning in the Chihuahuan Desert. The unexpected phylogenetic position of some samples suggests that the genus may contain morphologically cryptic species. Geometric morphometric analyses revealed a largely conserved cheliceral morphology, possibly due to hybridization among *Eremocosta* spp., as genetic tests confirmed considerable amounts of introgression. Phylogeographic analyses indicated that the distribution of *E. titania* has only recently colonized much of the Mojave Desert following the most recent glacial period. Results from this study underscore the power of genome-wide data for unlocking the genetic potential of museum specimens, which is especially promising for organisms like camel spiders that are notoriously difficult to collect.

Interaction modification in a pollination system: presence of beggarticks reduces foraging success of spiders occupying goldenrod

Victoria Schmalhofer

Center for Earth and Environmental Science, Indiana University-Purdue University Indianapolis, Indianapolis, Indiana, USA
vrschmal@iupui.edu

Foraging success of flower-dwelling predators depends on host plant attractiveness to insect prey, and plant attractiveness is affected by the presence of other concurrently blooming species. *Misumenoides formosipes* (white-banded crab spider) uses *Solidago juncea* (goldenrod) and *Bidens aristosa* (beggarticks) as host plants; when both plant species are in bloom, spiders experience greater foraging success on beggarticks. I investigated the possibility of interaction modifications by comparing spider foraging success on flowering goldenrod in the presence and absence of blooming beggarticks. Spiders on goldenrod captured more prey per day, larger prey, and gained mass at a faster rate when beggarticks was not in bloom; spider success on goldenrod (in the absence of blooming beggarticks) was similar to that of spiders using beggarticks. Presence of flowering beggarticks also resulted in significant decreases in the rate of pollinator visitation and the size of insects visiting goldenrod. These data provide evidence for an interaction modification in the spider-pollinator-goldenrod/beggarticks system. Presence of flowering beggarticks causes a change in behavior of insect pollinators, resulting in a decrease in the frequency of insect visits to goldenrod, as well as changes in the size distribution of goldenrod visitors, that ultimately impact spider foraging success.

Dancing to different rhythms: description of the reproductive behavior of two pseudoscorpion species

Laura M. Segura-Hernández*, Eileen A. Hebets

School of Biological Sciences, University of Nebraska-Lincoln, Lincoln, Nebraska, USA
laurasegura.bio@gmail.com

Pseudoscorpions are a small and enigmatic group of arachnids. Most research so far has focused on systematics and taxonomy of the group with far fewer studies focusing on their very interesting behaviors. Patterns of reproductive behavior, for example, have been noted among the different families but have only been thoroughly described for a limited number of species. In this presentation, I will describe the reproductive behavior of two pseudoscorpion species belonging to two distantly related families. Specifically, I will describe the reproductive behavior of a tropical species of Chernetidae (*Lustrochernes* sp.), as well as the reproductive behavior of a temperate species belonging to the family Cheliferidae (*Dactylocher silvestris*). Regarding the latter species, I will include footage of the use of the little studied ram's horn organs and discuss their potential function during courtship.

How daddy-long-legs make their long legs: Ten years of research in the first harvestman model system

Prashant P. Sharma, Guilherme Gainett, Vanessa L. González

Department of Integrative Biology, University of Wisconsin-Madison, Madison, Wisconsin, USA
prashant.sharma@wisc.edu

Among the most characteristic traits of Opiliones (harvestmen) are the elongate appendages of daddy-long-legs. While leg elongation has evolved repeatedly across Arthropoda, the appendages of daddy-long-legs represent a multifaceted and complex phenotype, consisting of hypertrophied podomeres (leg segments), subdivision of the tarsus into numerous articles (tarsomeres; these confer flexibility and even prehensility in some groups), and concentration of sensory organs in these "antenniform" appendages. Building upon ten years of methods development for the model species *Phalangium opilio*, we interrogated the developmental genetic basis for leg patterning in this harvestman. Here, we show that the Hox genes Deformed and Sex combs reduced play essential roles in the establishment of leg identity; knockdown of these genes transforms walking legs into pedipalps. To understand the basis for appendage elongation, we investigated the function of Epidermal Growth Factor Receptor (EGFR) signaling for the first time in any arachnid. We identified two paralogs of EGFR in the *P. opilio* genome and targeted one of these that retains a transmembrane domain. Gene silencing against EGFR resulted in short appendages, together with the loss of distal structures (tarsomeres and tarsal

claws), implicating EGFR signaling as a key player in making the quintessential trait of daddy-long-legs.

More than 500 introduced Euchelicerata are established in the United States

Annie Simpson

Science and Analytics Program, U.S. Geological Survey, Reston, Virginia, USA
asimpson@usgs.gov

Comprehensive reviews of the scientific literature and expert databases resulted in an extensive list of more than 500 introduced (non-native) taxa of spiders and their relatives that have become established (with reproducing populations) in Alaska, Hawaii, and/or the conterminous 48 states. Hawaii has, by far, the highest density of introduced Euchelicerata, with 165 Trombidiformes, 98 Mesostigmata, and 80 Sarcoptiformes (mites), 94 Araneae (spiders), 7 Ixodida (ticks), and 5 scorpions and relatives. Alaska, on the other extreme, has two ticks, one spider, and one introduced harvester that are established. The lower 48 states have 34 spider, 20 mite, and 15 tick introduced species that are documented as being established. The author seeks input from AAS members and associates to improve the taxonomic and ecological accuracy of this list of spiders and their relatives that have been introduced and become established in three regions of the U.S.

Differential use of unimodal signals within multimodal courtship signals of a wolf spider, *Schizocosa ocreata*

Brent Stoffer, David L. Clark, Madeline Lallo, G. W. Uetz

Department of Biological Sciences, University of Cincinnati, Cincinnati, Ohio, USA
stoffebm@ucmail.uc.edu

Few study organisms offer the ability to examine whether each sex might differentially use individual signal modalities within a multimodal signal. Such studies might shed light on differential selection pressures on the sexes. Male brush-legged wolf spiders, *Schizocosa ocreata*, use multimodal courtship signals, consisting of vibratory and visual displays. Male *S. ocreata* court in response to female chemical cues, but will also court in response to male competitors in attempts to intercept mating opportunities. Using video and vibratory playback techniques, we investigated the relative importance of vibratory and visual signals for both males (eavesdropping context) and females (mate preference context). Both males and females respond appropriately to each modality played in isolation. Female *S. ocreata* clearly prefer multimodal signals, while male *S. ocreata* court more in response to unimodal vibratory signals. Both sexes, however, demonstrate an ability to learn in each modality. The innate differences in

the weight of unimodal signals suggest different selection pressures on the relative importance of signal modalities or on the sensory systems of each sex.

Origin and diversification of free-living stick spiders of Sri Lanka including the description of four new species of *Rhomphaea* L. Koch, 1872 and two new species of *Neospintharus* Exline, 1950

Mathura Tharmarajan*, S. P. Benjamin

National Institute of Fundamental Studies, Kandy, Sri Lanka
mawva9@gmail.com

We investigated the origin and diversification of Sri Lankan species of *Rhomphaea* and *Neospintharus* representing two recognized genera of Argyrodinae free-living stick spiders, using sequences of three genes: mitochondrial cytochrome oxidase I (COI) and 16S rRNA (16S); and nuclear 28S rRNA (28S). Our phylogeny included 32 taxa (30 ingroup and 2 outgroup). We used Bayesian and Maximum likelihood methods to reconstruct the placement of species, divergent times and their foraging behaviour. The phylogeny strongly congruent with previous studies and offer further support for the monophyly of the Argyrodinae as well as the monophyly of *Rhomphaea* and *Neospintharus*, where *Rhomphaea* is sister to *Neospintharus*. The following new species will be described in future publications: *Rhomphaea* sp *A*, *Rhomphaea* sp *B*, *Rhomphaea* sp *C Rhomphaea* sp *D*, *Neospintharus* sp *A* and *Neospintharus* sp *B*.

Out of Sight Out of Mind: Assessing the Role of Vision in Venom Metering in the Southern Unstriped Scorpion (*Vaejovis carolinianus*)

Treson Thompson*, Alain Czaykowsky, Anjali Filinovich, Erin Burke, Daniel Patil, Wade Pierce, Blake Laing, Aaron G. Corbit, David R. Nelsen

Biology Department, Southern Adventist University, Collegedale, Tennessee, USA
verlethompson@southern.edu

Venom metering occurs when organisms regulate the use of this metabolically and ecologically expensive resource. Research indicates that various environmental factors affect venom use: prey type, prey struggle, and perceived threat of potential predators. Scorpions have sophisticated sensory modalities, but only a handful of studies have attempted to relate these senses to venom metering. We investigated the role of vision in venom metering using adult *Vaejovis carolinianus* (N = 36) scorpions in a randomized, repeated measures design. Vision was reversibly ablated with watercolor paint. We elicited venom use by prodding the scorpions with a parafilm covered loop and expelled venom was collected and quantified using a microliter capillary tube. We found that vision may affect venom use, with blind scorpions stinging more

quickly and being more likely to eject venom when stinging. Vision also may affect running escape behavior with blinded females running less than unblinded females and less than blinded males. Overall, we found marginal evidence that vision plays a role in decisions about whether to use venom or not, but not on the volume of venom released. Thus, the role of vision in venom metering may not be as critical as other sensory modalities in this species.

Eye size reflects habitat and sex in tarantulas

Lily E. Turri, Caitlin L. Nordheim, Saoirse Foley, Sebastian A. Echeverri

Pittsburgh Allderdice High School, Pittsburgh, Pennsylvania, USA
turri.lily@gmail.com

Environment and lifestyle can shape how animals' eyes evolve. For example, eye size, a critical factor in determining visual ability, is often correlated with habitat (e.g., terrestrial vs. arboreal) and/or behavior, such as activity patterns. However, much of our understanding of eye size evolution is limited to "highly visual" animals within a few groups—often vertebrates and insects. Here, we investigate how eye size evolves in an understudied group where vision is a secondary sense. Tarantulas (Araneae: Theraphosidae) have small eyes compared to many other spiders, and their vision is typically assumed to be unimportant. However, tarantulas live in diverse habitats with similarly diverse visual properties. While there have been almost no rigorous tests of tarantulas' vision, recent molecular work suggests a potential for color vision. We compiled morphological and ecological data from published literature and tested for correlations between eye size, and habitat and sex. We found that arboreal species have larger relative eye diameters than terrestrial species in three of the four eye pairs, as do males of both habitats. Arboreal species also have a larger absolute AME diameter. Our results suggest that, despite previous assumptions, arboreal tarantulas have experienced selection for improved (albeit still weak) vision.

Transmission of vibratory courtship signaling of *Schizocosa ocreata* (Hentz) and *S. saltatrix* (Hentz) wolf spiders in leaf litter.

George W. Uetz, Kelly Gunderson, Alyvia Kreps, Abigail Ketterer, Kara Mize, Olivia Bauer-Nilsen, Theresa Culley

Biological Sciences, University of Cincinnati, Cincinnati, Ohio, USA
george.uetz@uc.edu

Complex forest leaf litter has been shown to impact communication in lycosid spiders. We studied transmission of vibratory courtship signals of two co-occurring congeneric wolf spiders, *Schizocosa ocreata* (Hentz 1844) and *S. saltatrix* (Hentz 1844), on invasive Callery Pear leaves and those of native tree species (Maple, Oak, Sycamore), using laser Doppler vibrometry. On

single leaves, the power spectrum of courtship signals from *S. ocreata* (louder of the two species) showed higher amplitude in the midrange of frequencies on Callery Pear leaves than on other leaf species. Courtship signals of male *S. saltatrix* signals showed a similar pattern, although at lower amplitude. Despite differences in vibration transmission, microcosm mating trials showed no significant difference between litter types. One explanation may be that these co-occuring lycosid species have different courtship modes: *S. saltatrix* relies solely on vibratory signaling; *S. ocreata* has multimodal (visual and vibratory) signals. In addition, the structure of vibration signals is markedly different between these two spider species, which could affect transmission and perception. Overall, results suggest that invasive Callery Pear can affect frequency spectra and amplitude of vibratory signals, but its impact on mating remains unclear.

SPIN-CITY: urbanisation effects on colour, size and web building in *Araneus diadematus*

Bram Vanthournout, Pieter Vantieghem, Katrien De Wolf, Hans Matheve, Matthew Shawkey, Dries Bonte

Biology Department, Ghent University, Ghent, Belgium
bram.vanthournout@ugent.be

Cities can be viewed as “living labs” that provide unique opportunities to investigate evolution in real-time as they differ markedly in (a)biotic factors compared to surrounding rural areas. Urban areas can heat up considerably due to the heat island effect. It is expected that this increased temperature prompts an evolutionary colour response with lighter individuals in urban areas that can stay cooler compared to their darker counterparts. Because of smaller prey in cities, it is also expected that spiders build webs with smaller meshes to increase capture efficiency. We investigated urbanisation effects on *Araneus diadematus* in Ghent (Belgium) using a picture based approach, supplemented with spectrophotometry and thermography. We also present “SPIN-CITY for scientists”: we are currently looking for collaborators to investigate these urbanisation effects through replicated sampling of cities across Europe and North America (www.spiderspotter.com).

The ecology of spider sociality – A Spatial Model

Zsóka Vásárhelyi, István Scheuring, Leticia Avilés

Biodiversity Research Centre, University of British Columbia, Vancouver, British Columbia, Canada
laviles.ubczool@gmail.com

The emergence of animal societies offers unsolved problems for both evolutionary and ecological studies. Systems with a strong signal in their geographic distribution can shed light on the factors that favour or hinder group living. Based on 30+ years of research on the spider

genus *Anelosimus*, we developed a spatially-explicit simulation model to test the hypothesis that gradients of increasing insect size and disturbance (strong rain, predators) with proximity to the lowland tropical rainforest are necessary and sufficient to explain why social species are concentrated in lowland tropical areas, whereas subsocial species, absent from these areas, are present at higher elevations and latitudes. The model recreated the observed patterns when both insect size and disturbance gradients were present. With small prey everywhere, on the other hand, social species disappeared from the grid, whereas when high disturbance was applied everywhere, higher elevations became empty as large colonies could not form in the absence of large prey, but small colonies were wiped out due to disturbance. The model thus supports the need for large insects for large social colonies to form and the importance of disturbance in creating conditions that require group living while tempering the dynamics of large social groups.

Predicting the fate of nitrogen during spider-arthropod trophic interactions

Shawn Wilder, Cody Barnes

Department of Integrative Biology, Oklahoma State University, Stillwater, Oklahoma, USA
shawn.wilder@okstate.edu

Spiders prey on a diversity of arthropods. Yet, understanding how spiders affect the flow of nitrogen in food webs is complicated because spiders ingest some N-containing compounds like protein from prey and discard other N-containing compounds like exoskeleton. Feeding assays allow researchers to measure which parts of prey are digested versus discarded but it is not feasible to conduct feeding assays on all potential prey items. Here, we test if measures of exoskeleton can help predict how much N is digested versus discarded by spiders from a diversity of potential prey. Arthropod prey varied widely in exoskeleton content from 11 – 58 % of dry mass. Exoskeleton was approximately 9.5 + 0.8 % N. As a consequence, the total N content of arthropods overestimated the amount of N present in the soft tissues of arthropods. Non-exoskeleton N was more closely related to the amount of N present in metabolizable amino acids in prey. Our results suggest that a simple assay of arthropod exoskeleton content can improve predictions of how much prey N will be consumed by spiders versus discarded as uneaten prey parts.

Differential Scaling of Spider Groups (Order: Araneae)

Sara M. Wilmsen*, Edward M. Dzialowski

Department of Biology, University of North Texas, Denton, Texas, USA
sarawilmsen@my.unt.edu

Metabolic rate has a large influence on life history of animals, as such, allometric scaling of metabolic rate has been the subject of intense research for over 100 years. Metabolic rate scales with body mass to the 0.75 power when examined over a wide range of taxa and body masses. However, individual taxa may scale at different exponents. Spider's possess unique and variable respiratory structures and life history traits that might lend them to variable scaling. Respiratory structures range from one to two pairs of book lungs to book lungs accompanied by tracheae, to exclusive use of tracheae. Their predation strategies vary from active hunting to sit-and-wait predation. In this meta-analysis, I collected metabolic rate and body mass data on 59 species of spider representing 18 families from 38 previously published papers. Species were organized into 5 groups based on phylogeny, respiratory structure, and predation modes. I found that the RTA clade scales at a lower slope than expected. Additionally, while the mygalomorphs do scale at the predicted rate, they show lower metabolic rates per body mass. These results have implications for the role of respiratory structure and life history in the scaling of metabolic rate.

The effect of acclimation to a fluctuating temperature on CO2 production during and after exercise in the Desert Tarantula *Grammastola rosea*

Sara M. Wilmsen, Daniella C. Romano-Olivia, Stephanie E. Rector, Al S. Martin, Edward M. Dzialowski

Department of Biology, University of North Texas, Denton, Texas, USA
sarawilmsen@my.unt.edu

Thermal metabolic compensation is a theory stating that ectotherms acclimated to lower temperatures will have a higher metabolic rate at a given temperature than those acclimated to higher temperatures. This partial compensation of MR increases overall fitness at low temperatures for these animals. It is tempting to forget that organisms rarely experience constant temperatures. This is true for desert species that can see ranges of 15-20C within a 24 hr period. In this study *Grammastola rosea* was used to investigate the implications of fluctuating environments on CO2 production during and after exercise. We examined SMR and MR during exercise at 15C and 30C following acclimation to 15C, 30C, and a treatment fluctuating between the two temperatures. As expected, the lower temperature acclimated spiders had a higher SMR than those acclimated to the higher temperature. However, the 15C spiders produced less CO2 during and after exercise than the 30C spiders. In the fluctuating treatment, spiders had an even higher SMR at both temperature than other treatments. This study raises questions about the effects of acclimation to a fluctuating temperature on the overall physiology of the animals and has possible implications on the effect of climate change on small ectotherms.

Geometric morphometrics reveal sister species in sympatry and a cline in genital morphology in a ghost spider genus

Jeremy D. Wilson, Lorena V. Zapata, Mariana L. Barone, Darko D. Cotoras, Dante Poy, Martín J. Ramírez

División Aracnología, Museo Argentino de Ciencias Naturales, Buenos Aires, Argentina
jeremydwilson91@gmail.com

Morphological boundaries between species of the *Sanagosta maculatipes*-group are ambiguous, and the most widespread species, *S. maculatipes*, is variable and may represent multiple cryptic species. We performed a geometric morphometric analysis on the female genitalia of this group, visualizing and testing differences in shape between current and putative species. We complemented this with a multi-locus phylogenetic analysis to place the morphological results in a phylogenetic context. Our study revealed that two species in the group, *S. alticola* and *S. mandibularis*, are morphologically and molecularly distinct lineages, however, *S. maculatipes* actually consists of two widespread sister species which occur in sympatry throughout the grasslands of northern Argentina. We further discovered a geographical cline in the shape of the female genitalia of one of these sister species, such that specimens from the east and west of the range display morphological differences comparable to those between species, despite being virtually identical at the COI locus. Our study demonstrates the strength of a geometric morphometric approach for identifying species boundaries in complexes where morphological differences are subtle and confounding factors such as overlapping ranges, allometry and high levels of intraspecific variation are present.

The Environmental Impact of Spiders - Outreach for Adult Audiences

Winnifred Wolfe*

freddie.wolfe2009@gmail.com

Most of my outreach for the past seven years has been geared towards a K-12 audience. Because of this my focus had previously been based on folklore and hands-on activities. Due to the pandemic I put my educational programs on pause and I am working to develop a new model with a different emphasis that will appeal to older audiences. I will have more of an impact on more mature audiences if the materials I present to them are scientifically based so I am gathering evidence to develop and support this new model. I hope this outreach will have an even greater impact as some people with arachnophobia were raised to believe spiders are a threat. If adults are given positive education on spiders they will pass it on to the next generation. Furthermore, virtual experiences should be encouraged and continued beyond the pandemic so adults can interact with outreach animals from a distance. I hope my research not only benefits myself but also influences others who want to do similar outreach.

Evolutionary relationships among extant and extinct palpimanoid spiders

Hannah M. Wood

Smithsonian National Museum of Natural History, Washington, D.C., USA
woodh@si.edu

Palpimanoid spiders are comprised of five extant families, and have an extensive fossil record going back to the Jurassic. Palpimanoids have been described from Burmese amber (Cretaceous age), as well as from other parts of the world (e.g., Baltic amber, Eocene age, Inner Mongolia compression fossils, Jurassic age). Previous total evidence analysis of Archaeidae revealed a distinct Northern and Southern Hemisphere clade, with timing of divergence congruent with the break-up of Pangaea into Laurasia and Gondwana. Since then, many more palpimanoid fossils have been discovered. The current study expands upon this previous work by increasing taxon sampling to focus on the palpimanoids, rather than Archaeidae, and includes examination of over 100 fossil specimens. A morphological matrix of ca. 300 characters was developed with the goal of understanding the evolutionary relationships between extant and extinct palpimanoids. Preliminary findings suggest that all extant palpimanoid families have fossil representatives, with evidence that some had already begun to diverge in the Jurassic. Other results suggest that lineages in Burmese amber have Gondwanan affinities, whereas lineages in Indian amber have affinities to northern Europe. This research reveals ancient diversification patterns in an unusual group of spiders that have persisted over vast geological time scales.

Spiders of Iran: past, present and future

Alireza Zamani*

Zoological Museum, Biodiversity Unit, University of Turku, Finland
zamani.alireza5@gmail.com

Although the morphology, biology, and behavior of spiders have been used frequently as metaphors by Iranian (Persian) poets throughout the history and the first published observation of these arachnids in this country dates back to 1656, the scientific documentation of the species composition of this group in this vast and zoogeographicaly interesting region is relatively young and still far from complete. The first known scientific collection of Iranian spiders was made by Eugen von Keyserling and Theophil Bienert during 1859, but a scientific contribution was not published until a couple of decades later in 1874 by Eugène Simon; the first such publication by an Iranian researcher was published much later in 1958, and wasn't followed until mid-90's, when a few other local researchers began to investigate the spider fauna of the region. In the intervening period, several important taxonomic and faunistic papers were published by foreign researchers, and the most comprehensive collection of spiders of this country was made by Antoine Senglet in 1973–1975. Since the first checklist of Iranian spiders in 2001 which listed the occurrence of only 141 species, the number of species reported from

this region has almost sextupled thanks to dozens of taxonomic surveys and large-scale faunistic works. In my presentation, I will review the history of spider research in Iran, with a special focus on the data acquired the past seven years, and present a path toward the continuation of this field of study.