ABSTRACTS

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

ORAL PRESENTATION ABSTRACTS

Comparative spigot ontogeny across the spider tree of life

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Spiders are well known for their silk and its varying uses across taxa. Recent phylogenomics studies have shifted major paradigms in our understanding of silk use evolution, reordering phylogenetic relationships that were once thought to be monophyletic. Considering this, we explored the full spigot ontogeny in 22 species, in the first study of its kind and to incorporate the Araneae Tree of Life. We performed phylogenetic generalized least squares analyses on adult female and second instar spigot morphology. Six analyses had significant correlation coefficients, suggesting that instar, strategy, and spigot variety are good predictors of spigot number in spiders. We performed ancestral character estimation of singular, fiber producing spigots on the posterior lateral spinneret whose potential homology has long been debated. We found that the ancestral root of our phylogram of 22 species, with the addition of five cribellate or ecribellate lineages, was more likely to have either none or a modified spigot rather than a pseudoflagelliform gland spigot or a flagelliform gland spigot. We suggest that the modified spigot and pseudoflagelliform gland spigots are homologous structures. We can build on our efforts from this novel spigot ontogeny approach by growing the dataset to include deeper taxon sampling.

Session 2: Morphological evolution & taxonomy

Physiological control of microstructural-chemical interactions in adhesiveness of spider capture silk

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The University of Akron

The “bead-on-a-string” (BOAS) microstructure of viscid capture silk self-assembles due to Rayleigh instability. The final size and spacing is determined primarily by the initial glue coating thickness and we propose three hypotheses for how thickness is controlled: water uptake from air dominates the initial conditions so that web to web variation in BOAS is largely non-adaptive; spider spinning behavior largely determines the initial thickness so that spiders can approach a single, optimal BOAS across varying environments; the spider reacts physiologically to the humidity of the environment in a way that achieves different BOAS architectures that “optimize” glue’s water content for different environments. We measured glue microstructure and chemistry using webs from same individual spiders building in humid and dry conditions, and quantified the effect of microstructure on capture silk adhesion. Preliminary results suggest that BOAS microstructure is determined through an interaction between spider spinning behavior with the environment as both water uptake by the glue and the amounts of glue materials (glycoproteins, water and low molecular mass compounds) are different for wet-built versus dry-built webs. Understanding the control of BOAS microstructure self-assembly is therefore key to understanding capture silk function and to translating these design principals into synthetics.

Session 6: Silk II

A non-native ant-mimicking spider in western New York: habitat preferences, life history, and behavior

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The ant-mimicking spider Myrmarachne formicaria (Salticidae) is a recent arrival to North America from Eurasia with first reports of its presence in New York dating to 2006. Most published accounts and iNaturalist observations of this species in its invaded range are from domestic settings inside or near buildings. This study aims to describe M. formicaria's habits in more natural settings. M. formicaria has become noticeably more common in our campus's Roemer Arboretum in Geneseo, NY, often seen near ant nests under study, with silken shelters built on the vinyl flags marking colonies. To determine if these spiders are consistently associated with mound-nesting ants or particular habitats, grids of flags were employed as a sampling method. Though commonly encountered near Formica ant nest mounds, M. formicaria can be found in areas devoid of such nests. In addition to using artificial substrates, M. formicaria builds its shelters in the folds of leaves. Females remain in their shelters with spiderlings for an extended time. Overwintering sites may include hollowed stems, empty snail shells, and crevices in bark. Continued work in this system includes assessing the nature of this spider's interactions with ants and other spiders and describing its life history and breeding behavior.

Session 9: Ecology, diversity, & life history

Kin recognition in two species of cellar spiders, (Pholcidae), and its effects on inter- and-intra-specific predation of spiderlings

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Cannibalistic species should have a mechanism to identify offspring and potential mates and suppresses predatory behaviors toward them. A similar process may facilitate reduced competition and enhanced fitness when introduced to new environments by selectively killing and consuming the offspring of others. This intense predation on the young of heterospecific competitors may be one way that an invasive species can take over a habitat from a well-established population. We tested this hypothesis using two non-native species of pholcid spiders in Ohio, the larger, well established Pholcus phalangioides and the smaller, newly invasive Pholcus manueli. In the laboratory, we allowed females of both species to produce clutches. Once hatched, the spiderlings were separated from their mother, for 1 hour, and then introduced to the mother, a conspecific, or a heterospecific adult female. The number preyed upon was recorded. Our results showed that P. phalangioides predation patterns were consistent across species, but that P. manueli feed on P. phalangioides young at 3x the rate of young conspecifics. Further mothers did not prey on their own young. This shows that these species can selectively repress predation and that P. manueli may gain an advantage by selectively preying on the young of other species.

Session 11: Behavior II

New insights into the sophisticated performance of ancient capture silks

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Cribellate capture silk is the most ancient adhesive silk in prey capture webs. However, cribellate silk research mostly focuses on uloborids, whose capture threads lack coiled reserve warp fibers and are stiff and extend <100% - more like dragline than viscid silk. Here, we describe sophisticated performance for threads from two diverse cribellate species. Psechrus clavis shows that coiled reserve warp fibers maintain structural integrity of capture threads long after the core axial fibers break, allowing threads to extend 500% before breaking. Axial threads can repeatedly rupture during extension as the cribellate fibrils likely act as a binder. Both aspects add greatly to the work of adhesion performed by this cribellate silk. The reserve warp similarly promotes adhesion in the distant Progradungla otwayensis, but this spider also uses spinning behavior to produce a second mechanically distinct type of cribellate thread that is ~10x stronger and stiffer when they don't comb the reserve warp into its typical highly coiled state. Variation in cribellate silk performance is much greater than previously appreciated and should therefore be investigated as a potential driver/outcome of diversification of ancient cribellate capture webs.

Session 5: Silk I

Revisiting the role of silk in prey capture by nonaraneomorph spiders

Bond, Jason, Vera Opatova, Marshal Hedin, Chris Hamilton

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The Infraorder Mygalomorphae is one of the three main lineages of spiders comprising over 3,000 nominal species. This ancient group has a world-wide distribution that includes among its ranks large and charismatic taxa such as tarantulas, trapdoor spiders, and highly venomous funnel web spiders. A comprehensive phylogenomic treatment of the infraorder using 427 Anchored Hybrid Enrichment loci provides an evolutionary framework for revisiting questions regarding silk use in mygalomorph spiders. The first such analysis for the group within a strict phylogenetic framework shows that a sheet web is likely the plesiomorphic condition for mygalomorphs, as well as providing hints to the ancestral foraging behavior for all spiders.

Session 7: William Shear mini-symposium

Stable isotope analysis and venom gland transcriptomics of ecologically divergent long-jawed orb weavers (Araneae: Tetragnathidae: Tetragnatha versicolor)

Brewer, Michael, Zarif Hasan

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Spiders are the most successful group of venomous animals, comprising more than 47,000 described species with total estimates up to 120,000. Much of their success can be attributed to their approximately 2 million unique venom peptides. Despite this, many spider venomes are uncharacterized, including those of speciose and/or ecologically diverse taxa. To investigate the intraspecific evolutionary ecology of spider venomes, Atlantic Coastal Plain and Appalachian Highland populations of the widespread North American species Tetragnatha versicolor were studied. Divergences in trophic niches were determined via stable isotope analyses. Differential gene expression and differential transcript usage corresponding to trophic niche differences indicated expression-level variation of venom components. Using three novel bioinformatics tools, the sequence-level molecular evolution of venom peptides was examined. Venom gland expressed gene families were reconstructed and analyzed for evidence of pervasive selection. Additionally, orthologs were identified and tested under explicit phylogenetic frameworks for branch-specific rates of protein evolution between populations. Lastly, putative venoms were identified, many never before characterized in any spider, using a newly developed machine learning technique. These results indicate a complex yet logical framework of population-level evolution in ecologically divergent populations of T. versicolor.

Session 8: Intraspecific evolution & biogeography

Fertilization control via spermathecal morphology: opilionid mating from the female perspective

Burns, Mercedes

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Most arachnid fertilization occurs internally, allowing for a variety of post-copulatory mechanisms to take place. Females are expected to exert some level of control over sperm fate when 1) the the point of fertilization is particularly distant from the point of oogenesis, 2) the time of fertilization is occurs significantly later than the time of mating, 3) sperm are non-motile, and/or 4) the morphology of females allows for selective containment of sperm. Many of these conditions are met in Opiliones. Fluorescent microscopy of spermathecae from Opiliones of the suborder Eupnoi has revealed a variety of morphologies that may have critical function in controlling seminal movement, and we have evidence of polygynandrous mating and delayed oviposition in a number of species. Preliminary data on spermathecal morphology in genus Leiobunum has not followed initial expectations that more complex spermatheca would be found in species with conflict-based mating systems, as females of species with high sexual antagonism have relatively simplistic spermatheca, while females of species with low antagonism have multi-chambered organs with apparent valvular openings. These findings will have significant implications for the study of reproductive mode maintenance in parthenogenetic species that may use spermathecal mechanisms to withhold or bias paternity.

Session 7: William Shear mini-symposium

Global phylogeny and biogeographic history of net-casting spiders (Family: Deinopidae)

*Chamberland, Lisa, Tess Ruddy, Jay A. Stafstrom, Ingi Agnarsson

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Historically, morphology has indicated two genera within the net-casting spiders (Family: Deinopidae), Deinopis (the ogre-faced spiders– aptly named for their enlarged posterior median eyes (PME) and Menneus (the humpback spiders). Both genera within this ancient, Early Cretaceous era lineage share the unique net-casting hunting strategy in which they cast their nets over prey; however, only Deinopis have the enlarged PME. These eyes, the largest simple eyes of all arthropods and 2000 times more sensitive to light compared to human eyes, are adapted to enable Deinopis to hunt at night in low-light conditions. The introduction of molecular data within this family revealed an unexpected result– Old World Deinopis were more closely related to Menneus from South Africa than to New World Deinopis. We hypothesized that the size of the uniquely large posterior median eyes (characteristic of Deinopis) has been secondarily reduced in Menneus. Using a combination of standard Sanger and Next Generation sequencing data, we test whether Menneus dispersed over water to Australia from Africa or Menneus morphology (large PME) evolved independently on both continents. Here, I present a preliminary global phylogeny and outline the ongoing methods we are using to explore these exciting and unexpected evolutionary relationships.

Session 3: Molecular phylogenetics & systematics

Untangling the structure and function of social pseudoscorpion silk nests

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Psuedoscorpions build circular silk cells around themselves before molting. Colonies of the social pseudoscorpion Paratemnoides elongatus form a nest by linking several silk cells, and, unlike nearly all species of pseudoscorpion, use cells to lay clutches of eggs. Here, we present new findings regarding the structure and function of social pseudoscorpion silk. We investigated nest architecture and tested for antimicrobial properties of silk. We found that P. elongatus silk supports the growth of a seemingly mutualistic fungus that might aid in defending the colony from microbial invasion. Further, we characterize the nest architecture of this poorly understood species.

Session 5: Silk I

Sexual size dimorphism: evolution and perils of extreme phenotypes in spiders

Coddington, Jonathan, Matjaz Kuntner

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Sexual size dimorphism (SSD) is one of the most striking animal traits, and among terrestrial animals is most extreme in certain spider lineages. The most extreme examples (eSSD) are female biased size differences. eSSD itself is probably an epiphenomenon of gendered evolutionary drivers whose strength and direction are diverse. We demonstrate that eSSD spider clades are aberrant by sampling randomly across all spiders to establish overall averages for female (6.9 mm) and male (5.6 mm) size. At least sixteen spider eSSD clades exist. We explore why the literature does not converge on an overall explanation for eSSD and propose an “equilibrium” model featuring clade and context-specific drivers of gender size variation. eSSD affects other traits such as sexual cannibalism, genital damage, emasculation, and monogyny with terminal investment. Coevolution with these extreme sexual phenotypes is termed eSSD mating syndrome. Finally, as costs of female gigantism increase, eSSD may represent an evolutionary dead end.

Session 2: Morphological evolution & taxonomy

Scaring the silk out of spiders: The use of defensive silk in response to threatening, biological stimuli in the western widow spider (Latrodectus hesperus)

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The western widow spider (Latrodectus hesperus) is known to modulate its defensive behavior based on perceived level of threat, utilizing more costly and risky behaviors (like biting and venom use) as the perceived threat increases. One, little studied, aspect of their defensive behavior is the use of defensive silk. When threatened, these spiders actively try to place silk with large viscous globules on the potential threat. Preliminary evidence suggests that L. hesperus can modulate many aspects of defensive silk use, including the time to initial release, the volume produced, and the rate at which it engages in silk-releasing behavior. We examined whether L. hesperus can distinguish between threatening and non-threatening biological stimuli and modulate its defensive silk use accordingly. Using a repeated measures design, we exposed spiders to five different stimuli. These included specimens of both dried and frozen-then-thawed predatory wasps from several species, dried and frozen-then-thawed house crickets (Acheta domesticus), and a non-biological control. We found evidence that these spiders release defensive silk more quickly when exposed to the frozen-then-thawed crickets and wasps than the non-biological control. This suggest these spiders can distinguish between different biological stimuli and modulate their defensive behavior accordingly.

Session 10: Behavior I

Progress towards in-vivo 2-photon calcium imaging in the hackled orbweaver

Corver, Abel, Nicolas Wilkerson, Jeremiah Miller, Andrew Gordus

Johns Hopkins University

The neurophysiological basis of cognitive behavior is a longstanding question in the neurosciences. The web-making of the hackled Orb-weaver Uloborus diversus is highly stereotyped and structured across multiple timescales, suggesting a role for internal states in regulating this process. With on the order of 100,000 neurons, U. diversus offers a tractable model organism for the functional study of cognitive neural circuits. Here, we share our progress establishing functional, in-vivo calcium imaging in this spider, using recently developed membrane-permeable calcium dyes and 2-photon microscopy, and will highlight our behavioral assays and machine vision pipeline tracking the spider's limb movements and web structure in real-time. Together, our behavioral modeling and neurophysiology aim to establish a mechanistic state-space model of web-making.

Session 10: Behavior I

Dear ticks, do you have metal? An elemental analysis of the hard bodied tick's exoskeleton.

*Cote, Jessica

University of Massachusetts Lowell

Phylum Arthropoda includes a wide variety of insect and arachnid vectors. These arthropods are generally ectoparasites that depend on the blood of vertebrate hosts for both nourishment and reproduction, and as a result, function in the transmission of parasitic protists, bacteria, and viruses. Naturally, the disease-causing organisms are the focus of most studies, while details about the vectors are often less well known. Here, I provide new details on one group of well-known vectors in New England, the hard-bodied ticks. Ticks are arachnids, and as such, might be expected to have similar exoskeletons to spiders and scorpions, both of which contain metals in their mouthparts to aid in predation and defense. Presently, there are no studies on the elemental composition of the tick exoskeleton to verify this, so my aim is to test for the presence of metals in three well-known species: Dermacentor variabilis, Ixodes scapularis, and Ambylomma americanum. The mouthparts and general body cuticle were examined with energy dispersive x-ray spectroscopy to determine their trace element composition. Current data reveals the presence of chlorine throughout their exoskeleton and trace amounts of calcium in their chelicerae, but strangely, none in their hypostome. Studies of other species are ongoing.

Session 1: Functional morphology

The Curious Case of Tarsal Claws: taxonomic and phylogenetic significance of tarsal claws in solifugae (Solifugae: Eremobatidae)

Cushing, Paula, Jack O. Brookhart

Denver Museum of Nature & Science

The author‘s current research is focused on the evolutionary history, taxonomy, morphology, and behavior of solifuges in the family Eremobatidae. A recently published multi-locus molecular phylogeny of this North American family supported the monophyly of the family Eremobatidae, but indicated that the previous taxonomic subfamily division was not supported. Previous to this analysis, the Eremobatidae was divided into two subfamilies: 1) the Erembatinae, which included five genera and 2) the Therobatinae, which included three genera. The diagnostic character for the Eremobatinae was the presence of a single, modified tarsal claw on the tip of the first leg. The genera placed in the Therobatinae possessed two tarsal claws on the first leg. Using Scanning Electron Microscopy, we reanalyzed the tarsal claws in all eight genera of Eremobatidae and in different juvenile developmental stages to determine: 1) how variable this character is in the lifetime of eremobatids; 2) whether there is evidence of fusion of the two claws into one as the solifuges mature; 3) whether the number of tarsal claws had been correctly assessed previously using only light microscopy; and 4) if there is any evidence that this morphological trait can be used as a diagnostic character for well-supported clades.

Session 2: Morphological evolution & taxonomy

City of immigrants: a review of the introduced jumping spiders of New York City, with new data (Araneae, Salticidae)

Cutler, Bruce, Matt Parr

University of Kansas

As a major port of entry to North America, it is not surprising that New York City has seen the arrival of numerous non-indigenous salticid species, and that several of these have become established. This paper offers an overview of the city’s introduced fauna, with notes on the origins, history, and habitat preferences of individual species. It presents preliminary new evidence that Hakka, Heliophanus, and Pseudeuophrys—genera not previously reported in New York City—have also become established. Finally, it identifies synanthropic, non-native species observed elsewhere in the region that may arrive in the future. Monitoring these previously unreported populations and potential future arrivals is a task for which increasingly popular citizen-science platforms such as iNaturalist and BugGuide are proving themselves very useful.

Session 9: Ecology, diversity, & life history

Phylogenetic analysis of the family Cosmetidae (Opiliones, Arachnida) using a total evidence approach.

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Cosmetidae (Arachnida: Opiliones) is the most diverse harvestmen family in Central America, and second to the family Gonyleptidae in the Neotropics (Townsend et al., 2010). The family Cosmetidae remains a poorly studied group of Opiliones, and benefits from any taxonomic work. The current analysis is an attempt at understanding the relationships within the family Cosmetidae. A total evidence approach was used, using direct optimization in POY and Maximum Likelihood in RaxML. Five molecular markers were used (28S rRNA, 12S rRNA, 16S rRNA, COI, and H3), and a variety of morphological characters (i.e. genitalia characters, dorsal scutum outline, dorsal scutum armature) to determine monophyletic clades. What has been shown in these analyses is that the current subfamilies of Cosmetidae (Discosomaticinae and Cosmetinae) are not valid, pectination of tarsal claws III and IV arose multiple times in various forms. While some monophyly of genera is implied in this analysis (see Taito, Metalibitia, and Ferkeria), other genera who have been rediagnosed in recent literature (Cynorta, Paecileama, and Cosmetus) are not supported in this analysis, though this result is expected. New diagnoses should focus on genitalia characters, such as number and position of lateral setae of the ventral plate of the penis.

Session 3: Molecular phylogenetics & systematics

Phylogenomics of the enigmatic Fumontana deprehendor Shear 1977 (Opiliones: Triaenonychidae)

Derkarabetian, Shahan

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In 1977 Bill Shear described an enigmatic and rare harvester species from the Great Smoky Mountains in eastern North America that he included in the Triaenonychidae, a family that is found entirely in the southern hemisphere. Since it's description, it has been the focus of several papers, and as the lone northern hemisphere representative of a Gondwanan family, it has been an important taxon in higher-level Opiliones systematics. Using data derived from sequence capture of ultraconserved elements, I will discuss preliminary results of several ongoing research projects focusing on, or including, Fumontana deprehendor at different taxonomic levels. First, I will explore phylogeography of this species in the southern Appalachians using UCE-derived SNPs comparing results to previous work. Currently a monotypic genus, I will explore the possibility of undescribed Fumontana species by conducing species delimitation analyses using traditional and machine learning approaches. Finally, I will discuss its phylogenetic placement in the broader Triaenonychidae phylogeny. I'll also tell a story relating to Bill.

Session 7: William Shear mini-symposium

Reverse-engineering scorpion pectines: the making of a navigational algorithm

Gaffin, Douglas, Albert Musaelian

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The mechanism by which animals with simple nervous systems navigate back to their homes is a major open question. One hypothesis is navigation-by-scene-familiarity (NSF): An animal learns the surroundings of its home by going some short distance away and returning by dead reckoning; as it returns, it "remembers" the scenes it senses along the way. To return home from subsequent excursions, the animal continually moves in the direction that seems most familiar. We hypothesize that scorpions return to their burrows by using the dense matrices of chemo-tactile peg sensilla on their pectines and a variation of NSF. We have produced a simulated scorpion agent that navigates over a two-dimensional black-and-white landscape. The sensor properties are informed by current understanding of the sensitivity, information density, and scale of the pectines. Observed scenes are represented as matrices, and familiarity is measured by the sum of absolute pixel-by-pixel differences between the currently experienced scene and those stored in memory. The agent then moves in the direction of the most familiar scene. We have demonstrated the agent's ability to successfully recapitulate moderately complex training paths on small landscapes, even with low-resolution sensors.

Session 10: Behavior I

Evolutionarily divergent silk proteins may explain the unrivalled toughness of Darwin's bark spider dragline used in giant orb webs

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Spiders produce multiple silks with different mechanical properties. Of the seven silk types synthesized by orb weaving spiders, most studies have focused on dragline silk used in orb web radii and framelines due to its high tensile strength and toughness. However, far less attention has focused on interspecific variation of specific silk types. For example, dragline from different species substantially varies in toughness, as exemplified by Darwin's bark spider (Caerostris darwini), the dragline of which can be twice as tough as previously tested silks. Such extreme toughness may be adaptive given that this species constructs the largest measured orb webs. Variation in silk mechanics is in part linked to sequence variation in the structural proteins (spidroins) composing these fibers. Here we present the results of efforts to characterize proteins composing C. darwini dragline using transcriptomic and proteomic approaches. We find evidence of novel spidroin transcripts in this species' major ampullate silk glands that may explain the greater toughness of C. darwini dragline. We also present progress on our larger collaborative project aimed at characterizing dragline across the Caerostris genus to better understand the evolution of ultra-tough silk and giant webs.

Session 5: Silk I

Effects of non-photic zeitgebers on the circadian clock in the common house spider, Parasteatoda tepidariorum

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Circadian rhythms are endogenous cycles regulating physiological and behavioral changes, that can be affected by environmental factors, allowing most eukaryotic organisms to synchronize their daily activities with the 24-hour day. Parasteatoda tepidariorum, the common house spider, demonstrates a short-period circadian clock averaging 21.6 hours when left in constant darkness yet are able to entrain to the 24-hour light cycle. We tested whether these spiders were able to use non-photic Zeitgebers to entrain to the 24-hour day and observed the effects of consistent vs irregular Zeitgebers. Food, disturbance, and temperature were not found to be effective cues for the spiders' entrainment. While the spiders were not affected in terms of entrainment for either consistent or irregular non-photic Zeitgebers, their duration of activity was significantly different when given an irregular non-photic Zeitgeber. The spiders receiving a consistent food source had focused rhythmic activity reflecting a circadian specialist strategy. Spiders exposed to a food source provided randomly had more spread-out activity throughout the day reflecting a circadian generalist strategy. This suggests that Parasteatoda tepidariorum are capable of facultatively adjusting their circadian strategy to accommodate the surrounding food availability which causes individuals within the species to be specialist or generalist based on available resources.

Session 4: Circadian Rhythms

Bridging the gap: Bridge threads improve energy dissipation in Micrathena webs

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The webs of orb weaving spiders are designed to dissipate the kinetic energy of flying prey. The amount of kinetic energy capable of being dissipated is dependent upon dissipation of energy through the radial and capture threads of the web, as well as through aerodynamic dampening. However, one aspect of energy dissipation that has not been discussed is the role of the bridge threads-the supporting lines that border the web and anchor it to the surrounding substrate. In this study we examine the web of Micrathena gracilis, whose orb web is supported by long bridge threads. By shooting projectiles into webs with constrained and unconstrained bridge threads, we were able to see the effect bridge threads had on energy dissipation. Projectiles broke through webs with constrained bridges 94% of the time. In contrast, webs with unconstrained bridge threads broke only 55% of the time and dissipated more energy than constrained webs. This study shows that bridge threads play an underappreciated role in how energy is dissipated through a web and shows the value in studying webs in more natural settings as opposed to strict laboratory confines.

Session 5: Silk I

Genomic and morphological divergence in oasis-dwelling Habronattus (Salticidae) from western North American deserts

Hedin, Marshal, Brendan Boyer

San Diego State University

Low elevation deserts of the western US are some of the harshest terrestrial environments on Earth. At least for some taxa, this xeric harshness is recent, as large pluvial lakes connected by extensive riparian corridors occupied these regions during the Pleistocene. For the desert taxa associated with riparian habitats, it is expected that historical bouts of isolation and connectedness, modern-day isolation, and possible selective differences within and across basins will leave an evolutionary footprint. Here we explore this footprint in the salticid species Habronattus tarsalis. This species occupies a large range in regional deserts, but is tightly associated with desert saltgrass found along intermittent riparian corridors or at desert oases, in an otherwise inhospitable desert landscape. As such, H. tarsalis represents an inverted "sky-island" system useful for testing Pleistocene evolutionary hypotheses. Considering both morphological and genomic divergence we ask: do populations from a single paleodrainage basin share evolutionary history, divergent from populations found in separate basins? Are isolated populations within a paleodrainage divergent? Are populations within "sterile basins" (isolated both historically and currently) uniquely divergent? We reveal a system where patterns of morphological and genomic divergence are highly concordant, revealing rapid evolution that largely matches paleodrainage and drainage basin connectedness.

Session 8: Intraspecific evolution & biogeography

Hidden link between protein structure and mechanical properties of the world's toughest spider silk

*Htut, K Zin, Angela Alicea-Serrano, Saranshu Singla, Ingi Agnarsson, Jessica Garb, Matjaz Kuntner, Matjaz Gregoric, Todd Blackledge, Ali Dhinojwala

University of Akron

Spider silk is among the toughest biomaterials, stronger than steel by weight and tougher than Kevlar in energy absorption, inspiring genetically engineered biomaterials. Darwin's bark spider (Caerostris darwini) dragline silk makes frames and radii of the largest known orb-webs that can span rivers in Madagascar. Under some spinning conditions, they produce silk 2-3 times tougher than other spiders. In dragline silk, a blend of major ampullate silk proteins: MaSp1 containing alanine and glycine motifs that contribute high tensile strength by forming stiff linker regions beta-sheets and MaSp2 with proline-rich motifs forming stretchy beta-turns, making the silk extensible. Current research suggests that the unique MaSp4 protein may explain C. darwini's extraordinarily toughness and extensibility. In this study, the dragline silk mechanical properties of C. darwini and six other spiders (Argiope trifasciata, Larinioides cornutus, Neoscona crucifera, Parasteatoda tepidariorum, Nephila clavipes and Latrodectus hesperus) are correlated with the secondary structure obtained from Raman spectroscopy, testing preliminary hypotheses about how MaSp4 proteins may affect silk structure. Silk stretchiness initially increases as the mean amount of helices increases, but then stretchiness decreases with a high amount of helices. Thus, we hypothesize that an optimum helices amount is needed to achieve maximum dragline stretchiness.

Session 5: Silk I

Anticipation vs. opportunism: a test of a novel ecological hypothesis regarding the diel distribution of locomotor activity in spiders

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Locomotor activity is commonly interpreted as an indicator of neurological arousal, and is a useful indicator in studies of circadian rhythm. We have observed that some species of spiders exhibit tight and predictable bands of activity at particular times of day, while in other species activity is more dispersed throughout the day. The differences in these patterns are often exaggerated under constant darkness. We hypothesize that these patterns represent strategies along a circadian specialist-generalist continuum, trading off the ability to focus neurological arousal at a specific anticipated time, versus being able opportunistically respond to prey at any time. The hypothesis is supported by a simulation model that tests strategies under different prey temporal regimes. We also tested the abilities of four nocturnal spider species to opportunistically respond to an unexpected period of darkness. We found that in the predicted circadian specialist species, activity could not be elicited with unexpected darkness at any time of day, while the predicted circadian generalist became active in mid and late day. In two species intermediate on the specialist-generalist scale, we only elicited activity in the late day. This work represents a test of a novel hypothesis regarding the adaptiveness of circadian rhythms.

Session 4: Circadian Rhythms

Morphology of male abdominal ctenidia in North American Solifugae

*Jones, Richard, Paula Cushing

Denver Museum of Nature & Science

Solifuges, commonly referred to as camel spiders, are an enigmatic group of desert-adapted, cursorial arachnids. Notoriously hard to rear in captivity, many aspects of camel spider biology remain unknown. Ctenidia, swollen setae on the ventral side of the fourth abdominal segment, are held to be taxonomically diagnostic per individual species yet functionally obscure. Ctenidia are sexually dimorphic characteristics, being prominent on males and highly reduced in females, yet play no obvious role in courtship or mating. They can vary in shape, size, and number across North American taxa, being absent in some taxonomic groups and individual species altogether. Traditional light microscopy was used to survey and scanning electron microscopy (SEM) to capture the morphological variation of these structures across taxa. The taxonomic utility of ctenidia morphology above a species level was assessed using the phylogenetic analyses of the North American family Eremobatidae constructed by Cushing et al. (2015) as a backbone. Additionally, ctenidia were assessed for morphological consistency with arthropod tactile, mechano-, and chemoreceptive setae.

Session 2: Morphological evolution & taxonomy

Synergy between the support and adhesive components of orb web prey capture threads

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Virginia Tech

Araneoid orb webs are known for their adhesive capture spiral threads. This thread is a composite fiber, comprising of the supporting flagelliform axial line and the viscid glue droplets. As an insect struggles, the droplets extend and the axial line bows, forming the suspension bridge system. When formed, the suspension bridge sums the adhesive force of the droplets and the work to extend both the droplets and the axial line. Both thread components appear to contribute synergistically to insect capture, leading us to hypothesize that their properties have evolved in a complementary fashion. Critical axial line and droplet properties include the amount of material, as well as their elasticity and toughness. As larger spiders generally build larger webs, the role of spider size is also examined in relation to these properties. Correlations among these features were investigated in a phylogenetic context using PGLS. The fourteen study species encompass a broad range of habitats and spider sizes. A positive correlation between the extensibility of the droplets and axial line provided evidence for their coevolution, although other properties show less synergy. An evolutionary partnership between the material properties of both suspension bridge constituents could explain the success of araneoid orb weavers.

Session 6: Silk II

Whole-collection COI barcoding and species delimitation of New Zealand and South American neopilionid harvestmen (Opiliones)

*MacDougall, Jonathan, Kate Sheridan, Christina J. Painting, Gregory I. Holwell, Abel Pérez-González, Ricardo Pinto-da-Rocha, Gonzalo Giribet, Gustavo Hormiga

The George Washington University

The harvestmen of the family Neopilionidae are represented by 64 described species in 20 genera and are distributed across temperate Gondwana in southern South America, South Africa, Australia, and New Zealand. The family has the potential to be a valuable biogeographic model for New Zealand, but until recently neopilionid harvestmen have been taxonomically neglected. We sequenced approximately 400 New Zealand neopilionid specimens from Harvard University and 200 specimens from the University of Auckland for COI, and combined these with previously unpublished data from almost 100 South American specimens to create the most widely sampled neopilionid phylogeny to date. Additionally, we used the multi-rate Poisson tree process species delimitation method to further test our current taxonomic understanding of the family. Most genera were recovered as monophyletic, with the exception of Forsteropsalis, Pantopsalis, and Megalopsalis, while species delimitation analyses suggested the existence of more species than previously thought in Mangatangi, Thrasychirus, and Forsteropsalis. These analyses supported the synonymization of Thrasychirus and Thrasychiroides as well as Pantopsalis listeri and P. cheliferoides. Our results point to the need for a family-wide taxonomic revision of Neopilionidae.

Session 3: Molecular phylogenetics & systematics

Why the long pedipalps? Quantifying prey capture performance across amblypygid species

*McLean, Callum, Michael Seiter, Russell J Garwood, Charlotte A Brassey

Manchester Metropolitan University

Amblypygids are a charismatic arachnid order that possess a unique pair of spined pedipalps, hypothesised to be primarily optimised for prey capture. Pedipalp morphology varies greatly across amblypygids. Lengths, relative to body size, span nearly an order of magnitude, and spination varies notably. Functionally the pedipalps capture prey by scooping it towards the chelicerae and securing it. Increasingly, however, sexual selection is also recognised as playing a role in the evolution of pedipalp morphology. Selective pressure for longer pedipalps acting through intrasexual and territorial contest, and courtship, raise the possibility that pedipalp morphology may not optimised solely for prey capture. The biomechanics of amblypygid prey capture has never been quantified across numerous taxa. Here, we use high-speed videography and manual tracking to investigate prey capture in a morphologically diverse set of amblypygid species (n=6) across four genera within two families. Within our dataset, taxa with longer pedipalps are characterised by absolutely greater closing velocities and maximum reach, although these metrics scale slower than predicted by isometry. Prey capture performance in species with elongate pedipalps is therefore reduced relative to our expectations from simple lever mechanics, suggesting alternative behavioural or myological factors may be responsible for limiting kinematics in these taxa.

Session 1: Functional morphology

Lights, Clock, Action! : Circadian rhythms of locomotor activity in Larinioides cornutus indicate extreme flexibility in photo-entrainment

*Miller, Madeleine K., Thomas C. Jones, Darrell Moore

East Tennessee State University

Circadian clocks schedule many behavioral and physiological processes. The resulting daily rhythms synchronize (entrain) to external environmental cues (zeitgebers), enabling organisms to anticipate changing environmental conditions. Here we investigate the chronobiology of Larinioides cornutus (Araneidae), with emphasis on entrainment to light:dark (LD) cycles. Using locomotor activity to measure circadian output, we found both lights-off and lights-on are influential zeitgebers for both activity onset and offset. Furthermore, phase-shifting experiments reveal Larinioides can re-entrain at an accelerated rate compared to mammals, adjusting within 2 days to a 6-hour LD cycle shift and within 3 days when shifted 12-hours. This indicates an increased level of plasticity not observed in other organisms. In constant darkness (DD), the endogenous circadian period spontaneously shifted in 66% of individuals from about 23.4 to 25.2 hours, suggesting the interaction of multiple oscillators. Under constant light (LL) conditions, 65% of spiders were arrhythmic, indicating a high sensitivity to light. Spiders have received scarce attention with respect to their chronobiology, but due to the atypical rates of re-entrainment to LD phase-shifts, changes in free-running period under DD, and arrhythmicity in LL, we propose that spiders are a valuable comparative model system for elucidating fundamental mechanisms of circadian clocks.

Session 4: Circadian Rhythms

Unraveling the genetic basis of the web-building behavior in Uloborus diversus

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The Johns Hopkins University

Our long-term goal is to establish Uloborus diversus as a model for behavior, using web-building to understand how the brain structures behaviors spanning multiple timescales. U. diversus is an ideal model because it is a simple organism that produces a complex, reproducible, quantifiable behavior over long timescales. Web-building is highly stereotyped, involves carefully coordinated behaviors, is performed daily, and produces a highly geometric structure: the web itself. Previous research showed that pharmacological perturbations of different neuromodulatory pathways have different effects on the structure of the web; however, quantitative studies of the behaviors that produce these features are lacking. Using computer-aided vision, machine learning, and massively parallel computing tools, we are studying the web-building behavior itself in unprecedented detail. We hypothesize that perturbation of behaviorally relevant genes using genetic tools will produce behavioral phenotypes that phenocopy previously conducted pharmacological studies. These phenotypes may provide insight into the genetic structure of innate, complex behaviors spanning multiple time scales. To enable our studies, we are currently working toward assembling a reference-quality genome, which we will use to identify and target behaviorally-relevant genes for genetic manipulation.

Session 10: Behavior I

A phylogeographic study of Liocranoides (Araneae: Zoropsidae) from Appalachian caves

Milne, Marc, Erik Hart, Spencer Burton, Joel Williams, Kirk Zigler, Nathaniel Mann, Mary Yancey, Matthew Niemiller, Joshua Campbell

University of Indianapolis

Caves often act like islands in that organisms within them live apart from the epigean fauna and adapt to a novel environment not experienced by non-cave organisms. The adaptations of the organisms within can vary depending on that cave's specific microenvironmental conditions (humidity, temperature, etc.). Spiders that begin to live within cave systems may also speciate due to these unique environmental selection pressures. Spider speciation within Appalachian cave systems may be morphologically obvious or cryptic, making species determinations difficult. Liocranoides is a genus of spiders (Araneae: Zoropsidae) that commonly live in caves throughout Appalachia. In order to determine the relationship among Liocranoides throughout the region, we compared morphological differences among many specimens from various caves in Tennessee, Georgia, Alabama, and Indiana. We also used molecular methods to compare the sequences of four different nuclear genes in these specimens. We then assembled a phylogenetic tree and used it to hypothesize about the taxonomic relationship among these species and the biogeographic history of speciation events. This study allows for a better understanding of spider evolution within Appalachian caves.

Session 8: Intraspecific evolution & biogeography

Nonconformity in Spider Circadian Rhythms

Moore, Darrell, Nadia Ayoub, Natalia Toporikova, Thomas Jones

East Tennessee State University

Circadian rhythms, nearly ubiquitous among eukaryotes, are biological processes that cycle (free run), under constant conditions, with a period that closely approximates 24 hours but also entrain to (synchronize with) daily environmental cues such as light/dark (LD) and temperature cycles. Despite the wide diversity of organisms, all circadian rhythms share certain fundamental characteristics. Our examination of circadian locomotor rhythms in 21 spider species, encompassing six families, reveal a number of chronobiological properties that exist at the extremes of known circadian rhythms. Among these extremes are three species exhibiting extraordinarily short free-running periods (FRPs) and two other species with exceptionally long FRPs, roughly approximating the 19-hour perS and 29-hour perL mutants in Drosophila, respectively. Within species, contrary to the norm, spider FRPs are broadly distributed, with % coefficients of variation an order of magnitude larger than those of well-known circadian model organisms. Contrary to findings in a diversity of other organisms, spiders thrive in a variety of LD cycles with periods that do not closely match the organism's endogenous circadian period. Spider circadian rhythms also show unusually rapid re-entrainment to LD cycle phase shifts. Such extreme features make spiders a valuable comparative model system for studying circadian clock adaptations.

Session 4: Circadian Rhythms

Risk assessment and the effects of learning walks on the defensive behavior repertoire in the southern scorpion, Vaejovis carolinianus.

Nelsen, David, Chad N. Harty, Emily M. David, Joseph B. Hector, Aaron G. Corbit

Southern Adventist University

Scorpions are prey to a myriad of other organisms; thus, selection should favor individuals that are able to acquire, process, and act on relevant environmental signals. Previous research has found that some species can modulate their defensive behavior based on perceived threat (risk assessment). Previous research also suggests that some species use their pectens to map their environment during learning walks. To date, no previous research has investigated if Vaejovis carolinianus is capable of risk assessment, or if learning walks affect the differential use of defensive behaviors. We tested 18 scorpions (N = 9 females and males) in a repeated-measures design. Scorpions were placed in an arena with varying number of hides overnight. We recorded overnight movement, and tested risk assessment by prodding them across three body locations. We found that V. carolinianus shows clear risk assessment with stinging being elicited sooner and occurring more frequently when prodded on the cephalothorax than either of the other two locations (chelae and metasoma). We also found interactions between sex and number of available hides and the use of stinging behavior. Our findings suggest that V. carolinianus is capable of acquiring, processing, and acting on environmental signals in a sophisticated way.

Session 11: Behavior II

Species delimitation of the Antrodiaetus unicolor species complex using a 3RAD approach

*Newton, Lacie, Jason Bond, James Starrett, Brent Hendrixson

UC Davis

Although species delimitation can be highly contentious, the development of reliable methods to accurately ascertain species boundaries is a fundamental and necessary step in cataloguing and describing Earth's quickly disappearing biodiversity. Species delimitation in spider taxa has historically been based on morphological characters; however, certain mygalomorphs are morphologically indistinguishable from each other yet have considerable molecular divergence. Previous research by Hendrixson and Bond (2005) described a new sympatric species Antrodiaetus microunicolor in the A. unicolor species complex using morphological criteria (i.e. size and setal character differences) and behavioral criteria (non-overlapping mating seasons). Subsequently, they used two molecular markers COI and 28S and discovered that A. unicolor is paraphyletic with respect to A. microunicolor. To further delineate this species complex, we implement the cohesion species concept and employ multiple lines of evidence for testing genetic exchangeability and ecological interchangeability. Our integrative approach includes extensively sampling homologous loci across the genome using a version of RADseq called 3RAD, assessing population structure across their geographic range, and evaluating ecological similarity by niche-based distribution modeling. Based on our analyses, we conclude that this species complex has two or three species in addition to A. microunicolor.

Session 8: Intraspecific evolution & biogeography

Progressive changes in the glycoprotein glue of Argiope trifasciata capture threads during orb web construction

Opell, Brent, Sarah Stellwagen

Virginia Tech

During the last phase of the stereotypical behavior responsible for orb web construction a spider adds an adhesive capture spiral to the web's radial threads. In large orb webs, like those constructed by Argiope trifasciata, a series of switch back threads are typically placed at the bottom of the web before a spider lays a continuous capture spiral that progresses from the web's periphery to its interior. We characterized the properties of the glycoprotein cores of the thread's glue droplets from the bottom, top, middle, and inner regions of webs to determine if they changed during web construction as a result of resource depletion or changes in resource allocation. This involved measuring a droplet's glycoprotein volume and capturing a movie of its extension to pull off at 23° C and 55% relative humidity. We observed a progressive increase in the force on a droplet at pull-off and in glycoprotein elastic modulus (stiffness) and toughness in droplets representing the progression of capture spiral deposition. The volume of glycoprotein within droplets decreased during web construction, resulting in the work of droplet extension to pull-off being greater in the middle and inner regions of the web than in its bottom and top regions.

Session 6: Silk II

Aromatherapy for spiders: volatile plant oils as repellents or attractants for preferred vegetation

Persons, Matthew, Dante' Dobbins

Susquehanna University

Spiders associate with particular plants, but it remains unclear if volatile plant oils attract or repel them. The long-jawed orb weavers, Tetragnatha laboriosa and T. viridis are frequently syntopic in their ranges but Tetragnatha laboriosa prefers tall grass while T. viridis prefers conifer trees. The syntopic crab spider, Mecaphesa asperta often resides on goldenrod. We measured spider responses to volatile oils from citronella grass (Cymbopogon nardus), goldenrod (Solidago canadensis), black spruce (Picea mariana), and Scots pine (Pinus sylvestris). All test subjects were collected within meters of each other, but from either goldenrod (M. asperta), timothy (T. laboriosa), or pine trees (T. viridis) (N = 85/n=27-29). We used proximity measures as indicators of attraction with each spider tested for one hour across each of all four extracts. We found significant species and extract type interactions in preference. Spruce extracts were significant attractants to both Tetragnatha species while Mecaphesa showed avoidance. Pine was an attractant to T. viridis but not T. laboriosa. Goldenrod was a significant repellent for both tetragnathids but was neutral for Mecaphesa. Citronella strongly attracted T. viridis and repelled T. laboriosa and Mecaphesa asperata. Our results indicate that plant volatiles may serve as possible mediators of spider plant selection.

Session 10: Behavior I

Developmental expression of the Doublesex sex determination genes in the common house spider, Parasteatoda tepidariorum.

Petko, Jesscia

Penn State York

Animals have evolved a diverse set of mechanisms for acquiring sex specific structures and characteristics. The means by which environment and/or genetics plays a role in establishing sex is diverse even within taxa, yet these processes tend to converge on a common set of transcriptional machinery. Understanding various methods of sexual differentiation can give insights into the evolution of gene regulation and reproduction, along with an understanding of how sex can be manipulated by symbionts. Spiders inherit an ancient genome duplication, which makes them an interesting model for such evolutionary genetic studies. The goal of this study was to identify and determine the expression of the spider orthologs for the most well-conserved sex determining transcription factor, Doublesex. I have identified five Doublesex orthologs and demonstrate two that have expression patters that are both sex-biased and localized to reproductive tissues/cells in the common house spider Parasteatoda tepidariorum.

Session 2: Morphological evolution & taxonomy

Systematics of the genus Erginulus (Opiliones: Laniatores: Cosmetidae)

Proud, Daniel, Austin Grace, Jasson Tahhan, Victor R. Townsend Jr.

Moravian College

Cosmetidae is the second most diverse family of harvestmen, but the convoluted taxonomic history of this lineage has created many challenges to revising genera. Recently, revisions to cosmetid genera from South America have offered clues as to the morphological characters that are useful in redefining the genera. In Mesoamerica, cosmetids dominate the opiliofauna, but little revisionary work has been conducted. In this study, we begin to unravel the obscure evolutionary relationships of cosmetid species from Central America and Mexico. Using a molecular phylogenetic approach, we tested the monophyly of the genus Erginulus, whose members exhibit surprisingly diverse genitalic forms compared to the conserved morphology of most Central American cosmetids. We rediagnose and redefine Erginulus based on several synapomorphies, particularly the penis morphology. Several taxa that fit the Roewerian definition of Erginulus are removed based on penis morphology. Molecular phylogenetic data support the monophyly of our new definition of Erginulus. Our work contributes to a better understanding of the diversity of Cosmetidae from Central America and Mexico.

Session 3: Molecular phylogenetics & systematics

Circadian resonance and entrainment in three spiders (Frontinella communis, Metazygia wittfeldae, and Cyclosa turbinata)

*Ragsdale, Raven, Colin Shone, Madeleine Miller, Thomas C. Jones, Darrell Moore

East Tennessee State University

Circadian clocks are vital to the proper functioning of organisms' internal processes and behavior and typically have endogenous periods that approximate the 24-hour solar day, with this period agreement termed "circadian resonance". Organisms fail to synchronize (entrain) their activity with non-resonant light/dark (LD) cycles and this failure typically leads to a number of physiological disruptions, including lifespan reduction. The object of the present study is to investigate whether the phenomenon of circadian resonance also pertains to two spider species which naturally possess a circadian rhythm significantly different from 24 hours (Frontinella communis: τ=29.05±0.62 hours; Cyclosa turbinata: τ=18.54±0.28h). Approximately 50 individuals of each spider species as well as Metazygia wittfeldae (τ=22.74±0.24h) were placed into chambers with periods of 19 (9.5:9.5h L:D), 24 (12:12h LD), or 29 hours (14.5:14.5h LD). No spider species exhibited decreased longevity in non-resonant LD cycles. In a second experiment, 10-11 spiders from each species were placed into infrared activity monitors to determine if their locomotor activity could entrain to the three different LD cycles. Individuals from all three spider species entrained to all LD period lengths. Taken together, these results indicate a level of plasticity in spider circadian rhythms unique among all studied organisms.

Session 4: Circadian Rhythms

A novel bacterial symbiont manipulates the reproduction of a Linyphiid spider, Mermessus fradeorum

*Rosenwald, Laura, Jen A. White

University of Kentucky

Maternally-inherited bacteria can manipulate the reproduction of their arthropod hosts to promote bacterial transmission to the next generation. Many of these manipulations have been investigated in insects, but are not well-documented in spiders. Mermessus fradeorum (Linyphiidae) is an agricultural spider that exhibits bacterially-induced cytoplasmic incompatibility and feminization, but it is not clear which symbionts are causing what phenotype. Using next-generation sequencing, we first determined M. fradeorum can be infected with up to five strains of maternally-inherited symbionts from the genera Wolbachia, Rickettsia, and Rickettsiella. Wolbachia and Rickettsia are both well-known reproductive manipulators, but Rickettsiella has not been documented as such. We next tested whether Rickettsiella manipulates the reproduction of M. fradeorum. Reciprocal crosses of Rickettsiella-infected spiders with spiders from cured matrilines revealed that Rickettsiella induces cytoplasmic incompatibility in M. fradeorum. When cured females were mated with infected males only 11% of their eggs hatched; in contrast, 92% of eggs hatched in the other cross types. Our study demonstrates that spiders are infected by diverse and novel symbionts, and will be important for future studies to determine the mechanisms of reproductive manipulation, the ecology of symbiont interactions within a host, and the evolutionary trajectory of shared hosts.

Session 9: Ecology, diversity, & life history

Anthropogenic selection: assortative mating likely reduces gene flow between nearby populations of a wolf spider.

Rypstra, Ann

Miami University

Animals that live in human created habitats face unique stressors and, as a result, selection may lead them on alternative evolutionary trajectories. Spiders are common and important predators in agroecosystems where they must cope with habitat disturbances including soil disruptions and chemical applications. The wolf spider, Pardosa milvina (Araneae, Lycosidae), is common in the corn and soybean fields of eastern North America but more natural populations live in riparian flood plains. We explored the mating behavior of field caught males and females from natural and agricultural populations. Animals from the same habitat type readily mated with one another. Cross-population matings were rarer and there were differences in the behavioral interactions between the spiders. Males from agricultural populations initiated courtship sooner when paired with females from natural populations. Courtship intensity was more important to acceptance for agricultural females than for females from natural areas. These results suggest that the agricultural environment is imposing selection pressures on P. milvina that affected their mating interactions and could potentially lead to genetic isolation.

Session 10: Behavior I

Range-wide RADseq and mtDNA data reveal an extraordinary post-glacial range expansion in scorpions from the Mojave and Great Basin deserts

Santibanez-Lopez, Carlos, Jef R. Jaeger, Matthew R. Graham

Eastern Connecticut State University

With warm summers and extreme winters, the Great Basin Desert is inhospitable to many arid-adapted organisms in the adjacent, and overall hotter, Mojave Desert to the south. However, despite these climatic differences, some species like the black-clawed scorpion (Anuroctonus phaiodactylus) inhabit both deserts. In a phylogeographic analysis using mtDNA and RADseq data collected throughout the species' range, we found that A. phaiodactylus only recently colonized the Great Basin Desert as climates warmed following the Last Glacial Maximum, a scenario consistent with climate-based distribution models. Both data sets identified unique lineages in the White-Inyo Mountains and the southern Sierra Nevada of southern California. Genome-wide SNP data indicate that the species colonized the Great Basin Desert along two colonization fronts that began in the northwestern and northeastern Mojave Desert. Our results add to accumulating phylogeographic evidence that much of the Great Basin biota only recently colonized the region, making it a desert ecosystem in its infancy.

Session 8: Intraspecific evolution & biogeography

A "Wise" story with a modern twist: molecular untangling of spiders' webs

Schmidt, Jason

University of Georgia

Promoting biodiversity for sustainable pest management requires thorough knowledge of functional roles of generalist predators. However, little is known about the structure of food webs and dynamics of these feeding relationships in many agricultural systems throughout the world. Here, we investigated the spider feeding connections with cotton pest species and alternative prey collected in a grid system of points separated by 50m. A total of three sample dates at 17 points were collected each year (2015-2017) during key cotton developmental stages: vegetative growth, flowering, and boll development. We reconstructed feeding links between spiders, pest species and alternative prey using DNA-based molecular gut content analysis. In 2015 and 2016, the dominant spider taxa testing positive for prey and alternative prey were Salticidae, primarily Hentzia spp. Major prey species detected were aphids, thrips and spidermites. In 2017, predator abundance was evenly distributed, and the major prey species detected were aphids and thrips spp. Communities and subsequent interactions varied within season and between years. Results, therefore, suggest that spiders are contributing to biocontrol on multiple pest species in cotton, but levels of predation by the entire community of predators is lacking on some key pests.

Session 9: Ecology, diversity, & life history

Spiders with tales to tell

Selden, Paul

Paleontological Institute, University of Kansas

A long time ago, Bill Shear and I, with other colleagues, described some arachnid fragments etched from Devonian rocks of New York. These included trigonotarbids, and what appeared to be the oldest spider: Attercopus. Some strange flagella-like structures associated with Attercopus were dismissed as belonging to another, unknown arachnid. Some years later, material collected from a nearby locality in the Catskill Mountains showed unequivocally that a) the flagellum was an anal structure of Attercopus, and b) that the silk spigots were not on spinnerets, but arranged along the edges of ventral plates. Hence the order Uraraneida was established for these proto-spiders. Also included in this new order was Permarachne, an animal resembling a mesothele but lacking spinnerets and with a terminal flagellum, from the Permian of Russia. To our great delight, a couple of years ago, an animal resembling our vision of a missing link between uraraneids and spiders appeared in mid-Cretaceous Burmese amber: Chimerarachne. This arachnid bears a terminal flagellum and true spinnerets. In this talk, I will relate this story, and suggest what tantalizing events might be revealed in the next chapter.

Session 7: William Shear mini-symposium

New species in the Leiobunum calcar species complex from the southern Appalachian Mountains and the taxonomic and functional significance of the neoglans

Shultz, Jeffrey, Justin Lee

University of Maryland

The Leiobunum calcar species complex is distinguished from other members of the L. calcar species-group (L. nigropalpi and L. euserratipalpe) by mating structures, including a well-developed latching device at the female pregenital opening, retrolateral femoral apophysis in the male palp used in clasping trochanter I of the female, and a penis with the terminus curving dorsally in a semicircle such that the tip often points in a functionally paradoxical rearward direction. A feature newly described here, the neoglans, consists of a subterminal region of the penis with variably developed solid lateral projections (alae) associate with a bilateral pair of lateral grooves. This region is delimited proximally by a ventral band of flexible cuticle spanned internally by the tendon of the intrinsic penial muscle. Muscle contraction appears to cause significant ventral flexion of the penis that results in the terminus projecting anteriorly. It is suggested that the alae/groove mechanism delivers a nuptial fluid to the female mouthparts while the penial terminus rests against the female's ventrally adjacent pregenital opening. The species complex, as defined above, previously encompassed two species, L. calcar and L. hoffmani. Four additional species circumscribed by variations in the neoglans and other mating structures are briefly described.

Session 2: Morphological evolution & taxonomy

The shy-bold syndrome: repeatability in a wolf spider

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The Ohio State University

Spiders are universally known as solitary, aggressive, and indiscriminate predators. With such a reputation, it is not at all surprising that sociality in this group is exceedingly rare. The correlated syndromes “aggression” and “shy-bold” have shown high repeatability among individual spiders and tends to be conserved evolutionarily. Broad fitness implications may include higher reproductive success by risk-prone individuals relative to conspecifics that are risk-averse. This study defines boldness by two parameters: 1) latency to explore a new environment and 2) latency to resume movement after an aversive stimulus. We obtained repeated latency measurements from individual wolf spiders (Schizocosa ocreata: Lycosidae) and quantified the intraclass correlation coefficient (ICC) via generalized linear mixed models (GLMM). Our goal with this preliminary work was to establish a baseline shy-bold spectrum for S. ocreata. With these data, we will better understand how the structure and strength of this syndrome vary under experimental conditions.

Session 11: Behavior II

Phylogenetic analysis of Nearctic Schizocosa (Araneomorphae, Lycosidae), with implications for the evolution of traits under sexual selection

Starrett, James, Rowan McGinley, Eileen Hebets, Jason Bond

University of California Davis

Nearctic species of the genus Schizocosa Chamberlin, 1904 have received considerable study regarding traits under sexual selection, with most emphasis on comparisons between apparent sister species with distinct morphological traits. A robust phylogeny has been lacking for Schizocosa, however; relationships are supported by few morphological synapomorphies or based on a limited number of molecular markers. Here, we apply the anchored hybrid enrichment probe set to obtain over 400 loci from a comprehensive taxonomic sample of Nearctic Schizocosa, two species of Neotropical Schizocosa, and representatives of other lycosid genera. We infer the phylogeny of Schizocosa and their relatives using concatenation and coalescent-based methods. Relationships largely agree across analysis methods, with generally high nodal support. We find support for a monophyletic Nearctic Schizocosa group that is sister to other Nearctic lycosid genera, and support for Neotropical Schizocosa monophyly, but overall Schizocosa is polyphyletic. We explore relationships within Nearctic Schizocosa and perform ancestral state reconstruction of primary and secondary sexual characters. Evaluation of these traits in a comparative framework will better illuminate how sexual selection influences character evolution.

Session 3: Molecular phylogenetics & systematics

Circadian strategy of cave dwelling orb-weavers

*Steele, Rebecca, Darrell Moore, Blaine Schubert, Rebecca Wilson, Thomas C Jones

East Tennessee State University

Circadian clocks are endogenous time keeping mechanisms that are ubiquitous among animals. They enable coordination of many essential physiological and behavioral processes in relation to the 24-hour light:dark cycle on earth. However, many habitats are not subject to this light:dark cycle. This study examines the potential genetic drift of the circadian rhythm of subterranean spiders and gathers general natural history information on these under-studied species. Our objective is to integrate circadian and foraging theory to evaluate species as circadian specialists and generalists based on how narrowly or widely their activity is dispersed over the 24-h day. We suggest that cave dwellers benefit from a generalist strategy, showing small bursts of focused activity widely dispersed across the 24-h cycle, allowing them to capture prey opportunistically whenever available. Live spiders were collected from area caves, monitored in an environment controlled for light and temperature, and returned to their cave of origin. The chronobiological activity of each spider was recorded under controlled conditions and then individuals from separate caves were analyzed for differences in circadian activity among and between populations to determine if significant drift in circadian strategy (endogenous period, temporal distribution of activity bouts, etc.) occurred between isolated populations.

Session 4: Circadian Rhythms

“Spiders of the Southern Appalachians” : Thirty years of araneid education in Highlands, NC

Stellwagen, Sarah

University of Maryland Baltimore County

Originally created and offered by Bill Shear and Fred Coyle, this two-week summer field course taught at the Highlands Biological Station has been attended by many of today’s prominent arachnologists. The course covers virtually all aspects of spider biology, from anatomy and physiology, behavior and ecology, to phylogeny and systematics, as well as collecting techniques and identification - both in the lab and in the field. With lectures in the morning, collecting trips in the afternoon, and spider identification late into the evening, the dissemination of skills through this course has been invaluable for the arachnid community. We will look back through time at “spider camp”, including the instructors and attendees beginning with the inaugural class of 1988, and honor the legacy that the founders of the course have given to arachnology.

Session 7: William Shear mini-symposium

Spiders on fast time: using mathematical modeling to understand the mechanism of an exceptionally short-period circadian clock

Toporikova, Natalia, Andrew Mah, Adrian Lam, Nadia Ayoub, Daniel Robb, Thomas C. Jones, Darrell J. Moore

Washington and Lee University

Because of the near ubiquity of circadian rhythms among living organisms, it is widely believed that having an internal clock oscillating at about 24 hours is adaptive. This allows organisms to initiate physiological and behavioral processes in anticipation of daily environmental changes. Enhanced fitness of cyanobacteria and insects whose clock period most closely matches the photoperiod demonstrates the importance of the internal clock resonating with the external 24-hour day. Recently, however, we discovered several spider species, in which the average free-running periods of activity is too short (17-18 hours). To our knowledge, these are the shortest naturally occurring circadian periods, comparable to 20-h and 18-h mutants in hamsters and the 19-h mutant in Drosophila. In theory, being so far out of resonance with the 24-hour day, these species should not exist. We used combination of computational and experimental efforts to understand biological mechanism for circadian clock in spiders and identify possible adaptive benefits for short and long circadian clocks

Session 4: Circadian Rhythms

New insights into the biology of cosmetid nymphs

Townsend, Jr., Victor, Maynard Schaus, Daniel Proud

Virginia Wesleyan University

In harvestmen, postembryonic development includes larval, nymphal and adult stages. For most species, the ecology and morphology is best known for the adult phase. The natural history of nymphs is poorly studied because they are difficult to identify and their relative abundance in the field may show considerable variation in phenology. In cosmetid harvestmen, the adult pedipalp features a flattened femur, spoon-shaped tibia and a tarsus adorned with a large claw. In contrast, nymphs have cylindrical, elongate pedipalps that possess a delicate pretarsus with a ventral patch of setae not present in adults. Observations of feeding indicate that adults use chelicerae and pedipalps to manipulate food items, whereas nymphs rely exclusively upon their chelicerae. In addition, we have observed ontogenetic variation with respect to emissions from the scent glands, ozopore morphology, and the size and shape of the tarsal aggregated pores. Analyses of fecal samples using SEM has revealed that adults and nymphs consume a variety of food items, including plant material and small arthropods. Future investigations of nymphs will include the conclusion of a stable isotope study, field observations of microhabitat use, and laboratory-based studies of secondary defenses.

Session 1: Functional morphology

El Niño and variation in the social grouping tendency of the colonial orb-weaving spider, Metepeira spinipes: a long term study.

Uetz, George, J. Andrew Roberts , Mark L. Tiemeier, Jenai Rutledge, Darius Pryzgoda

University of Cincinnati

The colonial orb-weaving spider Metepeira spinipes F.O. P-Cambridge (1903) occurs throughout central Mexico and the U.S. West coast. Extensive study of this species in Mexico suggests that ecological factors contribute to localized variation in social grouping tendency, group size, spacing and colony persistence. Prior to the 1997-1998 El Niño, populations of M. spinipes on the California coast consisted predominantly of solitary individuals with occasional occurrence of small colonies (2-3 webs attached). However, following that largest El Niño, the occurrence of larger colonial aggregations (>10) increased in several populations in coastal California, providing a research opportunity to understand the ecological mechanisms responsible for group-living in spiders. Census data collected over the past 20 years indicates that coloniality in populations of M. spinipes has remained common at several sites in California but has declined where environmental conditions are more extreme (i.e., xeric). Colony sizes and densities vary widely between sites along the California coast, although a pattern suggesting an El Niño/La Niña influence persists. Observational and experimental studies show that individual risk-sensitive foraging responses to prey availability, along with conditions associated with El Niño events driving prey abundance and reproduction likely contribute to variation in social grouping.

Session 9: Ecology, diversity, & life history

Endosymbiotic bacteria are prevalent and diverse in agricultural spiders

White, Jen, Alexander Styer, Laura C. Rosenwald, Meghan M. Curry, Kelton D. Welch, Kacie J. Athey, Eric G. Chapman

University of Kentucky

Maternally inherited bacterial endosymbionts that can manipulate host reproduction are common in arthropods, but their distribution and prevalence is poorly characterized in many host taxa, including spiders. Here, we evaluated the symbiotic microbiome of 267 individual spiders representing 14 species in 3 families (Linyphiidae, Tetragnathidae, Oxyopidae). We found 27 Operational Taxonomic Units (OTUs) that are likely endosymbiotic, including several strains of Wolbachia, Rickettsia and Cardinium, all of which are vertically transmitted bacteria that are frequently associated with host reproductive manipulation. Seventy percent of spider species had individuals that tested positive for one or more endosymbiotic OTUs, and specimens frequently contained multiple symbiotic strain types. The most symbiont-rich species, Idionella rugosa, had eight endosymbiotic OTUs, with as many as five present in the same specimen. Our sample included both starved and unstarved specimens, and dominant bacterial OTUs were consistent per host species, regardless of feeding status. We conclude that spiders contain a remarkably diverse symbiotic microbiota. Spiders would be an informative group for investigating endosymbiont population dynamics in time and space, and unstarved specimens collected for other purposes (e.g., food web studies) could be used, with caution, for such investigations.

Session 9: Ecology, diversity, & life history

The defensive silk enigma: The effects of humidity on the properties of atypical aggregate gland secretions in the Western Widow Spider (Latrodectus hesperus)

*White, Jacob, Weston Young, Aaron Corbit, David Nelsen

Southern Adventist University

Widow spiders (Latrodectus sp.) are known to produce a unique silk that is actively secreted for defense when these spiders are under threat from potential predators. One component of this silk is large viscous, sticky globules, which are produced by the spider's atypical aggregate glands. Previous research suggests that these globules have unique properties that differ from other spider adhesives in that they contract as they lose volume, they lose volume rapidly, and this loss cannot be explained by the evaporation of water. We examined the changes in volume in these globules under varying relative humidities. We found that both total and rate of volume loss decreased as humidity increased. We also found that, in some contexts, viscous globules can regain volume; however, the rate of volume increase is reduced and adhesive properties are lost. In addition, we observed some cases where, despite evidence of contraction and being under tension, the silk had a wavy appearance as if it was not under tension. These findings add to our knowledge of the properties of this unique silk but also deepen the mysteries surrounding it.

Session 6: Silk II

Macronutrient effects on juvenile jumping spider growth

Wiggins, Will, Shawn Wilder

Alderson Broaddus University

A large body size is important for many reasons, including increases in viable eggs, decrease risk of cannibalism, and increased success in male-male combat. However, building a large body is costly and may require particular amounts and ratios of nutrients. For many animals, especially carnivores on which less is known of their nutritional ecology, the balance of nutrients at which animals maximize growth and body size remains unknown. We manipulated the quantity and nutrient content of flies as prey to test how the lipid and protein content of prey affected the growth of spiders, and tested the influence of supplemental carbohydrates at a constant prey quantity. We measured the mass, body size, and growth rate of Phidippus audax in both experiments. The ratio of lipid to protein in prey had the largest effect on spider growth in the high prey abundance treatments, with spiders on the high lipid treatments growing heavier and larger, and spiders on high protein diets grew heaviest with supplemental carbohydrates. Our results suggest that spiders require energy rich food for maximal growth.

Session 9: Ecology, diversity, & life history

Three-dimensional x-ray tomography for functional and comparative morphology in terrestrial arthropods

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University of California, Davis

The increasingly widespread use of three-dimensional imaging technologies has tremendous potential to improve morphology-based systematic studies. These techniques are broadly applicable to terrestrial arthropods, including arachnids, insects, and myriapods. An animal can be scanned, segmented into isosurfaces, annotated, and then exported into a fully interactive 3D rendering that conveys vastly more information per pixel than a standard two dimensional image. In particular, reconstructed x-ray tomography data allow "virtual dissection" of internal anatomy, including skeletal musculature, without the need to destructively dissect specimens. Here I present the male and female genital morphology of the flat-backed millipede genus Pseudopolydesmus (Diplopoda: Polydesmida: Polydesmidae) using a suite of two- and three-dimensional imaging techniques. In Polydesmidae, the female genitalia (vulvae) are withdrawn into a membranous pouch in the body cavity and everted for copulation or oviposition. During copulation, the outer branch of the male's gonopod arcs over the everted vulva, with insemination accomplished by the gonopod's inner branch. Sperm is stored in the vulvae until it is required for oviposition. My findings emphasize that high-quality imaging is essential for understanding and communicating morphological anatomy and function.

Session 1: Functional morphology

POSTER ABSTRACTS

Geographical trends in size and fecundity of Japanese harvestmen

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University of Maryland, Baltimore County

Facultative parthenogenesis, the ability to switch between reproducing sexually and asexually from an unfertilized ovum, is of particular importance to understanding the widespread nature of obligate sexual reproduction. Japanese harvestmen include some of the few species known to exhibit facultative parthenogenesis. Leiobunum manubriatum and sister taxon L. globosum, found in Honshu and Hokkaido Islands, exhibit geographical parthenogenesis, meaning asexual and sexual reproduction differ across the geographical distribution. Adult female specimens and their eggs, if present, were collected from four species of Japanese harvestmen in 12 locations throughout Japan to compare their size, fecundity, and habitat conditions to determine if any trends amongst these characteristics are present. Microscope imaging software was used to determine the width of the dorsal carapace of specimens as a measure of size. The most important habitat conditions for explaining variation in the data were found using MaxEnt software and Rstudio; MaxEnt is a program that uses presence-only data and bioclimatic factors to construct a map of probable geographic range. No statistically significant trends were found. Future work involves analyzing offspring genotypes to incorporate mode of reproduction and compare to size, fecundity, and habitat conditions.

Poster #14

The stridulatory setae of Ceratogyrus marshalli: An examination of their location, morphology, and development

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Eastern Michigan University

Several species of spiders (Araneae) have the ability to produce sounds. One of the ways these sounds are produced is through stridulation; a process that occurs when one specialized body part is moved against another. These specialized body parts, also known as stridulatory organs, consist of the "scraper" and the "file". The "scraper" is a series of rigid setae, while the "file" is a region containing antagonistic structures. Stridulatory organs are found in at least 22 Araneae families; however, the location and morphology of these organs varies greatly. Ceratogyrus marshalli, the straight-horned baboon tarantula, is a stridulating species belonging to the Harpactirinae subfamily (Theraphosidae). While it is known that this species stridulates, the setae involved in this behavior have yet to be characterized. In this study, we used scanning electron microscopy to determine the location and morphology of the stridulatory setae. Additionally, we looked at the development of these setae by examining their presence across successive molts. From our analysis, we found that stridulatory setae first appear during the third instar on the surface of the chelicerae. We will discuss the location, morphology, and development of the stridulatory setae of this species and the future directions of this study.

Poster #15

Effects of bacterial infection on female visual assessment of male courtship signals in the wolf spider species, Schizocosa ocreata (Hentz).

*Bauer-Nilsen, Olivia, Alex Sweger, Madeline Lallo, George W. Uetz

University of Cincinnati

We examined trade-offs between immunity and mate choice in the wolf spider Schizocosa ocreata (Hentz 1844). Females were tested to determine whether infection by the bacterium Pseudomonas aeruginosa impacts choosiness. Four treatment groups included different exposure time (penultimate vs. adult) and time since exposure (1 hr, 24 hrs). During trials females were presented with a choice: two iPods playing visual signals of high and low quality courting males (small vs. large foreleg tufts). Female receptivity displays and time spent visiting either of the two screens within the 5-minute trials were scored. Results show that infection with bacterial pathogens significantly influences female mate preferences, and that the season of collection and time of exposure had a significant interaction. Oddly, some infected females were more likely to show a preference than their uninfected counterparts, but in many cases, choices were not significantly different across treatments. Adult females infected and exposed for 1 hour were significantly more receptive toward large tufted male stimuli, while females infected and exposed at the penultimate stage show the opposite, i.e. greater receptivity toward small tufted male stimuli. This demonstrates that there is a complicated effect of time of pathogen exposure on female mate preference.

Poster #12

Cover crops for pest management: Linking habitat to predator community structure and function

Bowers, Carson, Jason Schmidt, Michael Toews

University of Georgia

Biological control of insect pests is dependent on biotic and abiotic conditions influencing species interactions. We can potentially alter interactions between species by managing in-field habitat using winter cover crops to improve biological control services. The availability of cover crop resources may influence predator community function by altering the composition of predators in-field, and their feeding habits. In this study, we investigate the effect of two different winter cover crops on predator community structure and prey consumption throughout the cotton growing season. We established replicated cover crop treatments (crimson clover, rye, and no cover crop) and sampled predators at the six major cotton stages in 2017 and 2018. We conducted molecular gut-content analysis on whole body DNA extractions of predators using multiplex PCR for eight prey groups including cotton pests and alternative prey. Our results indicate a strong early season effect of cover crops on predator communities, with cover crop treatments harboring a greater abundance of spider taxa, including lycosid and linyphiid spiders, in the early season. Combined our results demonstrate that cover crops can structure predator communities early in the season by providing food resources to primary and secondary consumers, though consumption of key cotton pests was unaffected.

Poster #1

Phylogeography of the widespread spiny-backed orb-weaver, Gasteracantha, in the Caribbean

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University of Vermont

Among Caribbean spiders, widespread species are few compared to the prevalence of single island endemics. The taxonomic hypothesis, Gasteracantha cancriformis, circumscribes a species with profuse variation in size, color, and body form. Distributed throughout the Neotropics, G. cancriformis is the only morphological species of Gasteracantha in the New World within this globally distributed genus. Here, we used standard Sanger sequencing dataset to test the phylogeography of Gasteracantha populations from North, Central, and South America and the Caribbean islands. Mitochondrial and concatenated molecular Bayesian inferences revealed three clades within New World Gasteracantha, two mainland clades and a primarily island clade. The phylogenetic relationships between these clades remain ambiguous and will require Next Generation Sequencing methods to fully resolve. Within the Caribbean island clade, we estimated genetic diversity, population structure and gene flow among island populations. Whilst gene flow between island populations was high, particularly between larger islands in close proximity, results indicated high genetic variability was high among island populations. There is structured genetic and morphological variation within G. cancriformis island populations; however, genetic distances are short and distribution of haplotypes consistent with ongoing gene flow.

Poster #17

Chronobiological Plasticity in Frontinella communis

*Crain, Shae, T. C. Jones, Darrell Moore

East Tennessee State University

An organism's circadian clock persists internally and is known to oscillate at a period (tau) of ~24 hours in the absence of external cues. In the laboratory, such rhythmic output is known as a free-running period (FRP).

This study monitored locomotor activity of Frontinella communis to examine whether its free-running period, on average, remained the same throughout its active season (May-September). It was found that average free-running period in F. communis varied significantly over a five-month period. Average FRP appears to peak in June followed by a steady, linear decline as the season continues. A variety of organisms have been shown to exhibit seasonal responses that allow them to cope with environmental change. It is not known whether the change in Frontinella's FRP is such an advantage or is merely coincidental.

Any free running period detected under the alpha level of 0.05 was not ruled significant. Along with the rise and fall of average FRPs, the presence of FRP deemed significant was found to decline as the season ended- 42% of individuals (n= 19). While age has been found to correlate with circadian desynchrony in other taxa (rats, humans), an association in Frontinella remains to be tested.

Poster #25

Proteomics identifies diverse array of silk glue proteins across cobweb and orb-web araneoid spiders

Culbertson, Haley, Joshua Frost, Beau Merhige, Grace Roquemore, Kyle Friend, Nadia Ayoub

Washington and Lee University

The hyper-diverse spider super family Araneoideae is defined by the production of chemically sticky silk glue in aggregate glands. Araneoid species build diverse web types that make use of aggregate glue in distinctive ways. For instance, cobweb weavers apply aggregate glue to capture threads called gumfoot lines, which radiate from the web to the substrate. Orb-web weavers build capture spirals consisting of an axial fiber covered with aggregate glue. Using a proteomics approach, we are testing the hypothesis that glue protein composition differs between the two web types and correlates with variation in material properties of aggregate glue droplets. We collected gumfoot lines from four cobweb species using cards that separated fiber with glue from fiber without glue. We also collected capture spirals from twelve species of orb-web weavers. We purified proteins from each species' glue, confirmed the existence of glue-specific proteins with SDS-PAGE, enzymatically digested proteins with trypsin, and used liquid chromatography and mass spectroscopy (LC-MS/MS) to identify proteins. For proteomic searches, we constructed protein databases based on sequencing of mRNA from silk glands. The identification of these proteins can be used to duplicate bio-adhesives for real-world applications such as liquid stitches.

Poster #27

Molecular evolution of novel silk proteins in Caerostris bark spiders underlying the toughest silks

*Dawson, Molly, Robert A. Haney, Matjaž Gregorič, Matjaž Kuntner, Ingi Agnarsson, Todd A. Blackledge, Jessica E. Garb

University of Massachusetts Lowell

The recently described Darwin's bark spider (Caerostris darwini), an endemic species of Madagascar, spins the largest known orb webs from the toughest spider silk measured to date. The toughness of C. darwini major ampullate (dragline) silk is unrivaled relative to nearly all man-made synthetics. For example, resultant from its high tensile strength and elasticity, this highly extensible fiber is ten-fold tougher than KevlarTM. The origin of the superior mechanical performance of C. darwini dragline silk, and web gigantism within this species, may in part be attributed to a novel silk protein (spidroin) that evolved early in Caerostris, as these traits (extraordinarily tough dragline silk and giant webs) are present to varying degrees within the Caerostris genus. Thus, in order to elucidate the genetic basis of C. darwini's dragline silk, and the patterns of molecular evolution facilitating extreme toughness, we have carried out comparative analyses by utilizing Illumina and PacBio derived transcriptome sequencing of Caerostris silk glands to characterize dragline protein interspecific variation and spidroin transcriptional diversity found between Caerostris species. In addition to providing an invaluable resource for evolutionary studies of biomaterials, this research will provide a foundation necessary for material scientists to advance biomimetic applications

Poster #29

A demonstration of unsupervised machine learning in species delimitation

Derkarabetian, Shahan, Stephanie Castillo, Peter K. Koo, Sergey Ovchinnikov, Marshal Hedin

Harvard University

One major challenge to delimiting species with genetic data is successfully differentiating population structure from species-level divergence, an issue exacerbated in taxa inhabiting naturally fragmented habitats. Many fields of science are now using machine learning, and in evolutionary biology supervised machine learning has recently been used to infer species boundaries. These supervised methods require training data with associated labels. Conversely, unsupervised machine learning (UML) uses inherent data structure and does not require user-specified training labels, potentially providing more objectivity in species delimitation. Here we demonstrate the utility of three UML approaches for species delimitation in an arachnid taxon with high population genetic structure (Opiliones, Laniatores, Metanonychus). We find that UML approaches successfully cluster samples according to species-level divergences and not high levels of population structure, while model-based validation methods severely over-split putative species. UML offers intuitive data visualization in two-dimensional space, the ability to accommodate various data types, and has potential in many areas of systematic and evolutionary biology. We argue that machine learning methods are ideally suited for species delimitation and may perform well in many natural systems and across taxa with diverse biological characteristics. Specifically, the deep learning neural-network based approach of variational autoencoders or particularly promising.

Poster #22

Investigating potential signals of immunity, as well as its relationship with behavior in Tigrosa helluo (Araneae: Lycosidae)

*Godfrey, Jake, Ann Rypstra

Miami University

There is evidence suggesting the use of chemical communication in wolf spiders to assess variation in immunocompetency between conspecifics. Agroecosystems experience synthetic chemical application and constant disturbance which may make chemical signals less reliable, yet there has been little investigation into the ability for spiders to assess one another's immune state in these habitats. We examined a range of visual aspects that may be more detectable in these systems and determined if they could act as predictors of immunocompetence. Using principal component analysis, we investigated the relationship between immunocompetence, behavior, symmetry, and carapace color intensity in both males and females. Regardless of sex, encapsulation ability appears to be positively related to distance traveled in a novel environment and foreleg symmetry. Differences between the sexes appeared regarding coloration and latency until movement. Lighter coloration in males related to higher encapsulation and lytic activity. On the other hand, darker coloration in females was found to relate to higher lytic activity. Finally, higher lytic activity in males was found to relate to quicker latency to movement, while higher female encapsulation related to quicker latency. These results provide potential mechanisms of conspecific evaluation in environments where chemical cues may be commonly disturbed.

Poster #2

Revision of New World Ummidia (Mygalomorphae, Halonoproctidae)

*Godwin, Rebecca, Jason Bond

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Ummidia is a historically taxonomically difficult group of spiders belonging to the infraorder Mygalomorphae, one of the three main lineages recognized within spiders. Mygalomorph life history and their incredibly cryptic appearance make them difficult to identify, as a result they are frequently overlooked by spider systematists. Ummidia Thorell 1875 is a wide-ranging genus of trapdoor spider found both in the Mediterranean region of the Old World and in the New World from the eastern United States south to Brazil. Taxonomic work on New World Ummidia is sparse outside of original descriptions, the most recent of which are over half a century old. I am revising the genus Ummidia in the Nearctic region. I have approached this taxonomic problem by examining approximately 700 specimens of Ummidia from various collections (AMNH, MCZ, FSCA, CAS, AUMNH). Examination of museum material has seemingly confirmed the undescribed diversity of Ummidia; preliminary estimates of New World species ranging between 50 and 60, with particularly high amounts of diversity in the Florida and Virginia. This study, along with many others conducted utilizing museum collections, is indicative of the importance of natural history collections and their usefulness in discovering unknown biodiversity.

Poster #23

In silico modeling to design in vivo gene expression experiments

*Lam, Chi Shing Adrian, Andrew Mah, Nadia Ayoub, Daniel Robb, Darrell Moore, Thomas Jones, Natalia Toporikova

Washington and Lee University

RNA-Seq is widely used to determine behavior-related changes in gene expression. However, sample sizes must be weighed against cost of sequencing during experimental design. Additionally, false positives are likely when assaying thousands of genes simultaneously. We propose using in silico modeling to (1) determine optimal in vivo experimental conditions and (2) formulate specific a priori predictions regarding differential gene expression. As an illustration, we designed an in vivo experiment to identify circadian genes in the clock mechanism of the orb-web weaving spider, Metazygia wittfeldae. This experiment involved two groups of spiders, where one group received a 1-hour light pulse. We adapted an in silico model for Neurospora's circadian clock to determine optimal times to deliver this light pulse and collect samples that maximize the difference in gene expression levels between the groups. Furthermore, the model predicted specific gene expression patterns that can help identify the most probable set of circadian genes. For example, light-responsive circadian genes should switch the ratio of gene expression levels between the two groups across our collection times. Beyond circadian experiments, this technique of using in silico modeling to inform experimental design can be applied to identify genes involved in diverse behaviors across Animalia.

Poster #26

Recombinant spider silk protein expression to test fiber-glue interactions

Lilie, Tyler, Wade Patterson, C.S. Adrian Lam, Kyle Friend, Nadia Ayoub, W&L Genetics Lab Fall '18

Washington and Lee University

Orb-web and cobweb weavers in the superfamily Araneoideae produce at least 7 task-specific silks synthesized in specialized abdominal glands. For instance, the orb-web axial lines are synthesized in the major ampullate gland, while the capture spiral consists of an axial flagelliform fiber covered in an aqueous glue made in aggregate glands. Each silk fiber type is primarily composed of one or more members of the spidroin (spider fibrous protein) gene family. Aggregate glue composition includes at least 1 spidroin but also a complex mixture of additional proteins, lipids, sugars, and inorganic molecules. We identified candidate glue proteins through proteomics of capture threads. In order to test interactions among proteins in the composite fiber-glue capture threads, we isolated silk proteins through recombinant technology. We chose 11 published spidroins and 11 candidate glue proteins from two cob-web and one orb-web weaving species. Because spidroins are long and repetitive, one or two short domains with known functions were chosen from each spidroin for expression. In contrast, we isolated almost full-length glue protein-encoding genes. Targeted gene sequences were ligated to an expression vector and used to transform E. coli. Preliminary induction experiments successfully expressed 7 spidroin domains and 3 glue protein domains.

Poster #28

A comparative study of the behavior of the scorpion Centruroides vittatus in the Tamaulipan Biotic Region of South Texas in relation to microhabitat use and temperature

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Texas A&M International University

Study focused on the effect of temperature and microhabitat use on the behavior of the striped-bark scorpion, Centruroides vittatus. The study was conducted in the Tamaulipan Biotic Province in Webb Country, Texas. High frequency of smaller scorpions was found sit-and-waiting on grass and herbs, but the lowest frequency of smaller scorpions was actively foraging on shrubs, trees, and succulents. The highest frequency of the larger scorpions was sit-and-waiting on the ground. The activity of scorpions increased significantly with an increase in temperature. Larger scorpions were active at a higher frequency at temperatures greater than 30˚C. Results suggest that the smaller scorpions avoid predation by the larger scorpions by utilizing grass and herbs, which are rarely used by the larger scorpions. Use of vegetation by the smaller scorpions could be to avoid larger scorpions on the ground. Larger scorpions had a higher activity than the smaller scorpions at higher temperatures suggesting that the smaller scorpions were trying to avoid active foraging at the same time as the larger scorpions.

Poster #8

Identification of the Cardinium endosymbiont in Oklahoma Leiobunum species

*Montgomery, Tyler, Mercedes Burns

University of Maryland, Baltimore County

The endosymbiont Cardinium has been found in many arthropods, including harvestmen. This bacteria has been hypothesized to have an impact on reproduction and sex ratio biases in infected populations, similar to another better studied reproductive endosymbiont, Wolbachia. However, the exact effects and localization of this bacteria in host organisms is not yet known. Oklahoma populations of Leiobunum relictum have exhibited female-biased sex ratios in the past, and therefore specimens from the greater L. vittatum species group were selected for Cardinium endosymbiont screening. DNA was extracted from reproductive tissues to isolate Cardinium, and 16S sequencing was used to screen for the bacteria in the selected populations. Amplicons were then compared to known sequences in the NCBI BLASTn database. We identified Cardinium in two different species, but further investigation into rates of infection over time is needed. We also found amplifiable bacterial DNA in both gonad and muscle tissues of the infected individuals. Screening to find the prevalence of Cardinium in these populations will help to identify possible sex ratio biases related to infection rates and provide better understanding of how these biases originate and evolve over time.

Poster #13

The Role of Sight and Scent in Tigrosa helluo Mating Behaviors

*Murray, Thomas, Jake Godfrey, Ann Rypstra

Miami University

Studying the way animals interact with each other can be useful in understanding what roles specific signals have in communication. Studies of wolf spiders (Lycosidae) have contributed to the understanding of multimodal signaling because they are easy to manipulate in a laboratory setting. In our study, we investigated the importance of light and male chemotactile cues on mating success in the nocturnal wolf spider Tigrosa helluo. We approached this by documenting male and female interactions in a fully crossed design with or without male chemical cues and under white or red lighting. We compared the number of interactions and mating success between groups using generalized linear models. We found that males approached females most often under white light when they had not previously laid down cues. Females approached males most often under white light with male cues and least often under red light without male cues. Females were also found to be more aggressive under white light without male cues. Finally, mating was found to be the most successful when only either white light or male cues were present. These results suggest that chemical cues are used differently by males and females and under different lighting conditions.

Poster #4

Supercomputer to the rescue: Optimizing a scorpion navigational algorithm across environmental parameters.

Musaelian, Albert, Douglas Gaffin

University of Oklahoma, Department of Biology

The Navigation by Chemo-Textural Familiarity Hypothesis suggests that scorpions use dense matrices of ground-directed peg sensilla on their pectines to navigate across surfaces by learning their chemo-textural details. This project attempts to determine which sensory and environmental conditions contribute to successful navigation. We used cluster computing and a simulated scorpion agent to test navigation performance across multiple relevant variables: sensor spatial resolution, sensor “color” sensitivity, saccade width, training path complexity, and environmental information density. Landscapes were generated with various levels of local information content using a custom “diffusion of uncertainty” approach. Training paths were systematically generated with increasingly sharp turns. The navigation performance of the agent was measured by the root-mean-square deviation of the agent’s taken path from the training path as well as the percentage of the training path covered by the agent. The project is ongoing, but our preliminary results support the feasibility of our hypothesis and could provide insights into how sensor architecture is matched to landscape parameters in the real world.

Poster #10

Addiction-like behaviors in female Parasteatoda tepidariorum

*Nolt, Makenzie, Makenzie Nolt, Jessica Petko

Penn State University

The natural reward system drives organisms to eat, drink, and reproduce. Humans have found a way to stimulate the system with drugs and alcohol which can lead to addiction. The molecular basis of artificial stimulation is not completely understood; however, a common component is the neurotransmitter dopamine. Addictive substances cause overstimulation of dopamine receptors leading to a rewarding feeling that encourages the organism to repeat the behavior. The role of dopamine is evolutionarily conserved in invertebrate and vertebrate models. In the 1970's, famous studies by Peter Witt demonstrated that the web patterns of orb weaving spiders are altered by addictive substances. However, it remains unknown whether spiders find these drugs rewarding. In this study, I designed a place preference apparatus to study the behaviors of the common house spider, Parasteatoda tepidariorum (P.tep). Mature female P.tep were offered 10% ethanol or water through q-tips, and their behavior was recorded for several weeks. The results show that female P.tep spent more time in contact with and roosted on the alcohol-soaked q-tip compared to the water-soaked q-tip. These results suggest that female P.tep find alcohol rewarding. Future studies will aim to assess the role of dopamine and run the study on male P.tep.

Poster #5

Exploring the relationship between Larinioides cornutus viscid silk, humidity, and highly textured substrates: does over-lubricated spider glue stick better to insects?

*Onyak, Ariel, Angela M. Alicea-Serrano, Ali Dhinojwala, Todd Blackledge

The University of Akron

Spider viscid silk is a "smart-adhesive" that quickly changes droplet size, viscosity, and adhesiveness in response to atmospheric humidity. Different species "tune" water uptake to match their foraging environment, achieving a "universal" viscosity that optimizes tradeoffs in spreading versus bulk energy absorption during adhesion. Too much water lowers viscosity so that the glue spreads well, but cohesive failure occurs easily, generating poor adhesion. However, the optimal viscosity model of adhesion is based on adhesion to smooth glass. Here we test the hypothesis that a less viscous, "over-lubricated" glue, which shows poor adhesion on smooth glass, will be stickier on hairy insects because of its greater ability to spread across three-dimensional surfaces. We ran adhesion tests of the furrow spider (Larinioides cornutus) viscid silk on honey bee (Apis mellifera) thorax, with and without hairs, in either high or medium humidity. Our results show that "over-lubricated" glue increases adhesion on hairy surface, performing equally as well as an optimally viscous glue. This suggests that glue viscosity may could be targeted by natural selection to promote specialization on different types of prey.

Poster #30

Evolution and systematics of the spider infraorder Mygalomorphae

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The infraorder Mygalomorphae is an ancient group of spiders with world-wide distribution and over 3,000 nominal species. Numerous mygalomorph families (e.g., Hexathelidae, Ctenizidae, Cyrtaucheniidae, Dipluridae and Nemesiidae) were identified as non-monophyletic in the past. However, the data generated by Sanger-sequencing approaches were unable to provide sufficient resolution for the higher-level relationships such that the necessary changes in classification could be made with confidence. Here we present a comprehensive phylogenomic treatment of the Mygalomorphae based on phylogenomic data. We employed 472 loci obtained through Anchored Hybrid Enrichment sampled from individuals representing all currently recognized families. The highly-resolved relationships recovered in our phylogenetic analyses corroborated the non-monophyletic status of numerous families and as a result, allowed us to propose a new classification scheme. As a result, we relimit the generic composition of the families Ctenizidae, Cyrtaucheniidae, Dipluridae and Nemesiidae, elevate five subfamilies to family rank and propose three new ones.

Poster #18

Phylogenetics of the Vittatum group of Harvestmen using 3RAD short read sequencing

*Pakala, Mayukha, Mercedes Burns

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Approximately 35 species of leiobunine harvestmen are found in North America, but phylogenetic relationships among these species are not resolved. The Leiobunum vittatum group consists of the four species Leiobunum vittatum, L. crassipalpe, L. relictum, and L. uxorium, but specific relationships between species are not concretely known. Short read DNA sequences from across the genome can be analyzed to generate phylogenetic trees to better determine the phylogenies of closely related species. Three-enzyme restriction associated DNA sequencing was used to generate short read sequences of vittatum group species. This was achieved through restriction enzyme digest with EcoRI, MspI, and ClaI. Once the samples were sequenced, the data was processed using Stacks, a software pipeline for building loci from short-read sequences. The final stage of the pipeline consists of calling the variant sites in the population. Using the output from Stacks, a maximum likelihood phylogenetic tree was generated using RAxML. The maximum likelihood tree shows that L. vittatum and L. crassipalpe group based on locality, L. relictum forms a separate clade, and L. uxorium is diverged from the rest of the species. Phylogenetic inference will allow for the improved understanding of the speciation processes found among the L. vittatum group of harvestmen.

Poster #19

A new species of spider from Mexico in the genus Frontinella F. O. Pickard-Cambridge (Araneae: Linyphiidae)

Patrick, L. Brian, Michael L. Draney

Dakota Wesleyan University

A new species in the genus Frontinella F. O. Pickard-Cambridge 1902 is described based on the embolic division and other characteristics of the male, and on the epigynum and other characteristics of the female. This new species resembles Linyphia trifalcata (F. O. Pickard-Cambridge 1902), which is probably misplaced and should also be in the genus Frontinella. The current specimen is from secondary tropical forest near Hidalgo, Chapulhuacán, Mexico.

Poster #24

Are you what you eat? Prey diet and relative growth rate in tarantulas Ceratogyrus marshalli

*Perkins, Kendra, Cara Shillington

Eastern Michigan University

Extensive evidence on the detrimental effects an inadequate diet has on various species is well-studied in herpetology husbandry. Impacts include metabolic bone disease, visceral and arterial gout, and egg-binding; which is why various dietary supplements are available. Similar research has not been undertaken with arachnids, which are increasingly popular in the pet-trade. We investigated whether prey diet influenced growth of invertebrate predators in tarantula spiderlings. We hypothesized that tarantulas fed crickets on a nutrient-rich diet would have shorter intermolt periods and faster relative growth rates (RGR) than the control group. We randomly separated spiderlings into two groups: the control group were fed crickets on a nutrient-poor diet while the experimental group were fed crickets gut-loaded on a nutrient-rich diet. Spiderlings were fed twice monthly with similar sized crickets (regardless of diet) and weighed once a month. Prior to the different prey diets, both groups had similar growth rates. Throughout the experiment, groups showed continual increases in growth over a 3-month period, and by the 9th feeding, there were significant differences in RGRs between the groups ($p<0.05$). Thus, prey diet can influence predator growth; long-term health and fitness benefits for the tarantulas have yet to be studied.

Poster #6

Neonicotinoid insecticides suppress the ability of spiders to re-colonize disturbed agroecosystems

Řezáč, Milan, Milan Řezáč, Nela Gloríková, Petr Heneberg

Crop Research Institute

Agroecosystems are characterized by regular disturbances that cause extinction or migration of much of their fauna. Therefore, these ecosystems must be repeatedly recolonized from surrounding refuges. In spiders, such recolonization is potentiated by their ability to rappel and balloon. These are complex behaviors that we hypothesized to be affected by neurotoxins, namely, neonicotinoids. We tested this hypothesis using two model species of common farmland spiders. The spiders were subjected to two modes of contact exposure to formulations of neonicotinoids that are widely used in agriculture. We then recorded the effects on ballooning and rappelling behaviors at 1 h and 24 h following the treatment with neonicotinoids. We found that contact exposure to neonicotinoids suppressed the ability of spiders to produce the major ampullate fiber and anchor it to the substratum by piriform fibrils. Contact exposure to neonicotinoids also suppressed the ballooning behavior that is manifested by climbing to elevated places, adopting a tiptoe position and producing silk gossamer in wind. We found that all four tested neonicotinoids severely inhibited both ballooning and rappelling behaviors of spiders. Impaired ability of affected common farmland spiders to quickly recolonize disturbed agroecosystems after their regular disturbances may explain their decline in multiple farmland ecosystems.

Poster #11

North American camel spiders (Arachnida, Solifugae, Eremobatidae): systematic revision and biogeography of an understudied taxon.

Savary, Warren, Paula Cushing, Matthew Graham, Jack Brookhart, Carlos Santibáñez-López, Erika Garcia, Richard Ryan Jones

California Academy of Sciences (Field Associate)

The endemic North American family Eremobatidae (Arachnida: Solifugae), containing 188 described species currently placed in two subfamilies, eight genera and 18 species groups, accounts for the majority of Nearctic solifuge species. Despite a taxonomic history that dates back to the first formal description of a North American solifuge by Thomas Say in 1823, a firm understanding of the phylogenetic relationships and taxonomic boundaries within the Eremobatidae remains elusive. Funding provided under National Science Foundation grants DEB-1754587 to Paula Cushing (Denver Museum of Nature and Science) and DEB 1754030 to Matthew Graham (Eastern Connecticut State University) has enabled the assembly of a collaborative team of researchers (Paula Cushing and Matthew Graham, co-PIs; Jack Brookhart and Warren Savary, collaborators; Carlos Santibáñez-López, Postdoctoral Researcher; Erika Garcia, PhD student; Richard Ryan Jones, MS student) to elucidate the systematics and biogeography of this challenging group of arachnids, while also introducing undergraduate students and high school students to research opportunities and developing a robust website that provides a plethora of information about the order Solifugae.

Poster #20

Learning and foraging in the wolf spider Pardosa milvina (Araneae: Lycosidae)

*Shannon, Hailey

Miami University

The ability to learn about the surrounding environment is advantageous for many arthropods when searching for mates, avoiding predators, or foraging. It has been demonstrated that arachnids are capable of both simple and complex forms of learning within these situations. Simple forms of learning, such as classical conditioning have been well explored in arachnids, but studies on more complex learning, such as contextual associations, are still needed. Here I present data on contextual learning by the wolf spider Pardosa milvina (Araneae, Lycosidae) in connection with foraging. Spiders underwent training to associate unpalatable (quinine-coated) prey with a peppermint scented environment and palatable (water-coated) prey with a maple scented environment. After training, P. milvina was tested in a two-choice maze where individuals selected to travel either towards peppermint or maple cues. Over the course of the training period, attacks on the unpalatable prey declined relative to those on palatable prey. During maze testing, P.milvina demonstrated no significant preference for either maple or peppermint cues. These results suggest that P.milvina may be learning to associate these scents with the palatability of prey, but their use of this information to inform foraging decisions remains unclear.

Poster #7

Sequencing the mixed ploidy genomes of facultatively parthenogenetic Japanese harvestman Leiobunum manubriatum

Stellwagen, Sarah, Mercedes Burns

University of Maryland Baltimore County

Polyploidy, a condition in which an organism has three or more times the normal haploid chromosome number, frequently co-occurs with parthenogenesis, an asexual reproduction mode in which ova develop without fertilization. To explore hypotheses about the origin, consequences, and relationship of polyploidy to facultative parthenogenesis, we are sequencing the genome of endemic Japanese harvestman Leiobunum manubriatum. Both diploid and tetraploid individuals occur within the same populations, and females of both ploidies are able to reproduce asexually. We are using Oxford Nanopore technology to sequence the genome of diploid females, and have presently gathered approximately one-third to one-half of the estimated coverage needed for assembly. We report our current progress, including difficulties that may affect others who have interests in genomic sequencing of arachnids using a similar strategy. The completed genome will facilitate efforts to understand evolutionary mechanisms for the maintenance of sex, cytological processes of parthenogenesis, and genetic associations of polyploidy and sexual strategy.

Poster #21

Effects of activity and web coverage on growth rate in Psalmopeus irminia

Underwood, Tyler, Cara Shillington

Eastern Michigan University

Trade-offs in behavior and growth are not well-studied in invertebrates. Higher activity requires larger energy demands leading to slower growth. Faster growth rates in juvenile organisms may increase overall fitness due to increased survival and reproduction. In their individual containers in the lab, tarantula spiderlings adopt either a burrowing lifestyle, arboreal lifestyle, or a combination. We examined potential trade-offs in activity and growth and hypothesized that burrowing tarantulas exhibiting less locomotory activity, and those that produced less web would have faster growth rates. For each individual we recorded 1) amount of web coverage, 2) locomotory activity, and 3) resting metabolic rates (RMR). Spiderlings were categorized based on their lifestyle (burrowers, climbers, both) and web-produced and these categories were determined on percent of time/# of observations. All were fed and weighed on a similar schedule. We compared relative growth rates (RGR) and RMRs between lifestyles and web-production. Our data indicate burrowers have the highest average RGR and lowest RMR. While is is uncertain if individuals with intrinsically higher RMR adopt a more active lifestyle or if RMRs are higher due to the overall activity, this suggests lifestyle has energetic consequences and can significantly impact individual growth rates.

Poster #9

Investigating complex behaviors using spiders

Wilkerson, Nicolas

Johns Hopkins University

Commonly defined and studied behaviors occur over short time-scales on the order of seconds. Over longer timescales, behaviors undertaken by mice and flies are stochastic leading to trial-to-trial variability. Orb weaving spiders give a means to investigate previously understudied aspects of behaviors that occur over the minute to hour timescales. Spiders do not have many stochastic behaviors once they have assembled a web. Creating a web takes place over several hours, involves multiple stages, and many different types of actions. Spider webs are very ordered geometric shapes constructed in near-total, or complete, darkness. Web construction requires repeated testing and error corrections that are not necessarily local, implying the usage of a navigation strategy.

High resolution cameras and infrared LEDs allow for clear recording of a spider building its web in real time without perturbing the organism. Machine learning algorithms track the spider and its legs with high fidelity. Various mathematical techniques including a spectral transform and different dimensionality reduction algorithms highlight the patterns in the behavior. Ultimately this work will yield an easy to follow hierarchical map of this incredibly complex behavior. The map will use many models of sub-behaviors and build on their relations to model the whole process.

Poster #3

Pharmacology of duplicated dopamine receptors in the common house spider, Parasteatoda tepidariorum

*Winkowski, Madison

Penn State University- York

Dopamine is a neurotransmitter involved in sensation, locomotion, decision-making, and reward. The receptors for dopamine are G-protein coupled receptors (GPCR). GPCR receptors are divided into subfamilies based on structure and pharmacological properties. Invertebrates have three subfamilies DOP1, DOP2 and DOP3. DOP1 and DOP2 couple to stimulatory G-proteins that lead to increased cAMP while DOP3 is coupled to inhibitory G-proteins that serve to decrease cAMP. Aberrant cAMP signaling leads to alterations in gene expression and neural connectivity associated with addiction. The goal of this study was to identify and pharmacologically characterize the dopamine receptors of arachnids. We found that the common house spider, Parasteatoda tepidariorum genome encodes six dopamine receptors as compared to the three found in other invertebrates. The extra receptors are thought to have arisen from a whole genome duplication after spiders diverged form their common ancestor with insects. Based on amino acid comparisons these six dopamine receptors were expected to be classified as follows: one DOP1, two DOP2 and three DOP3-like receptors. By separately transfecting these receptors into HEK293 cells, we examined their signaling properties. Three receptors were tested for activation by dopamine through assessment of ERK phosphorylation, while the cAMP activity was assessed for DOP1.

Poster #16

Schedule Changes

Monday, June 17

Session 2: Morphological evolution & taxonomy

Canceled Moderator: Jonathon Coddington
Updated Moderator: Nadia Ayoub

CANCELED:

10:30am **Sexual size dimorphism: evolution and perils of extreme phenotypes in spiders**

Jonathan Coddington, Matjaz Kuntner

REPLACED WITH:

10:30am **Investigating the poly-paraphyly of North American camel spiders (Solifugae: Eremobatidae: Therobatinae) and their unique moveable palpal spines.**

Erika L. García, Paula E. Cushing, Damien Laudier
University of Colorado, Denver, USA

The North American solifuge family Eremobatidae Kraepelin 1899, is one of the most diverse families of camel spiders, comprised of two subfamilies (Therobatinae and Eremobatinae) and 179 species. A recent molecular phylogenetic analysis of Eremobatidae unveiled the dire need for further study since many groups, including the subfamily Therobatinae, were rendered as polyphyletic and paraphyletic. The goal of this comparative study is to provide morphological characteristics that could demarcate Therobatinae and Eremobatinae by comparing moveable pedipalp spines, a unique structure yet to be documented in any other arachnid. Preliminary scanning electron microscopy (SEM) data suggests that while moveable spines are present in all eremobatid genera, the bases of the spines display variable phenotypes. Obvious external differences in ridge shape between eremobatid genera could suggest that spine performance is variable among the eremobatids. Further investigation using histological techniques to examine the muscle microstructure involved in the movement of these spines could provide crucial characters that will help test the monophyly of Therobatinae. Ultimately, information acquired from this study will be integrated with a phylogenomic framework to thoroughly investigate the monophyly of the subfamily Therobatinae and the interrelationships of the Therobatinae genera.