

DENVER MUSEUM OF NATURE & SCIENCE REPORTS

NUMBER 3, JULY 2, 2016



Program and Abstracts
20th International Congress of
Arachnology
July 2-9, 2016
Colorado School of Mines, Golden, Colorado

Paula E. Cushing (Ed.)

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Edited by
Paula E. Cushing¹

Preface

Welcome to the 20th International Congress of Arachnology!

This congress is jointly hosted by the International Society of Arachnology, the American Arachnological Society, and the Denver Museum of Nature & Science.

A total of 375 participants are in attendance representing 39 different countries. An additional 36 accompanying participants are taking advantage of Colorado's scenery and charms. Of the registered participants 154 are students.

This book contains the schedule of events, the scientific program, and the abstracts.

In total, there will be five keynote addresses, nine formal symposia, 240 oral presentations (including symposium talks), and 129 poster presentations. The abstracts are arranged in alphabetical order by the surname of the presenting author. Above each abstract is an indication of the type of talk (i.e., keynote address, symposium talk, oral presentation, poster presentation. Student presentations that are part of the student competition are indicated with asterisks (*) in the abstract list and in the schedule. Speakers whose names are underlined in the program are session moderators charged with keeping the session on time.

Thanks to the following foundations and organizations for providing support for this meeting: ISA, AAS, DMNS, Kenneth King Foundation, Laudier Histology, Schlinger Foundation, Golden Chamber of Commerce, Siri Publications, BioQuip, Cricket Science.

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On behalf of the Organizing Committee,
Welcome to Golden – Where the West Lives!

Paula E. Cushing

CONTENTS

Preface	1
Emergency Contact Information & Wireless	3
Organizers and Committee Chairs	3
Proceedings of the 20th International Congress of Arachnology (2016) and guest access to New Zealand Journal of Zoology	4
General Information	5
Oral Presentations	5
Poster Presentations	5
Student Awards	5
Venue and Town	5
Golden Ticket	5
Vendors & Special Book Signing Event	5
Group & Committee Meetings	5
Arachnid Collecting	5
Reprint Table	6
Silent Auction	6
Alcohol Rules & Laws	6
Marijuana Laws	6
Smoking in Golden	6
Tubing in Clear Creek	6
Hiking on South Table Mountain	6
Social Events & Drink Tickets	6
Russian Party	7
Check-out Items for Dorm Residents	7
Promotion for the Next ICA and AAS meetings	7
Daily Schedule	8
IUCN Workshop Thursday, June 30–Saturday, July 2	8
Registration and Welcome, Saturday, July 2	9
Sunday, July 3	10
Monday, July 4	13
Tuesday, July 5	16
Wednesday, July 6, Mid-Congress Excursions	18
Thursday, July 7	19
Friday, July 8	21
Poster Session I, Sunday, July 3: List of Participants	23
Poster Session II, Tuesday, July 5: List of Participants	27
Arachnid FilmFest Program	31
Accompanying People Agenda	31
Post-Congress Excursion Agenda	32
Abstracts (Alphabetical by Surname of Presenter)	33
Attendees	209

EMERGENCY CONTACT INFORMATION & WIRELESS

Emergency Contact Information:

Police / Ambulance Emergency dial 911

Meeting Host, Paula Cushing:

Mobile Phone: 303-246-8382

Home Phone: 303-273-5707

Courtney Scheskie, DMNS Office Manager and Assistant Meeting Coordinator:

Mobile Phone: 864-642-7468

Patrick Casto, DMNS Volunteer and ICA Meeting volunteer:

Mobile Phone: 303-596-6382

Wireless:

When on campus, open your browser. Choose CSM Guest (not CSM Wireless). Enter your personal email address. This will serve as your password to connect to the internet.

ORGANIZERS AND COMMITTEE CHAIRS

Organizing Committee:

Paula E. Cushing, Denver Museum of Nature & Science

Courtney Scheskie, Denver Museum of Nature & Science

Patrick Casto, Denver Museum of Nature & Science

Program Committee:

Linda Rayor, Cornell University

Ingi Agnarsson, University of Vermont

ICA Website Management:

Peter Michalik, Ernst-Moritz-Arndt-Universität Greifswald, Germany

Heiko Metzner, psbrands GmbH, Germany

Travel Grant Committee Chairs:

Mike Draney, University of Wisconsin-Green Bay, USA (AAS Student Travel Grant)

Damien Laudier, Laudier Histology, USA (Laudier Student Grants for Histological Research)

Karen Cangialosi, Keene State College, USA (Kenneth King and Schlinger Foundation Travel Grants for Non-Students)

Student Competition Committee Chairs:

Richard Bradley, The Ohio State University, USA

Yael Lubin, Ben Gurion University, Israel

Committee members:

J. Andrew Roberts, The Ohio State University – Newark, USA (student travel grant)

Sarah Stellwagen, postdoc Army Research Laboratory, USA (student travel grant)

Rainer Foelix, Aarau, Switzerland (Laudier Grant)

Peter Michalik, Ernst-Moritz-Arndt-Universität Greifswald, Germany (Laudier Grant)

Elizabeth Jakobs, University of Massachusetts Amherst (non-student travel grant)

Maggie Hodge, Louisiana School for Math, Science, and the Arts, USA (non-student travel grant)

Al Cady, Miami University, USA (student research grant)

Bruce Cutler, University of Kansas, USA (student research grant)

Eileen Hebets, University of Nebraska, USA (HLMFAR)

Paul Selden, University of Kansas, USA (HLMFAR)

Todd Blackledge, University of Akron, USA (HLMFAR)

Thanks also to numerous colleagues serving as judges for the Student Awards!

Post-Congress Excursion Guides:

Paula Cushing, DMNS, USA

Paul and Maura Selden, University of Kansas, USA

Courtney Scheskie, DMNS, USA

Thanks also to officers of the ISA and AAS for their assistance.

Thanks to the following DMNS staff and volunteers for helping with the Congress: Ryan Bartlett, Kate Baughn, Gary Baxley, Jack Brookhart, Lynne Carpenter, Tim Chaney, Mark Christopher, Cat Davis, Jessica Ellis, Debra Freeman, David Footle, Mike Getty, Megan Gish, Karen Hall, Martin Heck, Kathy Honda, Jennifer M. Jennings, Patsy Kelly, Eric Knutson, Frank Krell, Efrain Leal, John Love, Jason Lucas, Gretchen K. Moritz-Hale, Tammy Ann Morris, Vicki Moyer, Gini Philipp, Rosine Ribelin, Nancy Roberts, Hilary Sachs, Steve Schilling, Nina Shilodon, Margo Stephenson, Jeff Stephenson, Chad Swiercinsky, Rick Teichler, Rebekah Thompson, Jill and John Weigel, Julie Whitman-Zai, Dennis Wojcicki.

PROCEEDINGS OF THE 20TH INTERNATIONAL CONGRESS OF ARACHNOLOGY (2016)
JOURNAL OF ARACHNOLOGY

The proceedings of the 20th International Congress of Arachnology (ICA) will be published in 2017 in volume 45, number 2, of the *Journal of Arachnology*.

The editors of the journal are pleased to invite submissions for the proceedings issue (details below). **Note that, in addition to the usual research/data papers, we also invite symposium organizers or participants to submit review papers keyed to the topics in their symposia.**

Open Access. All accepted ICA articles will be published as “immediate open access” papers, meaning that they will be openly downloadable from the JoA website upon publication, at no charge either to authors or to readers and without the need for a password.

Submissions. All submissions to the *Journal of Arachnology* are now made online at <http://www.editorialmanager.com/arachno/default.aspx>

When submitting a manuscript for the proceedings, be sure to choose “ICA Paper” when asked to “Choose Article Type.”

Deadline. October 1, 2016. Manuscripts submitted after the October 1st deadline will be considered for later issues of the Journal.

Format. Regular Congress manuscripts should be no more than 15 manuscript pages in length (double spaced, 12-pt font), not including figures and tables. For manuscripts longer than 15 pages, authors must contact the Managing Editor prior to submission. Review papers may be longer than 15 pages at the discretion of the Editor-in-Chief/Managing Editor.

Instructions to Authors are available at <http://www.americanarachnology.org/JOA.html#instructions> and should be followed closely when writing and assembling

a manuscript for submission. Congress manuscripts that do not closely follow the Instructions to Authors may not be considered for publication.

Authors who are not fluent in English are urged to have a native English speaker read, edit, and help revise the manuscript prior to submission.

Review. All Congress manuscripts will be reviewed in the same manner and with the same requirements for scientific quality and content as are all other submissions to the Journal of Arachnology.

NEW ZEALAND JOURNAL OF ZOOLOGY

New Zealand Journal of Zoology has graciously granted free access to attendees of the ICA from 1–31 July 2016. To access this journal, go to: www.tandfonline.com/r/NZ-Zoology

GENERAL INFORMATION

Oral Presentations. Each speaker (except plenary/keynote speakers) will have 15 minutes total including questions and discussion. We have two to three concurrent sessions. Speakers will be asked to step off the stage at the 15 minute mark in order for us to stay on schedule and allow audience members to attend talks in concurrent sessions.

Please prepare your presentation in MS Office PowerPoint for Windows (preferably) and download it to a USB memory stick. Presentation volunteers will be available to assist presenters to download presentations no later than the break prior to their session. Earlier is better.

Posters. Poster boards are situated in the Grand Lobby of the Green Center. Posters should be no more than 4 ft x 4 ft (1.2 m x 1.2 m) in size. Poster presenters may hang posters during the afternoon of July 3rd. Poster Session I presenters should be standing by their posters no later than 7 p.m. July 3rd. Poster Session II presenters should be standing by their posters no later than 7 p.m. July 5th.

Student Awards. Awards for best student oral presentations and best student poster presentations will be given during the banquet the evening of July 8th at the Denver Museum of Nature & Science (DMNS). For both oral and poster presentations, awards will be given in the categories of Systematics, Ecology, & Biogeography; Morphology, Physiology, & Silk; and Behavior & Ecology.

Venue and Town. Maps of the Colorado School of Mines (CSM) campus and the town of Golden can be found in your welcome material. Most events will be held on the CSM campus except where noted in the program. The organizers encourage you to explore downtown Golden, enjoy a stroll along the banks of Clear Creek, and sample the many restaurants and bars in town. During your free time, wander through the Pioneer “village” along Clear Creek, see the exhibits at the Foothills Art Center, or go on a Coors Brewery Tour.

Golden Ticket. The Golden Ticket in your welcome package is accepted in restaurants and stores with a Golden Ticket in the window. Do not scratch off the magic window until you are ready to pay your bill.

Vendors & Special Book Signing Event. We are pleased to welcome BioQuip and Cricket Science as our guest vendors. Vendor tables will be in the Grand Lobby of the Green Center July 3rd, 4th, and 5th. On July 4th from 5:30 – 7:00 p.m. the following book authors will be at the BioQuip table to sign their books: Richard Bradley – *Common Spiders of North America*; Rainer Foelix – *Biology of Spiders*; Heather Proctor – *Mites: Ecology, Evolution and Behaviour*; Justin Schmidt – *The Sting of the Wild*; and Richard Vetter – *The Brown Recluse Spider*. If you have your own copy of any of these tomes, bring them to the meeting to get the author’s signature and if you do not, BioQuip will have some copies of all these books available for purchase. Stop by the BioQuip table before heading over to the 4th of July barbeque!

Group & Committee Meetings. Please refer to the schedule for the times and locations of the following meetings: IUCN pre-congress workshop (June 30th–July 2nd); Student Competition Judges meetings (July 3rd and 8th); dinner for those interested in morphology, histology, and fine structure organized by Damien Laudier (July 3rd); AAS Executive Committee meeting (July 3rd); students & early career social event (July 3rd); Journal of Arachnology Editors’ meeting (July 5th); AAS Business Meeting and promotion of the 2017 AAS meeting in Mexico (July 7th); ISA Business Meeting and promotion of the 2019 ICA meeting in New Zealand (July 8th).

Arachnid Collecting. Permits are required to collect arachnids in County, State, and National Parks. No permits are required to collect arachnids in National Forests. Collecting is permitted in the high elevation areas (Loveland Pass and Berthoud Pass) where mid-congress excursion participants will travel but is not permitted at Rocky Mountain Arsenal where those excursion participants will travel to see bison and

wildlife. Meeting organizers will have some collecting supplies, including alcohol, available during the excursions.

Reprint Table. A reprint table will be set up in the Grand Lobby of the Green Center during the meeting. Reprints are free; however, donations are appreciated. Suggested donations are 25 cents US for regular reprints and 50 cents - \$2 for monographs. A donation jar will be on the reprint table.

Silent Auction. On July 7th, the Vendor Tables will be replaced with displays and bidding sheets of items for sale during the silent auction. These items will remain on display in the Grand Lobby from 10 a.m. July 7th until 1 p.m. July 8th. At 1 p.m., the silent auction items will be packed up and moved to the Denver Museum of Nature & Science. Silent Auction ends promptly at 6:00 p.m. at the DMNS.

Alcohol Rules & Laws. Alcohol (the kind you drink) is prohibited in all University residence halls and adjacent public spaces. Open containers of alcohol are not permitted on public streets.

Marijuana Laws. The possession, use, manufacture, or distribution of illicit drugs (including marijuana) in all University residence halls, public spaces, buildings and other facilities, is prohibited. No marijuana stores are in Golden. If you want to take advantage of Colorado's lenient pot laws, you will have to go to Denver or areas outside Golden to find pot shops. And please be aware that, according to Colorado law: you must be 21 to buy, have, or use retail marijuana; it is a felony for anyone to give, sell or share marijuana with anyone under 21; you must present a valid ID proving you are 21 or older; Colorado residents can buy and possess up to 1 ounce of marijuana at a time; adults with an out-of-state ID can purchase up to a quarter-ounce at a time; some stores may only allow cash purchase (no credit cards); only licensed retailers can sell marijuana products; adults 21 or older can give up to 1 ounce of marijuana to another adult but cannot sell it; having more than one ounce of marijuana in your possession can result in legal charges and fines; using marijuana

in any way (smoking, eating, or vaping) is not allowed in public places; use of pot on federal land (national parks, national forests) is still illegal; hotel owners can dictate rules for their own facility.

Smoking in Golden. The City of Golden passed a smoke-free law in 2015 that prohibits smoking or vaping on downtown area sidewalks and public rights of way on both sides of Washington Avenue between 10th and 14th Streets, as well as both sides of 12th and 13th Streets between Arapahoe and Ford Streets, including customer seating/service areas located on those public rights of way.

Tubing in Clear Creek. We will have a couple of tubes and life jackets to borrow (for a \$5 deposit) at the Registration / Information Desk in the Grand Lobby for anyone interested in tubing on Clear Creek. You can also rent tubes and life jackets in the Student Recreation Center. Remember that mountain streams are fast moving and rocky. Please don't drown (way too much paperwork!).

Hiking on South Table Mountain. The hike up South Table Mountain (the mountain that the solifuge on the logo is standing on) takes about 30–40 minutes (one-way). It is a fairly easy hike. You can access the trail by walking down 19th Street towards the mountain. Beware of rattlesnakes – they are abundant on the mountain but they are not particularly aggressive and will rattle in warning (usually). Please leave the rattlesnakes alone and don't get bitten (see parenthetical comment under tubing).

Social Events & Drink Tickets. The four alcohol tickets received by each participant can be used for one alcoholic beverage at the socials on July 2nd, 3rd, 4th, or 5th. Non-alcoholic beverages are free. The alcohol tickets may not be used for alcoholic beverages at the Russian Party, at the Butterfly Pavilion, or at the DMNS banquet. There will be cash bars at the Butterfly Pavilion and at the DMNS. If you use up all your red drink tickets we will have a volunteer drink vendor on hand to sell you more tickets (\$5 US each) that you can exchange for a drink on July 2nd, 3rd, 4th, or 5th.

The following ICA social events are open to all participants and accompanying people. You do not need a special ticket to attend the following events: July 2nd Welcome Social, July 3rd Poster Session Social, July 4th BBQ and Fireworks, July 5th Poster Session Social, July 6th Russian Party (but see below), July 7th Butterfly Pavilion Social, July 8th End-of-Congress Banquet at the Denver Museum of Nature & Science.

Russian Party. In keeping with ICA and Arachnological Congress traditions, we are sponsoring a Russian Party. There will be a DJ and a dance floor! We ask that all participants bring an alcoholic beverage, a non-alcoholic beverage, or food to share. If you come empty handed, then please provide a \$5 donation to offset costs. You are absolutely not allowed to bring any food infused with marijuana.

Check-out Items for Dorm Residents. Dorm residents may borrow pots, pans, dishes, and utensils for use in the dorm kitchens from the Registration/Information table in Green Center Lobby. Please borrow only what you need during your stay and return items by the end of the week.

Promotion for the next ICA and AAS Meetings. Cor Vink, host of the next ICA meeting in 2019, will give a talk about that meeting at the end of the ICA Business Meeting on July 8th in Ricketson Auditorium. The ICA Business meeting will be from 17:00–18:00. The 2017 AAS meeting will be hosted by Fernando Alvarez Padilla in Merida Yucatan, Mexico. Fernando will promote his meeting during the first 15 minutes of the AAS Business meeting to be held just before the Russian Party.



DAILY SCHEDULE

**Thursday, June 30 IUCN Workshop Group 1: Golden Visitor's Center
Conference Room, 1010 Washington Ave.**

9:00	Pedro Cardoso Introduction
10:00	Training
11:00	
12:00	Lunch (included)
13:00	13:00–17:00 Training Continued
14:00	
15:00	
16:00	

**Friday, July 1 IUCN Workshop Group 1 & 2: Golden Visitor's Center
Conference Room, 1010 Washington Ave.**

9:00	9:00–12:00 Training - Group 1
10:00	
11:00	
12:00	Lunch (included)
13:00	13:00–17:00 Redlisting species - Groups 1 & 2
14:00	
15:00	
16:00	

**Saturday July 2 IUCN Workshop Group 1 & 2: Golden Visitor's Center
Conference Room, 1010 Washington Ave.**

9:00	9:00–12:00 Redlisting Continued
10:00	
11:00	
12:00	Lunch (included)
13:00	13:00–17:00 Redlisting & Summary
14:00	
15:00	
16:00	
17:00	Welcome Social, Grand Lobby Green Center, Colorado School of Mines Campus

**Saturday, July 2 Registration and Welcome Social: Grand Lobby, Green Center, 1500
Illinois Street, Golden, Colorado on the Colorado School of Mines Campus**

9:00	Registration and Check-In
10:00	
11:00	
12:00	
13:00	
14:00	
15:00	
16:00	
17:00	17:00–20:00 Welcome Social
18:00	
19:00	

Sunday, July 3 (*indicates student competition; name indicates session moderator)

	Metals Hall	Petroleum Hall	Marquez Hall MZ126
8:30	Bunker Auditorium: Welcome from Golden Mayor Marjorie Sloan and ICA Host Paula Cushing		
9:00	Keynote in Bunker Auditorium. Ximena Nelson - Trans-taxa: Spiders that dress as ants		
10:00	Break - Grand Lobby		
	Symposium: Biology of Scorpions	Ecology	Biodiversity
10:25	Alfredo Peretti - Reproductive biology of scorpions: Patterns and mechanisms of sexual selection	Marco Isaia - The dark side of climate change	* Nicholas DiRienzo - Developmental experience shapes life history, behavior, and web structure of black widows
10:45	Lionel Monod - Are male copulatory structures in the order Scorpiones informative at suprageneric levels?	* Sarah Rose - Understanding how changes in the ground spider community can enhance restoration practices	Ann Rypstra , - Experience with contaminated soil affects learning in a wolf spider
11:00	Edmundo Gonzalez-Santillán - Centruroides as a model to understand the origin and evolution of venoms	Jagoba Malumbres-Olarte - How far is far? Spatial variation in the structure of spider communities in Tanzania	J. Andrew Roberts - Influence of predators and senescence on male courtship investment in a wolf spider
11:15	Carlos Santibanez-Lopez - Filling pieces in the scorpion venom puzzle	* Stefano Mammola - The ecological niche of subterranean spiders	* Rachel Gilbert - Immune stress and sexual signaling in the wolf spider <i>Schizocosa ocreata</i>
11:30	Prashant Sharma - Comparative analysis of euechelicerate genomes supports a single origin of the arachnid book lung	* Mark Robertson - What factors affect the relative abundance of dense three dimensional webs?	Peter Midford - An Ontology for Spider Behavior
11:45	* Emily Setton - Developmental Genetics of Respiratory Structures in Arachno-pulmonate and Non-Arachnop. orders	Alan Cady - Spiders in grazed pastures: Comparisons between rotational vs. conventional grazing	Richard Vetter - Effect of seasonal photoperiod on molting in <i>Laxosceles reclusa</i> and <i>Laxosceles tula</i>
12:00	Lunch on your own; Poster Presenters hang posters Grand Lobby; Student Competition Judges Meeting (lunch provided) Golden Visitor's Center Conference Room, 1010 Washington Ave.		
	Symposium: Visual information acquisition, processing, and cognition	Taxonomy	Biodiversity
12:55	Skye Long - Variation in morphology and organization of the secondary eye optic neuropils across the order of Araneae	Jeremy Miller - Resolving the taxonomic impediment	Stefan Foord - The effect of elevation and time on mountain spider diversity: a view of two aspects in Cederberg Mtn. South Africa

13:15	Elizabeth Jakob - Jumping spiders as a model: integration of novel techniques for eyetracking & neural recording in the brain	Fernando Alvarez-Padilla - Cyberdiversity of Aranemorphae in Mexico	Juakaly Mbumba - Comparison of Rapid Assessment Protocol data from Panama and Congo Basin sites
13:30	Cole Gilbert - Visual scanning by the principal eyes of freely moving jumping spiders	* Thiago Silva-Moreira - Systematics of the “MPME clade” and the phylogeny of Linyphiidae (Araneae)	* Megan Sprovach - Spider diversity response to garlic mustard invasion in a Wisconsin forest understory
13:45	Martin Streinzer - Vision and visually guided behavior in the hunting spider <i>Cupiennius salei</i> (Araneae: Ctenidae)	* Allan Cabrero - Integrative species delimitation in the harvestman subfamily Briggsinae (Opiliones Laniatores)	Michael L. Draney - Comparing Araneoid biodiversity between high and low elevation Panamanian rainforest sites
14:00	Nathan Morehouse - Repeated evolution of color vision underlies rapid diversification of salticid male coloration	* Robert Kallal - Systematics of the Australasian araneid <i>Phonognatha</i> and evolution of orb-web leaf retreats	Matt Greenstone - Spiders attending sentinel egg masses prefer landscapes comprising native not exotic plants
14:15	Lisa Taylor - Prey color biases learning and colorful courtship in jumping spiders	* Lukasz Trębicki - Taxonomy, phylogeny and biogeography of the <i>Cytaea</i> (Araneae: Salticidae) from the Australasian Region	Fabian Hofmann - Red list proposals of spiders for European countries and regions
14:30	Daiqin Li - Jumping spiders as models for the study of animal coloration	* Gustavo Miranda - Revision phylogeny of Charinidae (Arachnida Amblypygi) based on morphological and molecular data	Ferenc Samu - Spider metacommunities: local & landscape scale processes on natural habitat islands in agricultural landscapes
14:45	Daniel Zurek - Retinal specializations and the architecture of visual signals	Pekka Lehtinen - Ultrastructure in phylogeny of Araneomorpha	Theo Blick - Spiders in sloping blockfield habitats in the Fichtel Mountains (NE Bavaria Germany)
15:00	Break - Grand Lobby		
	Visual Information/ Biogeography	Biodiversity and Invasive Species	Biodiversity
15:30	* Sebastian Echeverri - Control of signal alignment during the dynamic courtship display of a salticid	Cor Vink - Another bloody Australian in New Zealand: The invasive spider <i>Latrodectus hasseltii</i>	Wimolwan Chotwong - The diversity of long-jawed spiders (Family: Tetragnathidae) in Thailand
15:45	Dinesh Rao - The visual ecology of anti-predator wing displays: a case study with jumping spiders	Salima Machkour M'Rabet - <i>Brachypelma vagans</i> a successful invasive species on Cozumel island, Mexico: a molecular perspective	Sudhikumar Ambalaparambil - Population structure of <i>Plesioiphritus nilagiriensis</i> (Theraphosidae) in western Ghats of India
16:00	Ricardo Pinto-da-Rocha - Beta-diversity and phylogeography of Opiliones across Brazilian Atlantic Rain Forest	Wioletta Wawer - Genetic consequences of rapid range expansion in <i>Argiope bruennichi</i> populations	* David Footle - Biodiversity survey of solifuge species within Big Bend National Park Texas. (Arachnida: Solifugae)

16:15	Stephanie Loria - Systematics and biogeography of the Asian forest scorpions genus <i>Heterometrus</i> Ehrenberg 1828	Robb Bennett - Documenting diversity: Surveying British Columbia's spider fauna	Yuri Marusik - Palaearctic and Nearctic versus Holarctic: How do spiders fit into zoogeographic regions?
16:30	* Victoria R. Smith - An unexpected journey: The evolution and biogeography of New Zealand Idiopidae	* Igor Cizauskas - Diversity mapping and ecological aspects of cave spiders from Brazil (Arachnida Araneae)	Jessica Szabo - Urban Islands: A biodiversity survey of spiders on Portland, Oregon green roofs
16:45	* Nicole Garrison - Investigating species boundaries in a trapdoor spider complex using anchored hybrid enrichment	Jason Schmidt - Influence of the biogeospatial environment on the distribution of spider communities	Arthur Decae - An Aristotelian view on trapdoor spiders
17:00	Sarah Boyer - Historical refugia have shaped biogeography of dispersal-limited mite harvestmen (Opiliones Cyphophthalmi) from the Australian Wet Tropics	Nobuo Tsurusaki - Cascading increase of chromosome number showing concentric rings in <i>Gagrellula ferruginea</i> Opiliones	Jon Reiskind - Instilling Arachnophilia: Spiders in Children's Literature
17:15	* Casey Richart - Glacial Refugia & Riverine Barriers: Biogeography of <i>Azuclavella</i> (Opiliones Ischyropsalidoidea) in N. Idaho	Jesper Bechsgaard - X chromosomes evolution in <i>Stegodyphus</i> spiders	Ogonna Nwankwo - Ecological studies of spider fauna of Awka, Anambra state
17:30	Group photo 17:30–17:45: follow instructions of volunteers		
17:45	17:45–19:00: Poster Presenters hang posters. 17:45–19:00: Laudier Dinner for those interested in morphology, histology, fine structure at Bridgewater Grill Restaurant inside Golden Hotel (corner of 11th St. & Washington Ave.). 18:00–20:00: AAS Executive Committee Meeting at Golden Visitor's Center Conference room, 1010 Washington Ave.		
18:00			
19:00	19:00–21:00: Poster Session I - Grand Lobby		
20:00			
21:00	21:00–23:00: Students, early career professionals, and postdocs gather for an evening of debauchery. Meet outside Green Center or go directly to Buffalo Rose, 1119 Washington Ave. Patio reserved for our group weather permitting.		
22:00	Reservation in either Cushing's name or School of Mines group.		
23:00			

Monday, July 4 (*indicates student competition; name is session moderator)

	Metals Hall	Petroleum Hall	Marquez Hall MZ126
8:45	Bunker Auditorium: Welcome and Information		
9:00	Keynote in Bunker Auditorium. Jason Bond - Spider phylogenomics: untangling the spider tree of life		
10:00	Break - Grand Lobby		
	Symposium: Sexual Selection	Morphology	Diet and Tritrophic Interactions
10:25	Gabriele Uhl - Securing paternity by mutilating female genitalia in spiders	Tharina L. Bird - Obscure features of Solifugae: comparative morphology of the lateral eyespots	Shawn Wilder - Measuring the nutrient content of prey for spiders
10:45	Anne Danielson-Francois - Dual function of male genitalia in <i>Tetragnatha</i> —sperm removal and sperm transfer	Rainer Foelix - How can desert spiders dig their burrows in dry sand dunes?	* Sean Kelly - Riparian tetragnathids rely heavily on aquatic subsidies in a tropical urban watershed
11:00	Anita Aisenberg - Hairy kisses mating plugs and female choice in <i>Leucange</i> (Araneae: Tetragnathidae)	Juliana Jurgilas - Sexually dimorphic tarsal features in mygalomorph spiders	* Cody L. Barnes - Consequences of Prey Nutrient Content for Nutrient Cycling by a Wolf Spider (<i>Hogna carolinensis</i>)
11:15	Peter Michalik - Morphological analyses of male reproductive system of Oonopidae revealed complexity in sperm structures	G.B. Edwards - Revision of <i>Mixmessis</i> (Araneae: Thomisidae) with observations on crab spider epigynal hoods	* Will Wiggins - Macronutrient effects on juvenile jumping spider growth
11:30	Maria J. Albo - Complex mating high male sperm effort and strong female control in a wolf spider	Rodrigo Monjaraz-Ruedas - Fossil and setae characters: the morphological phylogeny of the family Protoschizomidae (Arachnida: Schizomida)	* Radek Michalko - Effect of increased habitat complexity on pest suppression by winter-active spiders
11:45	Matjaz Kuntner - Genital evolution mating rates and sexual conflict in size dimorphic spiders	* Philip O. M. Steinhoff - Neuroplasticity in a jumping spider	* Orsolya Beleznai - Increased temperature alters beetle behavior to increase predator effects and decrease herbivory
12:00	Lunch		
	Symposium: Systematics in arachnids: integrating morphology and molecules	Sex and Communication	Taxonomy
12:55	Abel Pérez-González - Ransacking the incertae sedis opilionids: a new Indo-Malayan family of Grassatores	Ren-Chung Cheng - Do all spider genital components respond to sexual selection?	* Jesús Alberto Cruz-López - Phylogenetic analysis of Stygnopsidae (Opiliones), based on three molecular markers and morphology

13:15	Daniel N. Proud - Uncharted diversity and evolutionary history of Neotropical samooiid harvestmen (Laniatores: Samooioidea)	* Alissa Anderson - Assessing fitness benefits of increased sperm transfer in the copulatory silk wrapping of nursery web spider <i>Pisaurina mira</i>	* Catalina Romero - Morphometric characters used to delimitate species in the genus <i>Apolpium</i> (Olpidae: Pseudoscorpiones)
13:30	Gonzalo Giribet - The Opiliones Tree of Life: Resolution of harvestmen relationships through transcriptomics reflects ancient regionalization of Pangea and multiple instances of temperate Gondwanan vicariance	* Luciana Baruffaldi - Phylogenetic pattern of sex pheromone discrimination in widow spiders	Vladimir Ovtcharenko - Phylogeny and classification of Gnaphosidae: historical & contemporary approaches
13:45	Gustavo Hormiga - A phylogenomic approach to resolve the relationships among the main lineages of araneoid spiders	George Uetz - Comparative mate assessment in wolf spiders: results from multimodal playback studies	André Marsola Giroti - A light in the end of the “funnel”: preliminary results on the phylogeny of Segestridae (Dysderoidea)
14:00	Julia Cosgrove - Straightening out the pseudoscorpion backbone	Andreas Fischer - Volatile chemical communication in female <i>Latrodectus</i> ssp.	* Zingisile Mbo - A revision of the spider genus <i>Drassodella</i> Hewitt 1916 (Araneae: Gallieniellidae)
14:15	Ligia Rosario Benavides Silva - Phylogeny, systematics and natural history of pirate spiders (Araneae Mimetidae)	* Seira Adams - The mechanisms of chemical communication in <i>Tetragnatha</i> spiders	* Daniela Candia-Ramírez - Systematic revision of genus <i>Crasovius</i> Reichling & West 1996 (Araneae: Theraphosidae)
14:30	Martin Ramirez - The phylogeny of dionychan spiders: a combined analysis of sequences and morphology	* Timothy Meyer - Investigating the complex relationship between female state and courtship in <i>Schizocosa oreata</i>	Sunil Jose - Species diversity of the endemic genus <i>Amandalbella</i> in Western Ghats India
14:45	Sebastián Vélez - A molecular phylogeny of the New Zealand Enantiobuninae (Opiliones : Eupnoi : Neopilionidae)	Dustin Wilgers - Female mating status affects male mating tactic expression in the wolf spider <i>Rabidosa punctulata</i>	* Jesus Ballesteros - Species delimitation of the orchard-spider <i>Leucauge venusta</i> (Araneae Tetragnathidae) in North America
15:00	Break - Grand Lobby		
Biodiversity and Systematics			
15:30	Rosemary Gillespie - Diversity vs disparity: Contrasting patterns of adaptive radiation among Hawaiian spiders	Rodrigo Willernart - Chemical and mechanical warfare: defenses of armored harvestmen against spiders and flatworms	* Guilherme Gainett - Widespread putative hygro-thermoreceptors in harvestmen (Opiliones): an everted tarsal organ?
Morphology			

15:45	Mark Harvey - Phylogenetic relationships of AU trapdoor spiders (Nemesiidae: Anaminae): a multi-locus molecular analysis	*Michael Vickers - Odor alters color preference in foraging jumping spiders	*Anne-Sarah Ganske - Ultrastructure of chemosensory sensilla in <i>Argiope bruennichi</i> (Araneae: Araneidae)
16:00	Michael Rix - Next-generation systematics of Australasian idiopid trapdoor spiders: exploring a continental radiation	*Chan Deng - Adaptive timing of predatory activity by a mosquito-specialist predator	*Rachael Alfaro - Comparative spigot ontogeny and morphology across the Lycosoidea
16:15	Kristen Emata - Ancient biogeography in a radiation of short-range endemic harvestmen from California	*Chia-chen Chang - The joint effect of predator and prey personality on foraging strategy but not success rate	Guilherme Azevedo - Complicate or simplify sex? The evolution of genitalia in Gnaphosidae spiders
16:30	Xin Xu - Pre-Pleistocene geological events shaping diversification & distribution of primitively segmented spiders on East Asian margins	Justin Schmidt - Who eats whom -- life history strategies of the vinegareon <i>Mastigoproctus giganteus</i>	*Lenka Sentenská - Are males really so insensitive? Palp morphology of a spider <i>Philochromus cespitum</i> reveals innervation
16:45	Bernhard Huber - Multiple convergences in pholcid spiders: problem and promise	Charles Haddad - Biology behaviour and physiological adaptations of the termitophagous spider genus <i>Ammoxenus</i>	Victor Townsend - Leg injuries and wound repair among cosmetid harvestmen
17:00	*Chris A. Hamilton - Phylogenomics and taxonomic revision of the tarantula genus <i>Aphonopelma</i> within the United States	*Lucas Erickson - Behavioral response to environmental and dietary heavy metals by <i>Pardosa mihina</i>	Jose Paulo Guadanucci - Evolution of tarsal structures in Mygalomorphae
17:15	Marshal Hedin - Cryptic elevational zonation in the <i>Aliatypus janus</i> complex (Antrodiaetidae) from montane California	Gan Wenjin - Decoration-building behavior in an orb-weaving spider <i>Cyclosa octotuberculata</i>	Mathew Joseph - Intraspecific variation of pedipalp and epigyne morphology in <i>Plebs miratus</i> (Araneidae), & mating plugs
17:30	17:30–19:00: Authors' Book Signing Event, BioQuip Table, Grand Lobby: Common Spiders of North America by Bradley, Biology of Spiders by Foelix, Mites: Ecology, Evolution and Behaviour by Proctor, The Sting of the Wild by Schmidt, and The Brown Recluse by Vetter		
17:45			
18:00			
19:00			
20:00	18:00–22:00: Barbeque & Fireworks, Intramural Field North, between Elm St., West Campus Rd., and Parking Lot D,		
21:00	campus		

Tuesday, July 5 (*indicates student competition; name is session moderator)

	Metals Hall	Petroleum Hall
8:45	Bunker Auditorium: Welcome and Information	
9:00	Keynote in Bunker Auditorium. Cheryl Hayashi - Evolution of Spider Silk Genes	
10:00	Break	
	<i>Symposium: Spider silk biology, biotechnology, and biomimetic inspiration from Arachnids</i>	<i>Competition</i>
10:25	Todd Blackledge - Intelligent adhesives: the structure and function of humidity responsive spider aggregate glues	* Kenneth Chapin - Investigating resource contests with the amblypygid <i>Phrynus longipes</i>
10:45	Brent Opell - Humidity affects insect retention by spider orb webs	Susan E Riechert - Spiderling interactions on the group web: social tyranny rules in <i>Agelenopsis aperta!</i>
11:00	* Bor-Kai Hsiung - Blue tarantulas and dancing rainbow spiders inspire new color technologies	* Leilani Walker - Male-male competition and chelicera morphology in New Zealand sheet-web spiders
11:15	Crystal Chaw - Comparison of dragline silk gland morphology and silk genes in two spiders	Rowan McGinley - Assessment strategies in male-male contests of jumping spiders
11:30	* Angela M Alicea-Serrano - Do silk properties evolve during adaptive radiations of Hawaiian spiders?	Heather Proctor - Male polymorphism in bird-associated mites (Acariformes: Astigmata)
11:45	Ingi Agnarsson - De-novo genomes of orb-weaving spiders reveal the diversity and complexity of spider-silk genes	* Hua Zeng - Ornamental coloration associated assessment strategy in male-male contests of <i>Siler semiglaucus</i> jumping spiders
12:00	Lunch	
	<i>Symposium: Locomotion and Kinematics: From joints and legs to whole-body performance—Jonas Wolff</i>	<i>Silk biology - Systematics</i>
12:55	Jeff Shultz - Muscles, hydraulics and springs: perspectives on joint mechanics in arachnid locomotion	Sean J Blamires - Analysis of spider silk structural variability using small and wide-angle X-ray diffraction
13:15	Christian S. Wirkner - Three dimensional analysis of the arachnid locomotory system - topics and problems	* Hamish Craig - Broad species comparative meta-analysis of key amino acid densities and silk structural properties
13:30	* Jens Runge - Three dimensional analysis of the spider locomotory system - first answers and solutions	* Sandra Correa-Garhwal - Silk gene expression profiles of male versus female Cob-Weaving spiders
13:45	Christian Kropf - The hemolymph pressure pump of armored spiders (Araneae)	* Dakota Piorkowski - Ontogenetic shift towards stronger, tougher silk of web building Tasmanian cave spider

14:00	Bradley Carlson - Morphological constraints on sprint performance as drivers of anti-predator behavior in scorpions	Shichang Zhang - Spider silk does not support the growth of bacteria
14:15	* Pedro Coelho - Scorpion tail strikes: a trajectory shape analysis	Nadia Ayoub - Transcriptomics identifies gene repertoires underlying functional differentiation of spider silk glands
14:30	* Salvatore A Sidoti - Occupancy & locomotor behavior in <i>Schizocosa ocreata</i> : preliminary analysis & visualization in R	* Charles D.R. Stephen - A transcriptomic approach to exploring pseudoscorpion subterranean trait evolution
14:45	* Erin Brandt - Targeting or escape: differences between jump types in a jumping spider	
15:00	Break	
	Symposium: Locomotion and Kinematics - Continued	Systematics
15:25	William Eberhard - The beautiful behavior and morphology of how spiders find and grasp silk lines	Lauren Esposito - Biogeography of Caribbean Arthropods
15:45	Matthew Steffenson - The effects of leg autotomy on the outcome of predator-prey interactions in <i>Pardosa valens</i>	Susan Masta - Phylogeography and diversification of chthonid pseudoscorpions in the Pacific Northwest, USA
16:00	* Ignacio Escalante - Kinematic consequences in locomotor performance after autotomy in <i>Prionostemma</i> harvestmen	* Rebecca L. Godwin - Assessment of Ctenizidae monophyly
16:15	Sarah Crews - Extreme striking in <i>Selenops</i> (Araneae: Selenopidae)	James Starrett - High phylogenetic utility of an ultraconserved element probe set designed for Arachnida
16:30	Hannah Wood - Repeated evolution of power-amplified predatory strikes in trap-jaw spiders (Araneae, Mecysmauchenidae)	* David Ortiz - Multilocus phylogeny of <i>Bonnetina</i> and related tarantulas reveals extensive morphological homoplasy
16:45	Facundo Labarque - Spider feet evolution: multiple acquisitions of distal articulations in homologous location	Joel Huey - Species discovery in the Pilbara: the curious case of <i>Conothele</i>
17:00	Fernando Pérez-Miles - Scopula, pseudoscopula, and claw tufts in Mygalomorphae	* Shahan Derkarabetian - Population genomics and phylogeography of <i>Sclerobunus robustus</i> from the SW USA
17:15		Pedro Cardoso - The Sampled Red List Index of Spiders
17:30	17:30–19:00 - JoA Editors' meeting, Table Mountain Inn; 17:30–19:00 All others, free time for dinner	
18:00		
19:00		
20:00	19:00–21:00 Poster Session II, Grand Lobby	

Wednesday, July 6th**Mid-Congress Excursions, AAS Business Meeting & Russian Party**

8:00	Plains Excursion Participants - meet buses promptly outside Green Center. There will be one bus for this trip. You must have your ticket.	Elevation Excursion Participants - meet buses promptly outside Green Center. There will be two buses for this trip: one to Loveland Pass, the other to Berthoud Pass. You must have your ticket.
16:30	All Mid-Congress Excursions will return no later than 17:00.	
17:00	Dinner on your own.	
18:00	18:00–19:00 - AAS Business Meeting and Fernando Alvarez Padilla on 2017 AAS meeting in Mexico at American Mountaineering Center, 710 10 th St., Foss Auditorium, 1 st floor.	
19:00	19:00–23:00 - Russian Party , American Mountaineering Center, 710 10 th St., Conference Center, 1 st floor. Bring alcoholic or non-alcoholic beverages to share, food to share, or \$5 donation. Please no red wine (we will pay \$200 if you spill red wine on the carpet). Be ready to dance!	
20:00		
21:00		
22:00		

Thursday, July 7 (*indicates student competition; name is session moderator)

	Metals Hall	Petroleum Hall
8:45	Bunker Auditorium: Welcome and Information	
9:00	Keynote in Bunker Auditorium. Glauco Machado - Evolution of paternal care in harvestmen: devoted fathers or selfish lovers?	
10:00	Break - Grand Lobby & Silent Auction Items on Display - bidding begins!	
	<i>Symposia: Frontiers in Arachnid Sociality</i>	<i>Systematics</i>
10:25	Leticia Aviles - Why are they social?	Bruno Rodrigues - Preliminary results of the cladistic analysis of the genera of Prodidomidae Simon 1884 (Araneae)
10:45	Linda Rayor - How habitat and retreat limitation influence sociality in prolonged subsocial huntsman spiders	Marek Żabka - Salticidae (Arachnida: Araneae) of islands off Australia revisited
11:00	Eric Yip - Maternal feeding and webs influence dispersal in the colonial orb-weaver <i>Cyrtophora citricola</i>	* R.C. Santana - Phylogeny of <i>Selenocosmia crassipes</i> (Theraphosidae): combining morphology DNA and venom
11:15	Thomas Jones - Proximate to ultimate: vertically-integrated research on evolution of sociality in <i>Anelosimus studiosus</i>	* Gerardo A. Contreras-Félix - Scorpions of the genus <i>Vaejovis</i> : the mexicanus group a morphological phylogeny (Vaejovidae)
11:30	Jonathan Pruitt - Keystone individuals in spider societies: some pros and cons	Luis Norberto Piacentini - The phylogeny of wolf spiders (Araneae: Lycosidae)
11:45	* Lucia C. Neco - Social networks as a metric of sociality in spiders	Cristina A. Rheims - Cladistic analysis of <i>Neostasina</i> with comments on the phylogeny of Sparianthinae (Sparassidae)
12:00	Lunch	
	<i>Frontiers in Arachnid Sociality (cont.)</i>	<i>Systematics</i>
13:00	* Carl N. Keiser - Individual behavioral differences influence patterns of social interactions and bacterial transmission dynamics	* Caitlin Baker - Phylogenomics & historical biogeography of the Gondwanan family Pettalidae (Opiliones: Cyphophthalmi)
13:15	Yael Lubin - Crowding leads to fitness benefits and reduced dispersal in a colonial spider	* Jimmy Cabra-García - Molecular systematics of the Neotropical orb-weaving spider genus <i>Wagneriana</i> (Araneidae)
13:30	Trine Bilde - Changes in mating system with sociality leads to depleted genomic diversity at population and species level	Takeshi Yamasaki - Evolutional pattern of the mimic-model relationship in the genus <i>Myrmarachne</i> (Araneae: Salticidae)
13:45	* Suzana Diniz - Dispersal local density dependence and population stability in social spider metapopulations	* Charmaine Condy - Untangling evolutionary relationships of widow spiders (" <i>Latrodectus</i> "): phylogeny revisited
14:00	* Ruth Sharpe - Interspecific competition group size and dispersal in a social spider	Yong-Chao Su - Can genomic approaches resolve the phylogeny of Argyrodinae (Araneae: Theridiidae)?

14:15	* Colin Wright - Exploring the relationship between collective personality & behavioral plasticity in warring arthropod societies	* Rachel Werneck - A first glance at the coupled genitalia of the harvestmen <i>Phalangium opilio</i> (Eupnoi)
14:30	* Rosannette Quesada - Efficiency of paternal care on egg protection in the harvestman <i>Poassa limbata</i> : do females help caring?	Leonardo Carvalho - Biogeographic patterns of Atlantic Forest pholcid spiders (Araneae: Pholcidae)
14:45	* Jennifer Price - Exploring behavior and neurochemistry in the polyphenic spider <i>Anelosimus studiosus</i> (Theridiidae)	Miquel Arnedo - Multiple colonizations parallel evolution and adaptive radiation of linyphiid spiders in the Juan Fernández archipelago
15:00	Break	
	<i>Neuroethology</i>	<i>Symposium in Honor of H. Levi/ Fossils</i>
15:30	Eileen Hebets - Amblypygids as a model for exploring links between sensory systems and behavior	Sarah Kariko - Honoring Herbert W. Levi: Studies on <i>Phoroncidia</i> and an interdisciplinary project based on spider biodiversity in Grand Teton National Park
15:45	Brad Brayfield - Burrow adoption and navigation in the desert grassland scorpion <i>Paruroctonus utabensis</i>	Allen Brady - On the track of the wolf: Systematics of North American species described in the genus <i>Lycosa</i>
16:00	Douglas D. Gaffin - Exploring the chemotextural familiarity hypothesis for scorpion navigation	Wayne Maddison - Surprising sisters among the salticids
16:15	* Jay Stafstrom - Net-casting neuroanatomy: Sensory structure modifications match central nervous system investment in the net-casting spider <i>Deinopis spinosa</i>	* Matthew Downen - Fossil spiders and ancient salt lakes
16:30	Gil Menda - Neural responses to airborne pure tones from the brains of jumping, fishing, and net-casting spiders	Michael B. Cuggy - Late Ordovician chelicerate diversity - new insights from Manitoba Konservat-Lagerstätten
16:45	Brent Stoffer - The effects of octopamine and serotonin on a wolf spider's mating behaviors	Paul Selden - Burmese amber arachnids; biodiversity in a Cretaceous tropical forest
17:00	Matthew Persons - Behavioral effects of octopamine across contexts in the wolf spider <i>Pardosa milvina</i>	Jon Coddington - DNA barcode data accurately identify higher spider taxa
17:30	17:30 Meet outside Green Center for prompt departure to Butterfly Pavilion	
18:00	18:00–22:00: Social at Butterfly Pavilion, 6252 West 104th Ave., Westminster. Maps on Information Table for those interested in driving themselves.	
19:00		
20:00		
21:00		

Friday, July 8 (*indicates student competition; name is session moderator)

	Metals Hall	Petroleum Hall
8:45	Bunker Auditorium: Welcome and Information	
9:00	Keynote in Bunker Auditorium. Greta Binford - How the brown recluse got its bite: evolutionary assembly of spider venoms	
10:00	Break	
	<i>Symposium: Genomics</i>	<i>Mating Systems</i>
10:25	Henrik Krehenwinkel - Next generation sequencing for high throughput assessment of H1 arthropod diversity	Madeline Girard - What makes males red-hot: mate choice in the peacock spider <i>Maratus volans</i>
10:45	* Ellie Armstrong - Rapid diversification of spiders on islands - comparative and population genomic inferences	Matthias Foellmer - Male mating success locomotory performance and metabolic rate in <i>Argiope aurantia</i>
11:00	Susan Kennedy - Next generation sequencing of gut content to study niche ecology in spiders	Kasey Fowler-Finn - The bizarre world of reproduction in leiobunine harvestmen: the evolution of mating behavior
11:15	Darko Cotoras - Genetic mosaic among ecologically similar species within an adaptive radiation of Hawaiian spiders	* Joseph Hill - Activity patterns and mating behaviors of an arboreal tarantula: <i>Avicularia laeta</i>
11:30	* Abhilesh Dhawanjewar - Population genomics & mitochondrial-nuclear discordance in range expanding <i>Argiope bruennichi</i>	* Alexander Sweger - Behavioral responses to varying acoustic stimuli in the wolf spider <i>Gladicosa gulosa</i>
11:45	* Rebecca Wilson - Influence of catecholamines on circadian rhythmicity of anti-predator behavior in orb-weaving spiders	* Linda Hernández Duran - Sexual behavior and mating plugs as a tool of mating choice in the orb-web spider <i>Leucauge acuminata</i>
12:00	Lunch. Posters must be removed by noon. Student Competition Judges subgroup meetings. Silent Auction Items moved to DMNS	
	<i>Symposium: Genomics & Venom</i>	<i>Ecology</i>
12:55	Rosa Fernández - Unraveling the Chelicerata tree of life: phylogenomic resolution of chelicerate interrelationships based on deep taxon sampling	Yann Hénaut - The good the bad and the ugly. The association between a bromeliad, an ant and a spider
13:15	Jessica Garb - Genomic perspectives on the evolution of black widow and house spider venoms	Christopher Buddle - The natural history and thermal biology of an Arctic pseudoscorpion
13:30	Robert Haney - House spider venom and silk gland transcriptomes reveal a complex transcriptional landscape	Christopher A. Brown - Retreat site selection in two species of Sky Island scorpions from Arizona
13:45	Pamela Zobel-Thropp - If they could only bite you: venom composition and potency of daddy long-leg spider venom	Norman Horner - A myrmecophilic spider from West Texas with discussion of biology and taxonomy

14:00	Mercedes Burns - Population genomics and geographical parthenogenesis in Japanese harvestmen (Opiliones Sclerosomatidae)	Milan Rezáč - Radiation of <i>Dysdera</i> spiders in the Canary archipelago included unique evolution of diet generalists from specialists
14:15	Michael Brewer - Venom evolution in the genus <i>Tetragnatha</i> facilitates adaptive radiation and mate recognition	
14:30	14:30 Rolling Departure of buses to DMNS begins from Green Center and continues through 17:00. Directions to DMNS on Information Desk for those driving themselves. Please give others rides if you can. Please be ready to get on the buses as early as you can.	
15:00		
16:00	16:00–17:00: ISA Business meeting, Ricketson Auditorium, DMNS and Cor Vink on the next ICA meeting in New Zealand	
17:00	17:00–18:00: Pre-banquet social and silent auction, Science / Morgridge Atrium, 1st floor DMNS. All attendees must be in Science Atrium by 17:00.	
18:00	18:00–18:15: Silent Auction ends, winners pay and collect items.	
18:15	18:15–20:00: Student Competition Winners Announced followed by Banquet. Buses begin departing back to Golden at 20:30 & will continue until 23:30	
19:00		
20:00	20:00–23:00: Live music with the Heresies, Science Atrium	
21:00		
22:00		
23:00	23:30: Last buses depart for Golden; drop-off at Green Center	

Sunday, July 3 Poster Session I (*identifies student competition poster)

1	Maddison, Wayne	Phylogeny with introgression in <i>Habronattus</i> jumping spiders revealed by transcriptomes (Salticidae: Harmochirina)
3	*Bishop, Sasha	Phylobiogeography of two Caribbean ochyroceratid genera: <i>Theotima</i> and <i>Ochyrocera</i>
5	Pavlek, Martina	Overview of cave spiders in Croatia- 150 years of research
7	Dolejš, Petr	Iranian spiders (Araneae) in the National Museum in Prague (Czech Republic)
9	Marusik, Yuri	Spiders of the <i>Pardosa laura</i> -group (Araneae: Lycosidae) in the Far East Russia
11	Cheng, Ren-Chung	Global phylogeny and biogeography of Argiopinae (Araneae: Araneidae)
13	*Monjaraz-Ruedas, Rodrigo	Tails or heads? Setae patterns and annuli in the female flagellum of micro-whipscorpions (Arachnida: Schizomida)
15	*Shoemaker, A. Kenji	New Records of Harvestmen (Arachnida, Opiliones) from Minnesota, USA
17	Arnedo, Miquel	Diversity patterns of spider communities in white oak forests of the Spanish National Parks
19	Ihara, Yoh	Species diversity of <i>Cybaeus kuramotoi</i> -group (Cybaeidae) and evolution of mating plugs with antagonistic coevolution
21	Lo-Man-Hung, Nancy	On the <i>Neobabnia ernsti</i> (Simon, 1897) (Araneae: Hahniidae): redescription and new records
23	Florez, Eduardo	Sicariidae family (Araneae) in Colombia, new species and first records of <i>Sicarius</i>
25	González-Santillán, Edmundo	The tree of life of the family Vaejovidae (Scorpiones), one step short to establish a natural classification
27	Koomen, Peter	Database of South East Asian jumping spiders
29	Garcia, Erika	Systematics and Evolution of Plectreuridae Simon, 1893
31	Rheims, Cristina A.	Revalidation and revision of the genus <i>Sadala</i> Simon (Araneae: Sparassidae)
33	Rodrigues, Bruno	A new genus of Neotropical spiders of the family Prodidomidae Simon (Araneae)

35	Silva-Moreira, Thiago	Revision and phylogenetic placement of the genera <i>Jalapyphantes</i> and <i>Selenyphantes</i> (Araneae, Linyphiidae)
37	Brescovit, Antonio	Descriptions of new genera of the spider family Caponiidae (Arachnida, Araneae) and <i>Tisentnops</i> from Brazil
39	*Hailey Shannon	Variation in total mercury content among riparian and non-riparian wolf spiders
41	*Kennedy, Susan	Stable isotopes illuminate niche ecology in an adaptive radiation of Hawaiian spiders
43	*Potts, Leslie	Trophic cascades: The Triangle of Decomposition
45	*Tsutsui, Masaru	Spatio-temporal dynamics of generalist predators (<i>Tetragnatha</i>) and dipterans in eco-friendly paddy fields
47	Tsurusaki, Nobuo	Mass findings of an uncommon spider <i>Prodidomus rufus</i> : Time capsule of indoor spider fauna from Edo Period
49	*Hatton, Domonique	Quantifying non-consumptive effects of arthropod predators on agroecosystem pests
51	Stańska, Marzena	Low-input conventional farming supports biodiversity of spiders in eastern Poland
53	Samu, Ferec	Weather conditions affect developmental decision in a common wolf spider species
55	Leibensperger, Laura	Spiders from the "LLAMA" collection in the Museum of Comparative Zoology
57	Bird, Tharina L.	Termite-eating spiders (Ammoxenidae: <i>Ammoxenus</i>): distribution and coexistence of cryptic species
59	Lo-Man-Hung, Nancy	Sampling terrestrial spiders: Evaluation of sampling protocols and presentation of alternative methods
61	Rayor, Linda S.	The physiological basis for delayed development in social huntsman spiders: Impacts on sociality
63	Chuang, Angela	Behavior-driven range expansion in the colonial tentweb orbweaver, <i>Cyrtophora citricola</i>
65	*Corey, Tyler	Display architecture across social contexts in the amblypygid <i>Paraphrynus laevifrons</i>
67	Wong, Boon Hui	Role of eongated chelicerae in male-male contest and female mate-choice in the salticid genus <i>Myrmarachne</i>

69	*Fischer, Andreas	Fact or myth: Do natural substances repel invasive spiders?
71	*Whitinger, John Alan	Anti-predator submersion behavior: a coevolutionary arms race between two species of wolf spiders?
73	Nelsen, David R.	Sensory shifts following autotomy in the Golden Orb-Weaver spiders (<i>Nephila clavipes</i>)
75	*Murayama, Gabriel	The importance of trichobothria in prey-capture success in the scorpion <i>Tityus serrulatus</i> (Buthidae)
77	Stafstrom, Jay	Nocturnal no more: Body condition predicts diurnal foraging in the net-casting spider, <i>Deinopis subrufa</i>
79	Wrinn, Kerri	Competition and autotomy affect survival and development in cellar spiders
81	*Classen-Rodriguez, Leticia	Autotomized <i>Prionostemma</i> harvestmen have equal mating success than intact individuals
83	*Pickett, Emily	The effects of habitat on the active space of two wolf spiders
85	*Stanley, Michael	Female preference for male chemotactile cues in <i>Pardosa milvina</i> (Araneae, Lycosidae)
87	Tatro, Kaitlyn	Last male paternity bias in <i>Tetragnatha</i> —does intermating interval matter?
89	Shoenberger, William	Familiarity reduces aggression, but also mating success, for male <i>Leiobunum aldrichi</i>
91	Sweger, Alexander	Behaviors associated with mating success in the wolf spider <i>Gladicosa gulosa</i>
93	Watts, J. Colton	Fitness consequences of geographic variation in mate choice in a wolf spider
95	*Albín, Andrea	Substrate choice by burrowing males of <i>Allocosa brasiliensis</i> (Araneae-Lycosidae)
97	Moon, Myung-Jin	Nanoscale Fibrillar Attachment Devices for the Dry Adhesion in the Salticid Spider <i>Plexippus setipes</i>
99	Laudier, Damien	Comparison of zinc-based fixatives for histochemical and histomorphometric analysis of arachnid tissues
101	Huber, Bernhard	Multiple convergent evolution of male sexual 'head' modifications in pholcid spiders

103	Ganske, Anne-Sarah	Structure and distribution of different sensilla types in <i>Argiope bruennichi</i> (Araneae, Araneidae)
105	Myung-Jin Moon	Nanoscope structure of the silk spinning spigots in the cribellate spider <i>Nurscia albofasciata</i>
107	*Giroti, André Marsola	Male chemosensory scopulae in Segestriidae (Araneae): morphology and biological aspects in <i>Ariadna Audouin</i> species
109	*Barrales-Alcalá Diego	First report of a stridulatory organ in <i>Mastigoproctus giganteus</i> Lucas 1835
111	Ubick, Darrell	Sternal apodemes in phalangodid harvestmen (Opiliones)
113	Gainett, Guilherme	Not so touchy after all: ultrastructure of chemoreceptive tarsal sensilla in an armored harvestman (Arachnida: Opiliones)
115	Guadanucci, Jose Paulo	Morphology of setae in coxae and trochanters of spiders Theraphosinae: preliminary results
117	*Schrader, Sarah	Influence of web in prey detection: a comparison of four tarantula species
119	*Malley, Samantha	Influence of age and environmental enrichment on tarantula (<i>Grammostola pulchripes</i>) personality
121	*Scott, Catherine	Male black widows decrease competition via web reduction
123	Gomez Galvis, Luz Adriana	Sampling protocol and processing of orb-web spiders. Insights towards conservation strategies
125	Lo, Ying-Yuan	How citizen scientists help scientists to do real scientific researches on Arachnology?—A spider survey in Taiwan
127	Sanchez-Ruiz, Alexander	A new genus of the Subfamily Nopinae (Araneae Caponiidae) from Neotropical region
129	Orsolya, Beleznai	Non-consumptive effects of a spider predator on plant penetration behavior of virus vector leafhoppers

Tuesday, July 5 Poster Session II (*identifies student competition poster)

Poster #	Presenter Name	Title of Poster
2	Sharma, Prashant	High throughput analysis of shape evolution in the armored harvestman family Podoctidae
4	*Caicedo-Quiroga, Laura	Characterization of cryptic diversity of Phryniidae in the Caribbean bases on DNA barcoding
6	*Oberski, Jill	A dated molecular phylogeny for <i>Austropurvellia</i> , short-range endemic mite harvestmen (Cyphophthalmi, Pettalidae)
8	*Chamberland, Lisa	From Gondwana to GAARlandia: biogeography of ogre-faced spiders (Deinopidae) mirrors geologic history
10	Xu, Xin	Extant primitively segmented spiders have recently diversified from an ancient lineage
12	Michalik, Peter	The endemic New Zealand spider family Huttoniidae (Araneae)
14	Koomen, Peter	Towards a spider photo guide of Xishuangbanna, Yunnan, China
16	*Chae, Junho	Revision of <i>Sinopoda</i> (Araneae : Sparassidae) of Korea
18	Smith, Deborah	A new primitive trap door spider in Thailand
20	Richard, Miguel	The goblin spider genus <i>Ischnothyreus</i> (Araneae, Oonopidae) in Java and Sumatra
22	Smith, Victoria R.	The many faces of <i>Cantuarina</i> : morphological plasticity in New Zealand's trapdoor spiders
24	Waldock, Julianne	The genus <i>Chenistonia</i> (Mygalomorphae: Nemesiidae) in southern Australia and revalidation of the genus <i>Proshermacha</i>
26	Lemos, Rafael Yuji	Cladistic analysis of the genus <i>Spbecozone</i> O. P.-Cambridge, 1870 (Linyphiidae)
28	Johnston, David	Morphology of <i>Mundochthonius</i> (Pseudoscorpiones) in Western Oregon
30	*Ju Hyeong, Sohn	A new record of the genus <i>Idris</i> (Scelionidae: Scelioninae; Idrini) from South Korea

32	Ali, Pir Asmat	Documenting the subtribe Aelurillina from the Hindu Kush region of Pakistan (Araneae: Salticidae)
34	Mammola, Stefano	Ecology of <i>Argyroneta aquatica</i> in a small resurgence
36	Isaia, Marco	Threatening the giant: the response of <i>Vesubia jugorum</i> to climate change
38	*Barbarich, Tara	Submersion tolerance among riparian and non-riparian spiders
40	Rao, Dinesh	Islands in the trees: A biogeographic exploration of epiphyte-dwelling spiders
42	Brantley, Sandra	Signal in the noise: use of long-term spider data
44	Hénaut, Yann	The use of tarantulas in traditional medicine on three continents
46	Knutson, Eric	Diversity and community structure of arboreal spiders (Araneae) in grassland-shrub systems
48	Richman, David	Spider Identification Field Course at Southwestern Research Station of AMNH Contributes to Species Records
50	Henshaw, Michael	Population Genetic Structure of the Bold Jumping Spider, <i>Phidippus audax</i> : Evidence for distinct forms
52	*Segura-Hernández Laura	Expanding far from home: potential geographic occupancy of the invasive <i>Cyrtophora citricola</i> (Araneidae) in America
54	Haddad, Charles	First records and potential range of invasive <i>Badumna longinqua</i> in South Africa
56	*Kala, Muhammad	Island hideouts of thieves and assassins; biogeography of Indian Ocean Argyrodinae spiders
58	Miller, Jeremy A.	A broad spectrum inventory of a small Caribbean island
60	Murayama, Gabriel	Effects of starvation on foraging behavior in the scorpion <i>Tityus serrulatus</i> (Buthidae)
62	Sentenská, Lenka	Sexual dimorphism in venom gland anatomy in a sexually stinging scorpion
64	Michalko, Radek	Alteration of predatory behavior of a generalist predator by exposure to two insecticides

66	Godfrey, Jake	Misbehaving on atrazine; an herbicide's impact on <i>Pardosa milvina</i> (Araneae, Lycosidae)
68	Stoffer, Brent	The effects of dopamine on mating behaviors of a wolf spider
70	Gilbert, Cole	Spatial cognition in jumping spiders: Assessment of path length to prey and vantage point
72	Streinzer, Martin	SpiderVR: A virtual reality setup to investigate visually guided behavior in untethered hunting spiders
74	*Miller, Madeleine	Investigating the effects of fluoxetine on anti-predator behavior of orb weaver <i>Larinioides cornutus</i> (Araneidae)
76	Li, Daiqin	Effects of boldness on web-decoration behavior and foraging success
78	Smith, Deborah	Geographic structure and gene flow in a range-expanding communal spider, <i>Cyrtophora citricola</i> (Araneidae) in Israel
80	Yip, Eric	Cuticular compounds in a subsocial spider with kin recognition
82	Hodge, Maggie	Social polymorphism in <i>Anelosimus studiosus</i> : a longitudinal comparison
84	*Olguín-Pérez, Laura	Scorpion's sexual behavior: a remarkable performance of <i>Megacormus gerstchi</i> (Scorpiones: Euscorpidae)
86	Peretti, Alfredo V.	Level of polygyny and associated reproductive costs in a funnel-web lycosid
88	*Herrig, Ashley	Effects of <i>Wolbachia</i> infection on aggression in a socially polymorphic spider, <i>Anelosimus studiosus</i> (Theridiidae)
90	DeMarco, Alexander	Leg autotomy in the fishing spider <i>Dolomedes triton</i> and its effect on antipredator and locomotor behavior
92	Levine, Todd	Autotomy and surface incline interactively affect movement in pholcid spiders
94	*Silva-Pereyra, Valentina	Mechanical work of walking on level and inclined surfaces in the tarantula <i>Eupalaestrus weijenberghi</i> (Theraphosidae)
96	*Haber Kern, Andrea	Spider form and function: foraging guild, morphology and performance
98	McGinley, Rowan	Relationships between whole-organism performance, morphology and behaviour in spiders

100	*Auletta, Anthony	The organization of the spider nervous system as revealed by dopamine immunolabeling
102	Steinhoff, Philip O. M.	Brain structure of the jumping spider <i>Marpissa muscosa</i> (Arachnida: Salticidae), an arthropod with extraordinary cognitive abilities
104	Nelsen, David R.	Preliminary description of defensive silk in <i>Latrodectus hesperus</i>
106	Yamashita, Tsunemi	Assembly and annotation of the mitochondrial genome of the Striped Scorpion, <i>Centruroides vittatus</i>
108	Vienneau-Hathaway, Jannelle	Duplication, concerted evolution of MiSp-encoding genes underlie material properties of minor ampullate silks
110	Maddison, Wayne	Phylogeny with introgression in <i>Habronattus</i> jumping spiders revealed by transcriptomes (Salticidae: Harmochirina)
112	Mah, Andrew	Do RTA-clade spiders possess the same suite of silk genes as orb-web weaving spiders?
114	*Cole, Jeffrey	Characterization of the Venom Proteome for the Wandering Spider, <i>Ctenus hibernalis</i> (Araneae: Ctenidae)
116	*Horigan, Sophia	Test of the utility of venom expressed genes for reconstructing taxonomic relationships using Haplogyne spiders
118	Evans, Samuel	Resolving deep relationships within jumping spiders
120	Gilbert, Rachel	Gene expression analysis provides new insights into the arachnid immune system
122	Albín, Andrea	Immunocompetence tests to determine burrow-digging costs in <i>Allocosa brasiliensis</i> (Araneae: Lycosidae)
124	Albo, Maria	The fear of spiders: the effect of a single talk on school children
126	Milne, Marc	Seventy-two new spider distribution records and four undescribed species from Indiana forests
128	*Sanchez, Jose	Spider population response to spatial-temporal variability in prey: Lake Mývatn, Iceland

Arachnid FilmFest Program: Tuesday, July 5, Bunker Auditorium

Title	Presenter	Time
<i>Tetragnatha</i> Mating Behavior	Anne Danielson-Francois	21:00–21:15
Mealtime for <i>Liphistius</i>	Joe Warfel	21:15–21:20
Eight-Legged Diversity: Spiders and Their Kin	Linda Rayor	21:20–21:35
Predators!!! Ground Spiders in and Out of the Lab	Zingisile Mbo	21:35–21:45
Pygids	Tyler Corey & Matt Wilkins	21:45–21:50
Behind the Door	Marco Isaia & Pierluigi Rizzo	21:50–22:55
Homage	Sarah Kariko & Ariana Kam	22:55–23:00

Accompanying People Agenda: Saturday, July 2–Friday, July 8

Date	Activity	Meeting Place
July 2	Registration and Welcome Social	Grand Lobby
July 3 9:00–17:00	Bus to Phoenix Gold Mine Tour & lunch in Idaho Springs	Meet outside Green Center
July 4 9:00–17:00 18:00–22:00	Bus to train; train to downtown Denver for tour (mostly on your own); lunch on your own with voucher. 4 th of July BBQ and Fireworks	Meet outside Green Center Intramural Field North
July 5 9:00–17:00 21:00–22:00	Bus to Botanic Gardens & Denver Zoo; lunch on your own with voucher. Arachnid FilmFest	Meet outside Green Center Bunker Auditorium, Green Center
July 6 9:00–17:00 19:00–23:00	Mid-Congress Excursions (lunch provided) or on your own (lunch on your own). Russian Party (bring drink or food to share or \$5 donation).	Meet outside Green Center American Mountaineering Center, 710 10 th Street.
July 7 9:00–17:00 17:30–22:00	Bus to Rocky Mountain National Park; lunch provided. Depart for social at Butterfly Pavilion.	Meet outside Green Center Butterfly Pavilion, 6252 West 104 th Ave., Westminster.
July 8 9:00–17:00 14:30 onward	Walking tour of Golden with Ed Weising. Rolling departure for DMNS.	Meet at Colorado School of Mines Geology Museum at 13 th and Maple St. Denver Museum of Nature & Science, 2001 Colorado Blvd., Social and Banquet with band.

Post Congress Excursion Agenda

Saturday, July 9

- 8:30 Depart CSM Campus—meet outside Green Center
- 10:30 Arrive Florissant Fossil Beds National Monument
- 12:45 Arrive Monarch Pass, Continental Divide: lunch, rest, photos
- 15:00 Black Canyon of the Gunnison National Park
- 18:30 Montrose, Black Canyon Motel. Dinner on your own.

Sunday, July 10

- 8:30 Drive to Mesa Verde National Park
- 11:30 Arrive Mesa Verde. Bag lunch at the park.
- 15:30 Drive to Moab, Utah
- 17:30 Arrive Moab, River Canyon Lodge. Dinner on your own.

Monday, July 11

- 8:30 Drive to Arches National Park just outside Moab, Utah
- 10:30 Drive to Colorado National Monument, Colorado. Bag lunch on the way
- 14:30 Drive to Glenwood Springs
- 17:00 Dinner as group at The Pullman.
- 19:00 Free time, hot springs, overnight at Hotel Colorado

Tuesday, July 12

- 8:30 Drive to Denver
- 11:30 Arrive in Denver & begin drop off at hotels & airport

ABSTRACTS

Abstracts of keynote speakers are listed first in order of presentation, followed by other abstracts in alphabetical order by first author. Underlined indicates presenting author, *indicates presentation in student competition. Only students with an * are in the competition.

PLENARY presentation—Sunday, July 3

Trans-taxa: spiders that dress as ants

Ximena Nelson

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Batesian mimicry is a classic evolutionary phenomenon whereby animals experience reduced predation as a consequence of their resemblance to noxious, dangerous or unpalatable animals. Jumping spiders (Salticidae) are the largest family of spiders, and the genus *Myrmarachne*, with over 220 species, is the largest among the salticids. *Myrmarachne* are all ant-like spiders and appear to be Batesian mimics, using both appearance and behaviour to enhance their resemblance to ants. The interactions of ants, *Myrmarachne* and non-ant-like salticids provide a framework to thoroughly explore Batesian mimicry theory. In particular, I will discuss the effects of behavioural mimicry and costs associated with Batesian mimicry, including species recognition and effects of sexual selection.

Keywords: mimicry, Salticidae, *Myrmarachne*, ant-like

PLENARY presentation—Monday, July 4

Spider phylogenomics: untangling the spider tree of life

Jason Bond

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Phylogenomic inference is transforming systematic biology by allowing systematists to confidently resolve many major branches of the Tree of Life, even for ancient groups that

may have diversified quickly and are systematically difficult. Spiders are massively abundant generalist predators that are found in nearly every ecosystem on the planet and have persisted for over 380 million years. In addition to tremendous species diversity and importance in terrestrial ecosystems, they are also known for their extraordinary biomaterials like silks and venoms. The group has long provided evolutionary models for studying complex mating and web spinning behaviors, key innovation and adaptive radiation hypotheses, and has been inspiration for important theories like sexual selection by female choice. Past attempts to reconstruct spider phylogeny using standard molecular markers have been unable to produce a well-supported phylogenetic framework for the entire order. I will discuss a number of current efforts, in collaboration with others, to further resolve spider phylogenetic relationships using transcriptome and other genomics-based data. These data provide considerable insight into our understanding of web evolution, rates of diversification across the order, and seemingly indicate that major changes in spider classification are likely warranted.

PLENARY presentation—Tuesday, July 5

Evolution of spider silk genes

Cheryl Hayashi

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Spiders are unparalleled among arthropods for the many types of silks they spin. Silks are mostly protein and this presentation will focus on the genes that encode the silk proteins. I will trace the history of advances made in characterizing spider silk genes, from the initial gene-by-gene cloning efforts to recent transcriptomic and genomic studies. The most well known silk genes belong to a single gene family, the spidroin gene family, and analyses have shown that spidroin gene evolution has been dramatically shaped by gene duplication, followed by episodes of divergence and conservation. However, spidroins are not the entire

story of spider silk, there are other silk proteins, and they, too, are members of gene families. The evolutionary diversification of serial homologs, whether they are morphological (silk glands, spigots, spinnerets, etc.) or molecular (silk genes, iterated amino acid sequence motifs), is a major theme in understanding spider silk production.

PLENARY presentation—Thursday, July 7

Evolution of paternal care in harvestmen: devoted fathers or selfish lovers?

Glauco Machado

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Exclusive paternal care is probably the rarest form of post-zygotic parental investment in nature. This behavior is known to have independently evolved in 16 arthropod lineages, nine of them belonging to the small order Opiliones, which comprises nearly 6,500 species. Thus, harvestmen offer unique opportunities to test hypotheses on the evolution of exclusive paternal. In this talk, I will first review the theoretical background on sex roles and parental care, contrasting classical views with the most recent mathematical models. Then, I will present a series of studies conducted by my research group using Neotropical harvestmen as study systems. Using both field observations and experiments, we contrasted predictions from different theoretical models and evaluated costs and benefits of paternal care. Our findings indicate that paternal care increases males' attractiveness to females. Moreover, we show that paternal care confers high benefits to the offspring when compared to relatively low costs to the males in terms of decreasing survival and foraging rates. To conclude, I will integrate the available information for harvestmen and other arthropod species in order to derive general conclusions on the evolution of paternal care.

Keywords: paternal care, sexual selection, costs and benefits, Opiliones, sex roles.

PLENARY presentation—Friday, July 8

How the brown recluse got its bite: evolutionary assembly of spider venoms

Greta Binford

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Venoms are complex phenotypes with a large and diverse set of interacting molecular components. Spider venoms have particularly deep evolutionary histories, and are strikingly complex. We have much to learn about the structure of variability in venoms and factors that influence major evolutionary changes in venom function. I will discuss ongoing work to understand how spiders in the family Sicariidae, including the brown recluse, evolved their unique venoms that have toxins that are insecticidal and cause dermonecrosis in mammals (sphingomyelinase D toxins in the SicTox gene family). In the context of the biology and evolutionary history of these animals, I will discuss our improving understanding of the timing and circumstance of the evolutionary recruitment of the SicTox lineage for insecticidal venom function. I will also present comparative venom data that integrates HiSeq transcriptomes of venom glands, and Orbitrap proteomic analyses that characterize gene families contributing to venom proteomes. This will include comparative analyses of evolutionary dynamics of these gene family lineages. Our dataset includes sampling across representatives of diverse sicariids with common ancestry spanning ~10–100 million years, and a range of non-sicariid haplogyne spiders including three taxa in their sister lineage (*Drymusa*, *Periogops*, and *Scytodes*) and other haplogynes including pholcids and plectreurids.

Student - oral presentation

The mechanisms of chemical communication in *Tetragnatha* spiders

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The mechanisms by which reproductive isolation evolves and is maintained is central to understanding fundamental processes of evolution. Chemical cues are one of the most ancient and widespread modalities of communication, yet their importance in species recognition and reproductive isolation remains largely unknown. My work will focus on the role of chemical communication in reproductive isolation and speciation within the *Tetragnatha* spider family where visual and auditory cues appear to play little or no role in species recognition during mating.

Keywords: chemical communication, pheromones, sexual behavior, *Tetragnatha* spiders, species recognition

Oral presentation

De novo genomes of orb-weaving spiders reveal the diversity and complexity of spidroins

*Ingi Agnarsson*¹, *Paul L. Babb*^{2,3}, *Nicholas F. Labens*^{2,4}, *David N. Nicholson*^{1,2}, *Eun Ji Kim*^{2,4}, *Linden Higgins*¹, *John B. Hogenesch*^{2,4}, *Matjaž Kuntner*⁵, *Benjamin F. Voight*^{2,3,4}

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Spider silks are the toughest known biomaterials, yet are lightweight, extensible, and virtually invisible to the immune system, and thus have revolutionary potential

for medicine and industry. To investigate spider-silk genes (i.e. spidroins) systematically, we constructed the first annotated genomes for orb-weaving spiders: the golden orb-weaver (*Nephila clavipes*), and Darwin's bark spider (*Caerostris darwini*). Our results yield an unprecedented diversity of spidroins, most of which we were able to characterize in detail (full-length reconstruction) for the first time. We also find an impressive diversity in the basic construction blocks of silks including hundreds of unique repeated coding motifs and cassettes, and reveal patterns of shared motifs and unique cassettes that may underlie the observed differences in biomechanical properties among different silks. We associate spidroin sequences with silk gland expression challenging some long-held assumptions, e.g., that differentiated silk glands extrude spidroins exclusive to one silk class. We additionally find evidence of an alternatively spliced spidroin, a spidroin expressed only in venom glands, evolutionary mechanisms for spidroin diversification, and non-spidroins genes highly expressed in silk glands as candidates involved in silk production.

Keywords: silk, genomics, transcriptomics

Oral presentation

Hairy kisses, mating plugs and female choice in *Leucauge* (Araneae: Tetragnathidae)

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Though many studies have documented rapid male genital divergence, few have tested how these differences between close-related species correlate with their sexual behavior. *Leucauge* genus includes more than 100 species but courtship and copulatory behavior has been described in detail only for *L. mariana* and *L. argyra*. The two species show differences in courtship and copulatory

patterns, and frequencies of sexual cannibalism. Both *L. mariana* and *L. argyra* females can have mating plugs, but in *L. mariana* they are composed by substances transferred by both sexes, while in *L. argyra* they are produced only by females. Furthermore, in this last species mating plugs function as mortal traps for males. In both *Leucauge* female decision of plug production is linked to male pre-copulatory and copulatory courtship. Both sexes in *L. argyra* show unusual derived genital structures that could have evolved under sexual selection. In this presentation we will compare genital morphology and sexual behavior in *L. mariana* and *L. argyra*, discussing the differences under sexual selection hypotheses. We will also expose recent studies on cryptic female choice in *L. mariana* and suggest fertile areas for future research.

Keywords: sexual selection, cryptic female choice, genital plugs, copulatory courtship

Student–Poster presentation

Substrate choice by burrowing males of *Allocosa brasiliensis* (Araneae, Lycosidae)

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The burrowing spider *A. brasiliensis* inhabits beaches with different granulometry in Uruguay, characteristics that could affect burrow dimensions and excavation energy costs. Males construct longer burrows than females, and burrow length is under female selection. We analyzed *A. brasiliensis* male digging preferences between coarse or fine sand, and compared digging behaviors in the two substrates. We collected *A. brasiliensis* males at a fine-sand beach (San José de Carrasco, Canelones), and a coarse-sand beach (Paso del Molino, Lavalleja). Spiders were placed for 48 hours in glass terraria with fine-grain sand in one half of the terrarium, and coarse sand in the remaining half (n=30 males from each substrate). Males preferred digging in coarse sand, independently of their

origin (fine sand males: 20 coarse sand versus 10 fine sand, p=0.02; coarse sand males: 23 coarse sand versus seven fine sand, p=0.001). Fine sand males that constructed in coarse sand showed longer burrow compared with coarse grain males that preferred that substrate (U=147.5, p=0.04). General digging patterns were similar, but occurrences (mean±SD, fine sand: 25.70±26.30, coarse sand: 50.70±39.09; U=21.5, p=0.03) and durations of resting behavior (351.21±200.35 sec, coarse sand: 728.35±382.32 sec; U=21.0, p=0.03) were higher in coarse sand. Digging in coarse sand would be faster and less energetically demanding than in fine sand.

Keywords: granulometry, burrow, fine sand, coarse sand

Student - poster presentation

Immunocompetence tests to determine burrow-digging costs in *Allocosa brasiliensis* (Araneae, Lycosidae)

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Allocosa brasiliensis inhabits sandy coastal areas in Argentina, Brazil and Uruguay. Males build burrows in the sand, and females prefer to mate with those males presenting longest burrows. In some species of spiders there is a trade-off between characters, in the history of life and immune functions. Our objective was to determine if male digging behavior affected immune response in *A. brasiliensis*. We compared the immune response of digging males vs. non-digging males (control), and immune function was estimated through lytic activity (LA). LA was expressed as changes in optical density (with decreasing readings of optical density, higher LA). We did not find significant differences in optical density between the two groups, though results were close to significance

limit (digging males: 0.33 ± 0.09 , $n=14$, non-digging males: 0.42 ± 0.16 , $n=10$; $p=0.08$). We are increasing sample sizes to confirm whether male burrow digging implies an energetic cost in this species, or if it is exclusively performed by males with good body condition, for whom digging causes no impact in immune responses.

Keywords: lytic activity, immune functions, trade-off, burrows

Oral presentation

Complex mating, high male sperm effort and strong female control in a wolf spider

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Post-copulatory sexual selection is often expected in polyandrous species and it is especially promising to study in species with complex mating patterns. In the wolf spider *Schizocosa malitiosa* males perform two different consecutive copulatory patterns, which are characterized mainly by different number of pedipalp insertions. The full mating last 100 min, 80% of total insertions occur in pattern 1 and 20% in pattern 2. Both patterns produce similar number of offspring, but pattern 1 induce higher female reluctance to remating than pattern 2. By interrupting matings after pattern 1 and then offering the male a second female, which received only pattern 2, we investigated if the complex copulatory patterns are related to male sperm investment and sperm storage by females. We hypothesized that males strategically allocate the sperm during pattern 1 causing female reluctance. Second, by mating males with recently thawed, dead females we tested the possible active roles of females in sperm storage. Our findings show that males transfer in total 71% of the sperm available in their pedipalps, being higher but not significant in pattern 1 than pattern 2. Females drastically reduced the amount of sperm stored in their spermathecae and such control is stronger in pattern 1 compared to pattern 2. We propose that cryptic female choice is a main factor driving male sperm effort, and differences in copulatory patterns among

males would result in wide variation in their reproductive success. Receptive inhibiting substances rather than the sperm itself may be acting during pattern 1, but active female reduction in the amount of ejaculate that reaches her spermathecae most probably help to reduce her reluctance to remating.

Keywords: copulatory patterns, cryptic female choice, sexual behavior, wolf spiders

Poster presentation

The fear of spiders: the effect of a single talk on school children

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Loved and feared, spiders have been always mysterious animals for human societies. The majority of species are harmless, but probably due to their venom they are generally feared and disliked in many cultures. However, spiders use the venom to capture prey or defend themselves from predators, while only 1% are fatally dangerous for humans. In this project we were interested in examining children's knowledge and attitudes about spiders as well as in measuring the impact of our talks on their point of view and behavior. We surveyed 172 children from 9 school groups (10 and 11 years old) visiting the Institute (IIBCE) in 2015. We performed a multiple choice survey before any knowledge was given, including identification of native animals (particularly arachnids), whether they are afraid or not to spiders, if they like them or not, and what is their reaction if they spot one nearby. Afterwards, we divided them in two groups: children receiving a talk about spiders and other arachnids (spider group), children receiving a talk in another topic (control group). The same survey was repeated 30 days later at school by their own teacher. We compared pre and post-responses both within and between treatment groups. The results

indicated that before any talks: 65% of the children did not know about native harvestmen, 45% were afraid of spiders, 65% disliked them and 62% ran away or killed them in an encounter. Significantly more children learned about harvestmen in the spider group (40%). We did not find differences in comparisons using the other parameters. These findings remark how meaningful a single talk can be in children's learning, but also indicate the need of a much deeper educational work to demystify false concepts about spiders and nature in general.

Keywords: children education, fear, survey, spiders

Student - oral presentation

Comparative spigot ontogeny and morphology across the Lycosoidea

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Adult spigot morphology has provided useful taxonomic characters in many morphological datasets in spider systematics; however, the ontogeny of silk spigots is very under-studied across spider taxa. Silk spigot numbers and active glands change at varying stages throughout the spider life cycle. Recent phylogenomics studies have confirmed the paraphyly of the Orbiculariae and suggest that orb weaving cribellate spiders are sister to the highly diverse RTA clade, not the sticky silk orb weavers (Araneoidea). The majority of spiders within the RTA clade, including lycosoids, have lost the use of silk as a foraging tool, and some have retained the cribellum. Given this paradigm shift in spider systematics, it is important to look for homologous spigot structures between orb weavers and lycosoids during development. Here, I describe the spigot ontogeny for three species: *Tengella perfuga* Dahl, and for the first time, *Dolomedes tenebrosus* (Hentz) and *Hogna carolinensis* (Walckenaer). Lab colonies were established and specimens collected from every instar. Spinnerets from each spider (2nd instar to adult) were dissected and prepared for SEM imaging by critical point drying, mounting and sputter-coating the specimen in gold. SEM images were used to determine the quantity, type

and functionality of spigots present on each spinneret for every instar in each species. SEM imaging and spigot mapping are currently underway. *Tengella perfuga* are cribellate and possess a triad of spigots (modified spigot with flankers) on the PLS which may be homologous to the PLS triad (aggregate and flagelliform spigots) in araneoids, while *H. carolinensis* and *D. tenebrosus* do not. These data, along with published datasets within Araneoidea and Lycosoidea, and an unpublished *Phyxelida tangenensis* (Simon & Fage) dataset (Carlson & Griswold) will be used in comparative phylogenetic analyses, using the Lycosoidea phylogeny (Polotow et al.) to explore silk use evolution.

Keywords: cribellum, spinnerets, modified spigot, silk use evolution

Student - Poster Presentation

Documenting the subtribe Aelurillina from the Hindu Kush region of Pakistan (Araneae: Salticidae)

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The subtribe Aelurillina includes 262 species of jumping spider (family Salticidae) in 11 genera worldwide, with all but one distributed in Africa and Eurasia. We provide the first report of species in the group from Pakistan, and in fact one of the few reports of any salticids in Pakistan. In recent collecting in the Khyber Pakhtunkwa, Northern area and Federally Administrative Tribles Areas (F.A.T.A.) of Pakistan we have discovered at least 6 species of aelurillines, in varied habitats but mostly on stony ground of lower bare Hindu Kush mountains. The species found include *Aelurillus* cf. *logunovi* Azarkina, 2004, *Aelurillus* sp., *Langona* cf. *bhutanica* Proszynski, 1978, *Langona* cf. *pallida* Proszynski, 1993, *Phegra* cf. *bresnieri* (Lucas, 1846), and a species of *Stenaelurillus* new to science. Further studies are needed to determine the species identifications precisely.

Keywords: Jumping spiders, Salticidae, taxonomy, Pakistan

Student - oral presentation

Do silk properties evolve during adaptive radiations of Hawaiian spiders?

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Web architecture evolved rapidly during adaptive radiation of Hawaiian *Tetragnatha*, with a divergence of web forms in the same island but repeated convergence of web forms on different islands. But, whether silk properties also evolve during adaptive radiations remains a mystery. In this study we tested for diversification in silk properties. We predicted a relationship between silk properties and the performance of webs, where differences in web architecture selects for changes in silk tensile strength, extensibility and toughness, and glue adhesive forces. As silk density decrease in the webs of some species, we expected that toughness for major ampullate and capture spiral silk will increase as compensation. Adhesion forces on the other hand is expected to increase with web size since bigger spiders produce bigger glue droplets. Orb webs from three species were collected at two sites in the archipelago. *Tetragnatha hawaiiensis* was found in Upper Waiakea Forest Reserve, Hawai'i and *T. stelarobusta*, *T. trituberculata* and *T. hawaiiensis* were found at Waikamoi Nature Conservancy Preserve, Maui. Major ampullate and capture spiral silk were obtained directly from orb webs and tensile and adhesion tests were performed using a Nano Bionix test system. Since salts present in the glue determine in part adhesion forces, solution state NMR was done and salt composition of glues was assessed. Preliminary results showed higher adhesion forces of glue and higher toughness for *T. trituberculata*, the species with the lowest amount of capture spiral silk in its web. However further analysis is still needed to draw conclusions from this data. Results of this study will help us see if spider silk material properties are coupled to its architectures, which is important for understanding spider diversification, and may aid in the development of new "green" biomaterials.

Keywords: spider silk, silk properties, biomechanics, adhesion, adaptive radiation

Oral presentation

Cyberdiversity of Araneomorphae in Mexico

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The Order Araneae has approximately 46,000 described species, most of them included in Araneomorphae, and this number is estimated to represent between one-half to one-fifth of the total. The spider fauna of tropical and subtropical regions has been poorly studied and is expected to contain most of the new species. In Mexico about 2,500 species have been recorded in various catalogs, but this represents only a fraction of the total. Three ideas are discussed to expedite the documentation of Mexican spider diversity: the use of collecting protocols that allow some type of analysis, making the morphological and genomic information of these morphospecies easily accessible to the spider community and lending the specimens to specialist for formal species description. The theoretical bases for these ideas come from *The New Taxonomy* book and the Cyberdiversity initiatives with spiders and ants.

Keywords: faunistics, New Taxonomy, diversity

Oral presentation

Population structure of *Plesiophrictus nilagiriensis* (Araneae, Mygalomorphae, Theraphosidae) in the Western Ghats of India

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This study is an attempt to characterize the population structure of an endemic burrowing spider *Plesiophrictus nilagiriensis* (Araneae, Mygalomorphae, Theraphosidae) distributed along the Western Ghats, one of the biodiversity hotspots of the world, based on mitochondrial DNA

sequence data. DNA extraction, amplification and data analysis was conducted as per standard procedures. Among the five mtDNA haplotypes identified, three haplotypes were present in both Central WG and Northern WG and two were present in Southern WG. The neighbour-joining tree of the five haplotypes identified two distinct clades of haplotypes: clade 1 and clade 2. Estimates of gene flow show that there is little exchange between SWG and other part of the Western Ghats, compared to exchange among population within NWG and CWG regions. The resulted MP tree showing two monophyletic groups: one SWG group and CWG-NWG combined. The consideration of local population differentiation is important in deciding how to conserve a fragmented population. Most measures of local distinctiveness will predominantly reflect genetic variation between populations. Such variation can be regarded as indicating a departure from an ideal panmictic system, although it may reflect long-term evolutionary processes as well as recent disturbance.

Keywords: Western Ghats, biodiversity hotspot, population structure

Student - oral presentation

Assessing fitness benefits of increased sperm transfer in the copulatory silk wrapping nursery web spider, *Pisaurina mira*

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Male fitness is largely dictated by his ability to fertilize eggs and there is a plethora of male adaptations associated with increasing fertilization success. In the nursery web spider, *Pisaurina mira*, males restrain females prior to and during copulation by wrapping them with silk. Previous research demonstrates that copulatory silk wrapping reduces a male's chance of being sexually cannibalized, and increases the number of sperm transfer opportunities (termed insertions) that a male can achieve within a mating. While avoiding cannibalism provides an obvious survival benefit to males, the impact of insertion number on male fitness remains unknown. This study

tested the hypothesis that the increased insertion number realized through copulatory silk wrapping increases (a) the quantity of sperm transferred and (b) fertilization success. To accomplish this we directly quantified the amount of sperm in male pedipalps (i.e. the male sperm storage organ) before and after mating, and quantified fertilization success when males were capable of obtaining one versus two insertions within a mating. *Pisaurina mira* exhibits a unique mating behavior that may reflect an evolutionary history of conflicting reproductive strategies between males and females. We hope this study will begin to shed fundamental insights into the co-evolutionary dynamics between the distinct sexes.

Keywords: Pisauridae, sexual conflict, sexual selection, mating systems, sperm competition

Student - oral presentation

Rapid diversification of spiders on islands - insights from comparative and population genomic inferences

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Understanding the underpinnings of population divergence and the early stages of species formation is one of the new frontiers in evolutionary biology and has been enabled by next-generation genomics. However, the application of next-generation tools to arthropod systems can be difficult, as the characteristics of these genomes are relatively unknown. To address questions of early population divergence in spiders, we have applied several different methods, including ddRAD sequencing, de-novo whole genome sequencing and assembly, and low-coverage re-sequencing of several of the spider lineages based in the Hawaiian Islands. Although relatively few spider

families have colonized the Hawaiian Islands, several of these groups have diversified rapidly into large radiations with diverse ecologies compared to their mainland counterparts. The first study examined the early diversification of Hawaiian representatives of the genus *Ariamnes* (Theridiidae), a lineage with approximately 20 described species endemic to the islands. We investigated the population dynamics of spider populations on the islands of Hawaii, Molokai, and Maui in order to gain insight into how colonization and admixture play roles in population differentiation. We use several novel tools previously not used on populations and species with short divergence times. The second study makes use of whole-genome sequencing and low-coverage methods to investigate the basis of repeated ecomorph evolution in the adaptive radiation of Hawaiian *Tetragnatha* (Tetragnathidae). Here, we present whole genome assemblies comparing the use of different sequencing techniques. Future work will sequence additional genomes in order to answer questions regarding the adaptive evolution of the spiders and their general genomic architecture.

Keywords: genomics, adaptive radiation

Oral presentation

Multiple colonizations, parallel evolution and adaptive radiation of linyphiid spiders in the Juan Fernández archipelago

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We report on the colonization and diversification of linyphiid spiders in the oceanic archipelago of Juan Fernández. This subtropical volcanic archipelago is located in the southeastern Pacific, about 667 km west of continental Chile and comprises three islands ranging from 2.2 to 50 sq. km in size and from six to one million years in age. About fifty spider species occur naturally

in these islands, most of them are insular endemisms and about half of them are linyphiids. Linyphiidae have independently colonized Juan Fernández multiple times and include no less than 14 species of the Neotropical genus *Laminacauda* and two of *Neomaso*, all of them are single island endemics. In addition, there are three linyphiid genera endemic to this archipelago. To date, little if any data on the distribution and natural history of native linyphiids was available. We have recently conducted new collections on the archipelago that have revealed that while the continental species of *Laminacauda* and *Neomaso* are rather uniform both in somatic morphology and in the foraging webs (small sheet webs on the ground), some endemics exhibit morphological features and life history traits that are very rare or unknown in any other linyphiids, including gigantism, massive chelicerae or elongated legs. Some species may have even abandoned web-building. Moreover, some of these rare phenotypic traits seem to have evolved multiple times independently within the Juan Fernández islands. The taxonomic revision of museum collections and the newly collected specimens have allowed us to discover new species, complete descriptions and uncover new synonymies. A multi-locus genetic analysis of the endemic species confirms the multiple colonizations, even within the same genus, and the morphology based species boundaries, and further reveals that the *Laminacauda* species from Robinson Crusoe underwent rapid local diversification.

Keywords: adaptive radiation, ecological shift, biogeography, phylogeny, systematics, speciation

Poster presentation

Diversity patterns of spider communities in white oak forests of the Spanish National Parks

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Arthropods fill an unparalleled variety of ecological niches and functional roles providing an excellent model to assess biodiversity and detect ecosystem perturbations at fine temporal and spatial scales. Nevertheless, because of their high abundance and diversity but poor taxonomic knowledge, they have been rarely included in monitoring and conservation programs. Here we propose to circumvent limitations in the study of arthropod diversity by combining rapid biodiversity assessment protocols with DNA barcoding tools. Spiders are among the most diverse and ubiquitous arthropod groups and play a key role in ecosystem functioning as one of the most diverse and abundant predators in terrestrial habitats. In this contribution, we will present preliminary data on the biodiversity patterns of spider communities in the white-oak forests of the Spanish Network of National Parks. White oak woods are among the most representative Iberian forests, show high levels of endemism, are of conservation concern, and their evolutionary history in the peninsula is relatively well-known. Spiders were collected using the COBRA 50 protocol, a semi-quantitative inventorying protocol that standardizes collecting effort and efficiently combines different collecting methods, conducted during both daylight and night. We conducted a total of 384 hours of sampling in 16 1-ha plots distributed across six Spanish National Parks, spanning approximately 1000 km across both a latitudinal and a longitudinal gradient. We collected approximately 20,700 specimens, representing 40 families, 185 genera and 384 species. Among the specimens, we discovered 13 putative new species and 11 additional new records for the Iberian Peninsula. Species richness ranged from 40 to 100 species. We further generated a DNA barcode library of the identified species to facilitate automatic identification for future monitoring programs, and provide phylogenetic information for inferring phylogenetic diversity patterns. Keywords: bioinventorying, DNA barcodes, species richness, replacement, gradients

Student - Poster Presentation

The organization of the spider nervous system as revealed by dopamine immunolabeling

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Spiders (Arthropoda: Araneae) display remarkably diverse and sophisticated behaviors despite possessing fewer than 100,000 neurons. This numerical simplicity makes spiders excellent model systems for understanding the evolution of behavioral complexity and the neural mechanisms that underlie it; however, little research has been done on arachnid neurobiology. To address this gap, we utilized immunocytochemical techniques to characterize the distribution of dopamine (DA) in the central nervous system (CNS) of the Floridian wolf spider *Hogna lenta* (Lycosidae). DA is a universally important modulator of many complex behaviors across animal taxa, and our study is the first to examine its distribution. We found that DA was globally expressed throughout the central but not the peripheral nervous system of *H. lenta*. In the so-called supraesophageal mass, we found that DA was particularly concentrated in the first and second optic neuropils (ON1 and ON2) of all eight eyes, indicating that DA plays a critical role in modulating visual processing. DA was also found throughout multiple layers of the arcuate body and the bridge of what has been termed the mushroom body, both sites of higher order sensorimotor integration. We also observed large dopaminergic neurons in the abdominal neuromeres, which appear to project anteriorly to the supraesophageal mass via large plurisegmental tracts. In addition to these findings, our immunolabeling revealed distinct divisions in the leg and abdominal neuromeres, which may reflect ancestral segmentation of the nervous system. Taken together, these findings reveal that DA is widespread in the spider CNS and underscores the important modulatory functions of DA in spiders.

Keywords: Lycosidae, *Hogna*, dopamine, neurobiology, behavior, immunocytochemistry, physiology

Oral presentation

Why are they social?

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All spider species that exhibit cooperative web building, prey capture, feeding, and brood care, build dense tri-dimensional webs. We argue that it is the interaction between such webs with particular environmental factors that explains where species with different levels of sociality occur. Reviewing research carried out in the genus *Anelosimus*, we show that large social colonies can only form in areas where an abundance of large insects allows the spiders to overcome a scaling challenge of their tri-dimensional webs. The absence of subsocial or solitary *Anelosimus* in the lowland rainforest, on the other hand, may be due to the presence in this environment of strong rains and high rates of predation, which we demonstrate to be important for web quality and colony survival with a transplant experiment. Thus, somewhat surprisingly, it appears that the primary driver of sociality in spiders in this genus may be colonizing environments where solitary living may not be possible, with accessing large insects being a necessary, but secondary benefit of group living.

Keywords: social spiders, groups living, prey capture, scaling

Oral presentation

Transcriptomics identifies gene repertoires underlying functional differentiation of cob-weaving spider silk glands

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Spiders (Araneae) owe their ecological success as keystone predators in large part to their usage of silk. Orb-web and cobweb weaving spiders possess seven morphologically distinct gland types, each synthesizing a task-specific fiber or glue. The spectacular properties of these proteinaceous spider silks, including draglines with tensile strength rivaling steel and capture spiral filaments that can extend threefold, make them prime targets for the development of biomimetic materials through recombinant technology. Spider silk synthesis also is a model system to study the evolution of tissue-specific gene expression and the role of gene duplication in functional novelty. For instance, the spidroin gene family encodes structural constituents of fibers and diversification of spidroin family members is associated with new fiber functions. Using deep sequencing of mRNA, we profiled transcript abundance in each of the seven silk gland types, along with three non-silk gland tissues, for three cobweb weaving species. We identified the transcripts in each species that are significantly more abundant in particular silk glands than non-silk gland tissues. Gene expression patterns were consistent among all three species, likely reflecting coordinated functions of subsets of glands. Evolutionary analyses based on expression levels of homologous transcripts and phylogenetic reconstruction of individual gene families demonstrated broad conservation of expression patterns and suggested that when changes in expression pattern do occur, they do not have to be coupled to gene duplication. Our study is a landmark in understanding spider silk gland specialization, and more generally, the evolution of tissue-specific transcriptomes.

Keywords: spider silk, genetics, molecular evolution, tissue-specific expression

Student - Oral presentation

Complicate or simplify sex? The evolution of genitalia in Gnaphosidae spiders

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Spiders may be good models for studying genitalia diversity and evolution given their peculiar copulatory mechanism, with male external copulatory apparatus located in palps. Gnaphosidae are remarkable in having species with simple bipartite palps, with tripartite palps and a few elements, and species with several structures on tripartite palp. Some palpal homology studies suggest intermediate palp complexity as ancestral condition for the family from which both more complex and simpler palp would have evolved, but with trend to sclerites fusion. However, those hypotheses were never tested with phylogenetic background, since no Gnaphosidae phylogeny was available until recently. Regarding female genitalia, both the epigynum and vulva range from simple to complex, but there is no information on its evolution. Thus, despite the great diversity of Gnaphosidae, patterns of genital evolution and mechanisms involved in copulatory organ diversification in the family are barely known. The aim of this study was to contribute to the understanding of genital evolution through the exploration of macroevolutionary patterns related to copulatory organ diversity in Gnaphosidae. More specifically, the evolutionary trend in complexity and predictions about genital evolution were tested using phylogenetic comparative methods. A matrix of 336 morphological characters scored for 99 taxa was used to estimate the gnaphosid phylogeny. We sampled 35 female and 57 male characters to explore genital evolution, based on phylogenetic trees obtained. A bipartite palp with intermediate complexity was found to be the plesiomorphic condition, but there was no trend toward simplification or increasing complexity. The same intermediate complexity with no trend was found for females. Additionally, we discovered that complexity of female and male copulatory organs did not coevolve. Additional information on copulatory behavior of gnaphosids might contribute to the understanding of genital evolution.

Keywords: genital evolution, cryptic female choice, genital morphology, complexity, sexual selection, systematics

Student - oral presentation

Phylogenomics and historical biogeography of the Gondwanan family Pettalidae (Opiliones: Cyphophthalmi)

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Historical biogeographers have long looked for groups of organisms that retain signals of Gondwanan vicariance—that is, taxa with distributions across multiple formerly contiguous southern hemisphere landmasses, and that are old enough to predate the breakup of the former supercontinent. One such group is the mite harvestman family Pettalidae (Opiliones: Cyphophthalmi), which has members in Chile, South Africa, Madagascar, Sri Lanka, Western and Eastern Australia, and New Zealand. While a four-locus phylogeny previously demonstrated the monophyly of the family and each genus, relationships between the genera proved to be recalcitrant. To address this, we sequenced densely sampled transcriptomes of members of all genera for which molecular grade samples were available (9 of 10 described genera) and performed phylogenomic analyses on the mRNA dataset. We conducted maximum likelihood and Bayesian inference on matrices of different gene occupancy (>95%, 159 orthologs; >75%, 1111 orthologs; >50%, 3196 orthologs) to account for the effects of missing data. Finally, we dated the tree using Paleozoic and Mesozoic Opiliones fossils as calibration, as well as the Xiphosura-Arachnida split. Our tree resolves key aspects of the pettalid phylogeny, and we will discuss our findings regarding the timing and order of cladogenetic events as they relate to the breakup of Gondwana.

Keywords: phylogenomics, gondwana, biogeography, Opiliones, systematics, vicariance

Student - oral presentation

Species delimitation of the orchard-spider *Leucauge venusta* (Araneae, Tetragnathidae) in North America

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The North American orchard-spider, *Leucauge venusta*, is one of the most abundant and widespread species of orb-weavers in the Americas. Records of this species range from Southern Canada to Brazil. Of the 172 currently described species in the genus *Leucauge*, only two are known to occur in the US, where *L. venusta* is broadly distributed and *L. argyra* is restricted to the subtropical parts in Florida. Preliminary analyses based on the barcoding region of the mitochondrial Cytochrome Oxidase subunit I (COI) gene, reveal a deep gap between “northern” and “southern” populations of *L. venusta* in the US. Specimens from southern populations (Florida) group with specimens collected in Brazil. This biogeographic pattern is particularly surprising given the absence of obvious barriers to dispersal. Morphologically, individuals from these southern and northern populations are indistinguishable, and the possibility of a cryptic species has important implications for nomenclature because *L. venusta* is the type species of the genus *Leucauge*. We examine the phylogeographic structure and test the species boundaries of *L. venusta* using mitochondrial and nuclear genes from specimens collected in Central and South America and a dense sampling of North-American populations across known biogeographic barriers such as the Appalachian Mountains and the Mississippi River. *Leucauge* includes more than 170 described species but its taxonomy is very poorly understood. Untangling the identity of its type species of the genus is an important step toward understanding the diversity and evolution of orchard-spiders.

Keywords: phylogeography, spiders, population genetics, coalescence, taxonomy

Student - poster presentation

Submersion tolerance among riparian and non-riparian spiders

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Terrestrial arthropods that inhabit dynamic boundaries between terrestrial and lotic systems are under constant risk of flooding. Many spiders may have evolved behavioral, physiological, or morphological adaptations to cope with flooding either through avoidance or submersion tolerance. Mechanisms for coping with periodic flooding have important implications for predicting species composition, recolonization, and resilience against flood-related disturbance for riparian arthropod communities. We examined submersion tolerance of spiders by taxon and microhabitat. We compared web-building and cursorial, riparian and non-riparian, and ground-dwelling versus more arboreal species. We submerged individual spiders for three hours in distilled water and recorded survival, activity level immediately after removal, and activity level eight hours after removal (N=1,154). During trials we noted spiders that were in hypoxic comas versus those that formed putative plastrons (breathing bubbles) during submersion. We found large differences in submergence tolerance by taxon and habitat. Web-building spiders and vegetation dwelling cursorial spiders showed poor survival post-submersion, even those that live on overhanging vegetation along rivers and streams. Most ground-dwelling cursorial spiders including wolf spiders and fishing spiders showed no negative effects of submersion and most were active the entire time of submergence. We also found significant differences in submersion tolerance between populations of wolf spiders of the same species within the riparian zone compared to populations from other habitats, suggesting population-level local adaptation to flooding. Population-level differences in submersion tolerance indicate that riparian ground spiders likely persist during flood events rather than being recolonized by new spider populations.

Keywords: flooding submergence, riparian, cursorial

Student - oral presentation

Consequences of prey nutrient content for nutrient cycling by a wolf spider (*Hogna carolinensis*)

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The flow of nutrients through ecosystems is affected by both biotic and abiotic factors. Resources flow through organisms via ingestion, assimilation, allocation, and excretion pathways. The currency of resource conversion in consumers has traditionally been defined within energetic, elemental, and nutrition frameworks. Yet, multiple frameworks may need to be integrated to study resource flows as macronutrients are converted to inorganic nutrients by consumers. In the present study, we examined how variation in the macronutrient content of prey affected resource ingestion, egestion, excretion, and silk production in a large wolf spider (*Hogna carolinensis*). Our early findings suggest that macronutrients available for spider assimilation and deposition to ecosystems were related to the content within prey consumed. Further research will be critical for developing a broader understanding of resource withdrawal and recycling by spiders and other consumers. Keywords: foraging frameworks, nutrient cycling, resource deposition, wolf spider

Student - poster presentation

First report of a stridulatory organ in *Mastigoproctus giganteus* Lucas, 1835

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The current knowledge of the morphology of whipscorpions is basic, and its study has been neglected. There are few publications that deal in depth not only with this topic, but also in almost everything related to the order.

The genus *Mastigoproctus* contains 15 species, and there are no reports of stridulatory organs for any of them. Viquez & Armas (2005) described the genus *Valeriphonus* and reported the stridulatory organ as a diagnostic character. This character was subsequently mentioned or used for this genus in other publications. In this work we revised specimens of different localities of *Mastigoproctus giganteus* deposited in the National Collection of Arachnids (CNAN) in the UNAM and we observed and recorded the presence of a stridulatory organ in all specimens. The stridulatory structures are in the same position in *Mastigoproctus* as they are in *Valeriphonus*, namely the inner face of the pedipalp coxa and the ectal face of the chelicera, but they are structurally different. SEM images of the stridulatory organ of three subspecies of *M. giganteus* are presented, including notes on the behavior and use of the stridulatory organ.

Keywords: Thelyphonida, stridulation, SEM, behaviour

Student - oral presentation

Phylogenetic pattern of sex pheromone discrimination in widow spiders

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Most theory regarding signal diversification predicts sympatry will favour significant divergence in signal structure or receiver response between closely related species, whereas signals that do not affect the risk of interbreeding will slowly accumulate differences over evolutionary time. We studied functional divergence in contact pheromones in black widow spiders (*Latrodectus*); a genus of 30 species with worldwide distribution. Here we focus on six species (*L. geometricus*, *L. mirabilis*, *L. hasselti*, *L. hesperus*, *L. mactans* and *L. variolus*) from different clades and biogeographic regions, with no recent history of sympatry. We test the hypothesis that divergence in sex pheromones and mate recognition will be best predicted by

phylogenetic distance in *Latrodectus* spiders. Among these spiders, females release cuticular and/or silk-based sex pheromones (chemical signals) that can be detected as airborne volatiles (attracting males) or as contact chemicals (initiating courtship). We quantified 1) male responses to conspecific and heterospecific females and their sex pheromones using a bioassay of male searching activity on methanol extracts of females' silk; and 2) male courtship and mating success when on the webs of females. We compared male responses in light of the phylogeny, and as a function of estimated genetic distance between species. Consistent with our hypothesis 1) male *L. geometricus*, the most distantly related of our focal species, respond only to silk extracts from conspecifics; whereas males from the other species also responded to extracts from more closely related heterospecific species, however, 2) males of all species initiate courtship and attempt to mate when heterospecific females are present. Thus some males discriminate silk chemicals of more distantly related heterospecifics, but intact silk and/or females eliminate this effect.

Keywords: *Latrodectus* species, sex pheromones, genetic distance, male discrimination

Oral presentation

X chromosomes evolution in *Stegodyphus* spiders

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Substitution patterns (between species) and diversity (within species) of spider X chromosomes is predicted to differ from autosome evolution due to their hemizygous state in males. If new beneficial mutations on average are recessive or partially recessive more adaptive substitutions

are expected on the X chromosomes, so-called faster-X evolution. Also, since populations carry more autosomes than X chromosomes less diversity is predicted on X chromosomes; if everything being equal, 75% of the autosomes. However, both substitution patterns and diversity levels may be influenced by life-history and ecological factors such as sex ratio bias and population size fluctuations. Here we use transcriptome and RAD sequencing to explore the substitution patterns and diversity levels of X chromosomes and autosomes in two *Stegodyphus* species (*S. mimosarum* and *S. africanus*) with contrasting sex ratio and population dynamics. We found evidence of faster-X evolution in both species. Furthermore, we found that mutation rates are higher on autosomes, consistent with more cell-divisions in male gametes than female gametes. X to A diversity levels were highly similar among the two species suggesting that female bias and population size fluctuations in *S. mimosarum* have similar but oppositely directed effects.

Keywords: faster-X evolution, X chromosomes, population genetics, social spider

Student - oral presentation

Increased temperature alters beetle behavior to increase predator effects and decrease herbivory

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Predators can limit the abundance and/or activity levels of their prey, and the magnitudes of these effects are contingent on predator and prey traits that may change with environmental conditions. Aberrant thermal regimes could disrupt pest (herbivore prey) suppression through asymmetric effects, i.e. heat-sensitive predator vs. heat-tolerant prey. To explore the potential effects of warming on suppressing pests and controlling herbivory in a vegetable

crop, we performed a laboratory experiment exposing an important pest species to two spider predator species at different temperatures. First, we assessed the thermal tolerance (critical thermal maxima or CTM) of the cucumber beetle (*Diabrotica undecimpunctata*) pest, wolf spider (*Hogna helluo*) predator, and nursery web spider (*Pisaurina mira*) predator. Cucumber beetles and wolf spiders were equally heat tolerant (CTM > 40 C), but nursery web spiders had relatively limited heat tolerance (CTM = 34 C). Inside mesocosms, three beetles fed on squash plants for seven hours alone or in the presence of a single spider predator of either species at ambient (22 C) or warmed (38 C) temperature. Beetle feeding increased with temperature, and while wolf spiders were always effective predators, nursery web spiders were relatively less lethal at high temperature. Compared to the non-predator control, neither spider species reduced herbivory at ambient temperature. However, at warm temperature both species of spiders reduced herbivory with evidence of a dominant non-consumptive effect. Our experiments highlight the contingent nature of predator-prey interactions and suggest that non-consumptive effects should not be ignored when assessing the impact of temperature change. Keywords: predator-prey interactions, temperature stress, cucumber beetle

Student - poster presentation

Non-consumptive effects of a spider predator on plant penetration behavior of virus vector leafhoppers

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To combat plant viruses, a readily available option is to suppress their insect vectors. Leafhoppers feed on plant sap by penetrating their mouthparts into the plant while they can transmit plant pathogens into them. This penetration

process can be monitored by Electrical Penetration Graph (EPG) method. Predators can reduce population size of prey by consuming them. However, non-consumptive effects (NCEs)—like predator presence - may also decrease prey fitness, e.g., by triggering physiological and behavioral changes in prey animals, including escape behavior and lowered feeding duration. NCEs were observed in two series of experiments, where we used *Psammotettix alienus* (Cicadellidae) as a leafhopper prey and the spider *Tibellus oblongus* (Philodromidae) as a predator. First, we made an EPG setup to record leafhopper penetration behavior in the presence of the predator. Second, we made microcosms experiments, where spiders were unable to catch leafhoppers, but leafhoppers could sense spider presence. The EPG results showed that leafhoppers responded to predation risk by extending the duration of the mesophyll penetration phase, and also increasing its recurrence, while the phloem ingestion phase was postponed, appearing later in the feeding sequence than in the control group. In mesocosms experiments we counted the number of penetrations where salivary sheaths ended up in sieve elements, and penetrations where salivary sheaths ended up in mesophyll tissues after 24 hours. In full agreement with the EPG studies, these results showed that in the presence of spiders leafhoppers made penetrations to mesophyll tissues in higher numbers than in the control group. Our novel method to use EPG for the study of NCEs gave the opportunity to make detailed, time-explicit observations on the feeding behaviour of leafhoppers when exposed to predators and showed that predators, like *T. oblongus*, can contribute to biological control of plant pathogen vectors by their NCEs.

Keywords: leafhopper, spider, electrical penetration graph (EPG) technique, non-consumptive effects

Student - oral presentation

Phylogeny, systematics and natural history of pirate spiders (Araneae, Mimetidae)

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The spider family Mimetidae, commonly referred to as “pirate spiders” due to their aggressive mimicry behavior, has world-wide distribution, with the highest species diversity in Central and tropical South America. Although Mimetidae were thought to be exclusively araneophagic, mimetids can be kleptoparasitic on the webs of other spiders and can also feed upon other arthropods. The family includes 158 described species and 13 genera. Currently, the relationships among genera within the family are poorly understood. To date, phylogenetic analyses have been limited to morphological characters and outgroup sampling has lacked many key taxa. Here we present the results of the first molecular analysis of the family sampling 92 mimetid terminals and 119 outgroup taxa from 12 families. With this data set we aimed to (1) test the monophyly of the family, (2) test the monophyly of mimetid genera, and (3) examine the relationships among genera. Using data from six standard molecular markers we estimated the phylogeny of Mimetidae using parsimony, maximum likelihood, and Bayesian inference methods. Across analyses our results show broad consensus for the following relationships: *Gelanor* is monophyletic and sister to the rest of the family. *Ero* is monophyletic and sister to a lineage that includes a new genus described elsewhere (previously *Mimetus*), *Australomimetus* and *Mimetus*. However the placement of different clades of *Mimetus* (Neotropical, Indomalayan, North American, Malagasy) varies under different methods of analysis with our current mimetid sample. Using the molecular phylogeny as a guide, we identify potential morphological synapomorphies for all mimetid genera. We also present new natural history data demonstrating that at least some mimetids use maternal care for eggs and offspring. Keywords: Molecular systematics, morphology, pirate spiders, maternal care

Oral presentation

Documenting diversity: surveying British Columbia’s spider fauna

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In 2006, the Royal British Columbia Museum began systematically documenting the full diversity of British Columbia’s spider fauna. Museum specimens and literature records were used to update an existing checklist and identify poorly sampled habitats in British Columbia. Annual field surveys of spiders, primarily targeting alpine and subalpine habitats, began in 2008 and have resulted in a large number of specimens added to the collection including many new provincial, national, and Nearctic records as well as numerous undescribed species. Databased spider specimens have increased from nearly 4300 in 2008 to about 9000 in 2016. Data from many specimens, however, remain unrecorded and currently (2016) the museum collection houses approximately 18000 vials estimated to contain over 90000 specimens. The number of species recorded in British Columbia has climbed from 570 in 1988 to more than 850. Over 70 of the new records are Canadian or Nearctic firsts. The progress of this work has attracted regional, national, and international attention resulting in donations of important voucher specimens and other spider material; collaborative research with other scientists on spider ecology, taxonomy, systematics, and faunistics; and recognition of British Columbia as an important area of Nearctic spider diversity.

Keywords: collections, curation, alpine, Beringia, collaboration

Oral presentation

Changes in mating system with the evolution of sociality leads to depleted genomic diversity at both population and species level

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The evolution of sociality in animals is frequently associated with a shift from outcrossing to inbreeding. This suggests that short-term benefits outweigh costs of inbreeding. Over evolutionary time, inbreeding populations experience a severe reduction in effective population size increasing the rate of genetic drift and accelerating loss of genetic diversity. This process predicts reduced evolutionary potential and elevated extinction risk. Empirical evidence for the evolutionary dead end hypothesis comes mainly from phylogenetic analyses; quantitative estimates of genome-wide diversity in species with contrasting mating systems are scarce. We tested the combined effects of sociality and mating system on genome wide diversity using a comparative RAD sequencing approach. Our analysis included multiple populations of each of three independent sister-species pairs of social inbreeding and subsocial outcrossing *Stegodyphus* spiders and a subsocial outgroup. Genetic diversity in the social species was extraordinarily low: heterozygosity and within population genetic diversity were 6–10 fold lower in inbreeding compared to outcrossing species, and demographic modelling revealed a tenfold reduction in effective population size of inbreeding populations. Species-wide genetic diversity depends on population divergence and viability of genetic lineages. Population genomic patterns were consistent with high lineage turnover, which homogenizes the genetic structure that builds up between inbreeding populations, ultimately depleting genetic diversity at the species level. Indeed, species-wide genetic diversity of social species was 5–8 times lower than that of subsocial species, and amongst the lowest estimated for any species. This severe loss of genome-wide diversity is likely to affect all social inbreeding species, limiting their evolutionary potential as predicted by the evolutionary dead end hypothesis.

Keywords: mating systems, inbreeding, comparative population genomics, sociality, social spiders, *Stegodyphus*

Oral presentation

Obscure features of Solifugae: comparative morphology of the lateral eyespots

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Lateral eyes in Arachnida are presumed plesiomorphic. Photosensitive areas without lenses placed laterally on the prosoma were recorded for various arachnid orders (e.g. Ricinulei, Scorpiones, Shizomida) and their homology with lateral eyes are generally assumed. The presence of lateral eyespots in the anterolateral propeltidial lobes of Solifugae (solifuges, sunspiders, false spiders) are often overlooked and even their basic external morphology is little known. This is notwithstanding their potential importance within the Arachnida towards interordinal, and within the Solifugae towards intraordinal, phylogenetic relationships. In this study, eyespots were examined in representative of major Solifugae taxa. Eyespots were generally easily distinguishable either in lateral view, ventral view, or both. Broad trends in eyespot configuration were found at family level, especially regarding number and relative placement, but also to an extent in shape, size and reflectiveness.

Keywords: comparative morphology, homology, photosensitive, lateral eyes

Poster presentation

Termite-eating spiders (Ammoxenidae: *Ammoxenus*): distribution and coexistence of cryptic species

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Niche theory and the principle of competitive exclusion dictate that species which occupy the same niche, e.g., use the same resource and occupy the same habitat in the same manner, cannot coexist. Spiders belonging to the southern African genus *Ammoxenus* (Araneae, Ammoxenidae) are specialists, feeding exclusively on termites. Up to four *Ammoxenus* species were found to coexist in sympatry. These species are cryptic, and can be separated only by the structure of the palp and epigyne, sometimes only very slightly so. Collection data indicate that these spiders utilize the same termite food source in a seemingly identical manner in space and time. One plausible explanation for the high levels of sympatry in these spiders could be that the abundance of the termite food source mitigate competition, resulting in little to no niche partitioning, in accord with ecological neutral theory model predictions. Conversely, given that the spiders hide in the small, soft soil mounds made by the termites, which allow them to correlate their activity patterns with that of termites, the limiting resource could be microhabitat (termite mounds) availability, which might have driven niche partitioning. Field observations on behavior and microhabitat use are needed to establish possible cryptic niche partitioning. For example, anecdotal evidence in the literature indicate differences in post-capture termite processing. This could have implications for differential predatory pressures. Even if evidence for niche partitioning is found, however, it would only partially explain the distribution patterns seen in *Ammoxenus*. Our aim is to provide possible explanations, including the still contentious sympatric speciation that could be further investigated to explain the distribution and the level of sympatry seen in these spiders. Keywords: biogeography, competitive exclusion, niche partitioning, sympatric speciation

Student - poster presentation

Biogeography of two Caribbean ochyroceratid genera: *Theotima* and *Ochyrocera*

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The Caribbean island system is a region of high biological diversity. The islands are home to much unknown arachnid diversity that has evolved in the context of complex biogeographical histories of the islands and associated land masses. This study analyzes patterns of diversity in the family Ochyroceratidae, a relatively uncharacterized group in the Caribbean. Sampling is centered on two genera: *Theotima*, a smaller, parthenogenic genus, and *Ochyrocera*, a non-parthenogenic genus. Though there is minimal documented evidence of their dispersal capabilities, both genera are small, leaf-litter dwelling spiders with biologies consistent with poor dispersers. We use phylogenetic analyses to comparatively assess genetic structure and biogeographic pattern of these two genera. Phylogenies use two mitochondrial genes (COI and 16s) and two nuclear genes (28s and H3) with representation of a total of 200 individuals collected from across the Caribbean islands and southern Mexico. Both genera display high levels of genetic depth, however patterns of relatedness in *Ochyrocera* reflect more island-, and region-level genetic structure than *Theotima*. These patterns suggest the possibility of higher dispersal rates in *Theotima* relative to *Ochyrocera*. Genetic structure of COI suggests approximately 29 distinct genetic lineages within our sampled taxa, greatly expanding the sampling beyond 16 known species within the region.

Keywords: Ochyroceratidae, biogeography, biodiversity hotspot

Oral presentation

Intelligent adhesives: the structure and function of humidity responsive spider aggregate glues

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The evolution of viscid aggregate glues is associated with the radiation of orb-weaving spiders. Aggregate glue forms the sticky droplets on prey capture threads and is a composite of viscoelastic glycoproteins and organic salts. While the glycoproteins are the primary adhesive, the salts absorb atmospheric water, thereby plasticizing the threads, and directly solvate the proteins, helping the glycoproteins to spread across surfaces. The high extensibility of the droplets allows them to extend in a “suspension bridge” system that also recruits adhesion across the entire thread’s length. Here, we explore how each of these elements is responds responsive to humidity and results in the capture threads of diverse species of spiders function optimally at different humidities. We argue that the chemical composition of the organic salts is a highly evolvable mechanism that “tunes” orb function to particular microhabitats, and that this principle can be exploited in the design of synthetic smart adhesives.

Keywords: adhesion, aggregate, biomechanics, biomaterials, orb web, prey capture, viscid silk

Oral presentation

Analysis of spider silk structural variability using small and wide-angle X-ray diffraction

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Spider major ampullate (MA) silk is nature’s toughest material. Attempts to synthesise silk-like fibers have so far been unsuccessful. One reason for this is that the structures and properties of MA silk are variable across environments. The high strength and extensibility in MA silk is a product of its protein arrangements and tertiary structures. It is

becoming evident that a more complete elucidation of the molecular mechanism behind the property variations of spider MA silk lies in understanding the evolution of spider silk performance. Small-angle X-ray diffraction imaging of silks produces an amorphous ring and equatorial streak allowing identification of the structure of the fiber along its meridian. Accordingly, it has been successfully used to elucidate the structure of the amorphous region. Wide angle X-ray diffraction on the other hand is useful for determining the size, alignment and orientation of crystalline structures. A combination of both small and wide-angled diffraction is essential for gaining a thorough insight into the structures of spider silk proteins. Because most of the work correlating protein structure with mechanical performance has thus far concentrated on the high performing silks of web building spiders, we do not understand the processes facilitating variations in silk performance at molecular scales across the spider phylogeny. I have performed experiments manipulating the diet of different spiders and examined the crystalline and amorphous structures of the silk proteins using small and wide angle X-ray scattering and found a combination of crystalline and amorphous features synergistically induce variations in protein strength and extensibility. Moreover, the mechanisms of structural variability seem to be consistent across different spiders. Future research will use SAXS/WAXS analyses to examine the protein structures in the silks of a wider range of web building and non-web building spiders. Keywords: silk, nano-structures, X-ray diffraction properties

Oral presentation

Spiders in sloping blockfield habitats in the Fichtel Mountains (NE Bavaria, Germany)

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Motivated by the research on stony debris (talus) habitats of the spider and invertebrate fauna by Ruzicka (Czech Republic) and Molenda (Germany/Belgium to Italy), we obtained funding for research on these special habitats

in the Fichtel Mountains (Upper Franconia, NE Bavaria, Germany). The mountains are of Variscan origin (380-280 my old) and the rocks are mainly Granite. The sloping blockfields contain mainly large rocks (>1m). Knowing of single species specialized on such habitats from the region (*Clubiona alpicola*, *Sitticus saxicola*, *Acantholycosa norvegica*, *Choleva lederiana*), we expected to find more specialists and at more sites. A pre-study confirmed this estimation. A variety of sites was selected, with the focus on the natural sloping blockfields (felsenmeer). But we also included artificial sites (from mining) as well as rocky sites and adjacent forested or grassland sites. The altitude range was from 560m to 1050m, with most sites between 800 to 1040m. Besides the spiders, some beetle-groups, harvestmen, pseudoscorpions, and snow flies (*Chionea*) are determined to species level. Several spider species specialized on talus habitats were found, also several species which live only at higher elevations. Mostly the typical talus spiders live also in other habitats in the Alps over 2000m. One species (*Bathypantes eumenis buchari*) is not known from the Alps and has its origin in stony (riparian) habitats in Siberia and the Arctic. Together with some other species, it is judged to be a glacial relict (peri- or postglacial). These species are all endangered by current climate change. A classification of the recorded spider species and coenoses was made according to various parameters: total distribution, threatened status in Germany, frequency in Germany, stenotopy, naturalness of its preferred habitats. These data confirm the specialness of the talus habitats, even compared with adjacent rocky and other sites.

Keywords: spiders, Germany, mountains, blockfield, specialists

Oral presentation

Historical refugia have shaped biogeography of dispersal-limited mite harvestmen (Opiliones, Cyphophthalmi) from the Australian wet tropics

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How did Pleistocene glacial cycling affect the diversity of rainforest life? Over the past several decades, biologists have tested the hypothesis that forest contraction and fragmentation drove speciation in rainforest animals, concluding that in most cases species-level divergences predate the Pleistocene. More recently, focus has turned to the role of Pleistocene refugia in preserving lineages, effectively acting as “museums” of biodiversity. We tested this model in a lineage of tiny dispersal-limited mite harvestmen (Opiliones, Cyphophthalmi) distributed throughout in the rainforests of the Australian wet tropics. We generated a model of habitat suitability for the genus *Austropurcellia* and projected it onto paleoclimate data layers dating back to the Last Glacial Maximum (LGM). We compared the power of present-day and past distribution of suitable climatic conditions to predict present-day distribution of diversity across subregions of the Wet Tropics. We found that the distribution of suitable climatic conditions during the LGM is the best predictor of both number of species and phylogenetic diversity in our study system, outperforming current distribution of suitable climatic conditions. This finding is consistent with a model in which historical refugia have played a significant role in establishing present-day biogeographic patterns.

Keywords: biogeography, Opiliones, phylogeny, species richness

Oral presentation

On the track of the wolf: systematics of North American species described in the genus *Lycosa*

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A brief synopsis of continuing research focused upon the systematic relationships of North American species of

wolf spiders originally described in the genus *Lycosa* will be presented. In this summary the morphological characteristics that were used to establish the genera *Gladicosa*, *Rabidososa* and *Tigrosa* will be illustrated. The same characteristics are being utilized to establish the new genus *Lentacosa*, composed largely of North American species originally placed in the genera *Lycosa* and *Hogna*. The genera *Gladicosa* Brady, 1980, *Rabidososa* Roewer, 1954 and *Tigrosa* Brady, 2012 have been shown to be distinct from the largely Mediterranean distributed *Lycosa*, exemplified by *Lycosa tarantula* (Simon) and *Hogna*, exemplified by *Hogna radiata* (Latreille). Eleven species are representatives of the new genus *Lentacosa* which is primarily concentrated in the southeastern United States. Members of this genus can be distinguished by a combination of characters including the color pattern on the dorsum of the cephalothorax, a solid black venter on the abdomen, and the structure of the male and female genitalia, distinguishing them from *Lycosa* and *Hogna*. Illustrations will be utilized to demonstrate these defining characters.

Keywords: systematics, Lycosidae, *Lycosa*, *Hogna*, North America, Herb Levi symposium

Student - oral presentation

Targeting or escape: differences between jump types in a jumping spider

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Jumping is a mode of locomotion convergently evolved in many arthropod taxa. Although well-studied in insects such as grasshoppers, less study has been conducted in spider jumping. In particular, jumping spiders (Araneae: Salticidae) use jumping as a primary means of locomotion and utilize a very different jumping mechanism from other animals. In this experiment, we used *Habronattus conjunctus*, a desert-dwelling jumping spider, to investigate how jumping differed between escaping from danger and attempting to reach a specific endpoint. We found that spiders spend more time preparing for targeted jumps and attain relatively lower velocities. We also noted imprecise,

often unpredictable aerial paths, and clumsy landings in escape jumps. We suspect that the gains in speed and unpredictability are so important to predator evasion that a high degree of physical robustness has evolved in these spiders to allow them to withstand unwieldy landings. Finally, although we carefully calibrated the targeted jump setup to mimic distances that spiders would naturally jump, we found that spiders were unable to attain a distance that they could otherwise easily attain in an untargeted jump. We explore accuracy at different distances and speculate as to why distances on targeted jumps are so much shorter.

Keywords: jump, salticid, locomotion, jumping spider

Poster presentation

Signal in the noise: use of long-term spider data

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As is true for most predators, spiders tend to be rare at the species level, making ecological analyses difficult. However, even with low numbers, long-term data can increase our ability to see patterns associated with abiotic and biotic factors. At Bandelier National Monument in the Jemez Mountains of northern New Mexico, I have been working with ground-dwelling spiders since 1997, documenting habitat affinities and species composition changes over time. Because the southwestern US is predicted to become warmer and drier with climate change, forested areas are expected to decline while areas dominated by shrubs and small trees are expected to increase. Here I compared lycosid spiders between a ponderosa pine (PP) forest and more open pinyon-juniper (PJ) woodland, asking if the spiders are specific to a given habitat or season and what that may mean for future climate-related changes. Spiders were collected in pitfall traps 4 times/year, providing both seasonal and annual relative abundance data. Lycosid taxa included *Alopecosa kochi*, 6 *Pardosa* spp., *Schizocosa mccoocki*, and *Varacosa gosiuta*. Periods of high abundance varied with taxon:

Alopecosa (PJ, April), *Schizocosa* (PJ, June and August), *Pardosa* (PP, June and August), and *Varacosa* (PP, April and October). MDS based on taxon and abundance showed good separation of the two habitats (MDS 1), and of abundance levels correlated with precipitation (MDS 2). These lycosid species show strong habitat fidelity, suggesting that if the PP habitat becomes more like PJ as is predicted, *Pardosa* and *Varacosa* species will likely decline. *Alopecosa* occurred mostly in the spring; a warmer climate may also reduce its numbers. *Schizocosa* is the only species likely to continue in its current patterns of high summer abundance in PJ woodland.

Keywords: climate change, ecology, community structure, Lycosidae

Oral presentation

Burrow adoption and navigation in the desert grassland scorpion, *Paruroctonus utahensis*

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Animals have many navigation tools, including path integration, polarized light detection, optic flow tracking, magnetoreception, and others. Unlocking the physiological mechanisms of navigation has been difficult because many acclaimed navigators (such as bees and butterflies) are too small for researchers to monitor their neural activity. We think that sand scorpions make good models to study navigation. They are long-lived, are easily maintained in the laboratory, are accessible to electrophysiological recordings, and fluoresce under UV light. Most importantly, they home to burrows and are easily tracked by video. Scorpions also have ground-directed organs called pectines with dense fields of peg-shaped sensilla that possess chemo- and mechano-sensitive neurons. We hypothesize that scorpions use their pectines to sense the chemical and/or textural aspects of the substrate around their burrows and use this information to get home. Testing this chemo-textural familiarity hypothesis requires an efficient homing assay; here we report the development of such an assay. To encourage burrow adoption, we confined individual

scorpions to a small area containing a man-made burrow within a larger, sand-filled arena. We then removed the barrier and monitored activity in the entire arena for six days. During days 1–3 post burrow adoption, the proportion of animals that returned to or remained inside the burrow increased from 63% to 89%. During days 4–6, the scorpions were presented with two additional burrows in the large arena. Fidelity to the originally adopted burrow subsequently decreased to 52%, 32% and 47% during these three days. While some animals returned to their burrows during darkness, most animals returned after initiation of daylight. After roaming the arena, some animals appeared to efficiently navigate to their home burrow, while others engaged in systematic searching behaviors. Our assay should allow for testing hypotheses about specific navigational mechanisms.

Keywords: pectines, homing, burrow, fidelity

Poster presentation

Descriptions of two new genera of the spider family Caponiidae (Arachnida, Araneae) and an update of *Tisentnops* from Brazil

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New members of the spider family Caponiidae from Brazil are presented. We described two new Brazilian species of *Tisentnops* (*T. mineiro* sp. n. and *T. onix* sp. n.), a genus known only from its damaged type species. These two new species allowed us to complete the information on the morphology of the genus, and also allowed us to extend its distribution range and know a little more about its natural history. Additionally, two new non-nopinæ Brazilian genera are proposed: *Nasutonops* gen. n. including three new species from northwestern of Brazil and *Carajas* gen. n., known only from the type species from North of Brazil. Both new genera are non-nopinæ that have tarsi entire, rather than sub-segmented. Among all these findings, we are describing the first known blind caponiids in the world: *Tisentnops mineiro* sp. n. from State of Minas Gerais and

Carajas paraua sp. n. from State of Pará, both are Brazilian species found only in caves, and lack eyes completely. Another amazing finding, are the new species of *Nasutonops* gen. n. which are characterized by the presence of a projected clypeal horn, unique among caponiids.

Keywords: Taxonomy, new species, haplogynae, new genus, Neotropical region

Oral presentation

Venom evolution in the genus *Tetragnatha* facilitates adaptive radiation and mate recognition

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Venoms are considered a key innovation that allowed ecological diversification in a number of lineages including snakes, anguimorph and iguanian lizards, and cone snails. Venoms are complex cocktails of bioactive compounds with high target specificity and serve multiple functions. Commonly, venom serves a role in predation and defense but can be involved in intraspecific conflict and mate recognition. Sexual dimorphisms have been observed in the venoms of several taxa, indicating a potential role in mate recognition. This sets up a possible dual role of venoms in both ecological divergence and mate choice that could influence reproductive isolation of populations through local adaptation. Though disparities in venoms between sexes can sometimes be explained by differences in feeding behavior, evidence also suggests that venom can play a role in intraspecific communication. Our work on *Tetragnatha* venoms, namely transcriptomics and proteomics, shows most species display sexual dimorphisms; males express high molecular mass venom components that are present at much lower levels or absent in females. Additionally, a Hawaiian clade has undergone an adaptive radiation with concomitant

evolution of venom peptides, including the derivation of novel venom gene families. Given the unusual mating behavior (cheliceral locking) in many tetragnathids, these dimorphic venom components may play a role in mate recognition while other components have evolved in response to dietary niche partitioning. Here we present the current state of our ongoing tetragnathid venom research. Keywords: venom, sexual selection, mate recognition, adaptive radiation, transcriptome, proteomics, gene expression

Oral presentation

Retreat site selection in two species of Sky Island scorpions from Arizona

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The Sky Island Mountains of Arizona and New Mexico harbor a number of species of small scorpions in the genus *Vaejovis*. As is the case for many scorpions, little is known about the ecology or behavior of these species. In the present study, we examined size and thermal characteristics of retreats (rocks) for two Sky Island *Vaejovis* scorpions: *V. electrum* from the Pinaleno Mountains and *V. casbi* from the Chiricahua Mountains. For both species, we measured the size of rocks selected as retreat sites as well as the size range of representative rocks in the habitat. We also recorded thermal profiles under rocks that were used by scorpions and those that were not used. In the laboratory, we examined thermal preferences of gravid and non-gravid females from each species, using a thermal gradient. Both *V. electrum* and *V. casbi* were found under rocks that were significantly larger and thicker than the average rock size for that habitat. Although the mean temperature under these selected rocks did not differ from the mean temperature found under rocks unoccupied by scorpions, both the range and the variance in temperature were lower under rocks occupied by scorpions. *Vaejovis electrum* selected larger rocks than did *V. casbi*, although this may be due to the fact that the Pinaleno site had rocks of a larger mean size from

which to choose. In laboratory trials, non-gravid females from each species did not differ in thermal preference; however, gravid *V. electrum* selected higher temperatures than did gravid *V. cashi*. For neither species did we find a significant difference between thermal preference of gravid and non-gravid females. These results suggest that scorpions actively select among available rock retreat sites, and that this choice may be influenced by a requirement for a more stable thermal regime. It also suggests that this choice is not influenced by a female's reproductive state.

Keywords: scorpion ecology, Sky Islands, *Vaejovis electrum*, *Vaejovis cashi*, thermal ecology

Oral presentation

The natural history and thermal biology of an Arctic pseudoscorpion

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The pseudoscorpion, *Wyochernes asiasticus* (Pseudoscorpiones, Chernetidae), is found in parts of north-west North America, including above the Arctic Circle, but also in Siberia and other regions in Asia: it is presumably a Beringian species, found primarily in regions that were unglaciated during the last glacial maximum in North America. Data on the species biology, collected over many years, illustrates its range in the Yukon Territory, and fundamental knowledge about its life history is presented: larger females tend to have higher fecundity, and females have an average of 10.5 eggs per brood sac. The species is always found under rocks near rivers that flood frequently. Studies on the species thermal biology suggest it is a freeze-avoidant species, and immersion in water shows the species is able to hold oxygenated air around its body and remain alive after submersion of up to 17 days. Despite many years of study, this small, charming arachnid continues to hold many mysteries.

Keywords: Pseudoscorpiones, natural history, thermal biology, biogeography, life history adaptation, Arctic

Oral presentation

Population genomics and geographical parthenogenesis in Japanese harvestmen (Opiliones, Sclerosomatidae)

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Geographical parthenogenesis refers to the common association of widely dispersed asexual populations with more narrowly distributed sexual populations. Some research supports the adaptive advantages of temporary or facultative asexuality as a colonization strategy. Other work points to a non-adaptive rationale for the association of asexuality to habitat margins, because parthenogens frequently display hybrid ancestry, genome duplications often precede parthenogenetic ability, and admixture of sexuals and asexuals within populations is expected to be rare. We explore these competing hypotheses in two Japanese species of harvestmen, *Leiobunum manubriatum* and *Leiobunum globosum*. Reproduction in these species proceeds with or without male fertilization, and female-biased localities are common in high-latitude and elevation habitat margins. Using next-generation sequence data, we compared genetic distance and differentiation between females collected at high and low latitude and elevation in order to evaluate genetic indicators of adaptation in specimens from marginal habitat. Preliminary molecular data recapitulates latitudinal structuring of localities sampled, but both species display single lineages comprised of individuals from geographically-distant populations. Ongoing cytological and mito-nuclear discordance work will serve to elucidate reproductive mode and potential gene flow to these putative populations.

Keywords: population genomics, geographical parthenogenesis, mitonuclear discordance, Opiliones

Student - oral presentation

Molecular systematics of the Neotropical orb-weaving spider genus *Wagneriana* F.O.P.-Cambridge, 1904 (Araneae, Araneidae)

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Although the taxonomy of the orb-weaving spider family Araneidae is relatively well settled, due to Dr. Herbert Levi's revisions, the monophyly of most genera was not rigorously tested and the phylogenetic relationships among them are not well supported, hampering evolutionary research. Using a combination of three mtDNA and six nuDNA loci, we provide the first species-level phylogeny of the Neotropical orb-weaving spider genus *Wagneriana* including 70% of its described species. Our results do not support the monophyly of the genus since the type species of *Acanthepeira* (*A. stellata*) falls inside a well supported *Wagneriana* clade. Within *Wagneriana* several monophyletic groups are recovered with high support values. Some morphological characters that Levi (1991) used in the identification key of *Wagneriana* species seem to be putative synapomorphies. This study shows partial results of an ongoing research project and our conclusions should be considered as preliminary. More thorough taxon sampling, specially within the subfamily Araneinae, and detailed study of morphological characters will allow us to propose a more rigorous hypothesis considering the total evidence approach.

Keywords: systematics, molecular phylogenetics, taxonomy, Araneae, Araneidae

Student - oral presentation

Integrative species delimitation in the harvestman subfamily Briggsinae (Opiliones, Laniatores)

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The Pacific Northwest is home to many described species of laniatorean harvestmen (Arachnida, Opiliones). Due to their limited dispersal and habitat specialization, the diversity within this order is probably underestimated. Limited dispersal and habitat specialization can lead to conserved morphology and possible cryptic species. Harvestmen in the subfamily Briggsinae exemplify this pattern, with all taxa limited to moist coastal forests and/or lava tube habitats. The Briggsinae were described by Thomas Briggs in 1971 and includes two genera, *Briggsus* (five species) and *Isolachus* (one species). Preliminary molecular studies also indicate the inclusion of a third genus within the subfamily, *Speleonychia* (one species). Molecular phylogenetic and species delimitation analyses were conducted for *Isolachus* and *Briggsus*. Multivariate cluster analyses of morphometric data were used to generate different species hypothesis. In addition, qualitative somatic and genitalic male characters were used in the discovery phase. Species trees were reconstructed using multispecies coalescent-based methods implemented in *BEAST. Putative species were then validated using Bayes Factor Delimitation. DNA sequence data from six genes delimited seven species in *Briggsus* and confirms the placement of *Speleonychia* within the Briggsidae. New species were described using molecules and morphology.

Keywords: Opiliones, Laniatores, systematics, species delimitation

Oral presentation

Spiders in grazed pastures: comparisons between rotational vs. conventional grazing

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Understanding arthropod community structures and dynamics associated with different grazers and grazing deferment schedules may provide a metric allowing identification of sustainable grazing regimes. Sampling the arthropod and spider communities inhabiting a rotational grazing schedule versus conventional grazing provided an

opportunity to identify indicators of a ‘healthy’ and sustainable pasture. Spiders in pastures at Polyface Farms (Swope, VA) under high-intensity, low-frequency rotational grazing, and three immediately adjacent continuously (conventionally) grazed pastures were collected in 0.25m² areas employing an intense two-stage suction-sampling system of the vegetation and substrate. The most abundant spider families in the pastures were Linyphiidae, Lycosidae, Thomisidae, Araneidae, Salticidae, Clubionidae, Tetragnathidae, and Oxyopidae; the linyphiids were most abundant. Although spider abundances significantly decreased after the initial rotational grazing event, their numbers, diversity, and evenness one day after grazing were still greater than in conventionally grazed pastures. Araneid, salticid, and clubionid proportions were most impacted after rotational grazing. The overall proportional representations of major spider taxa in rotationally grazed pastures changed after grazing, and resembled conventionally grazed areas. While spider abundances doubled post-grazing, spider number decreased during this same time period in conventionally grazed pastures. Discriminant analysis using spider genera reveals a clear separation of the rotationally grazed pastures (both pre- and post-grazing), from the conventionally grazed pastures. Differences in vegetation structure and soil compaction between pastures under rotational grazing versus conventional grazing may explain observed differences in the spider communities. With further sampling and analyses, pasture health may be assessed in the future by determining spider community structure.

Keywords: spider communities, rotational grazing, community dynamics, succession, pastures

Student - poster presentation

Characterization of cryptic diversity of Phryniidae in the Caribbean based on DNA barcoding

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The Caribbean biogeography project (CarBio) is beginning to reveal the vast biodiversity of arachnids in the region. Whip-spiders are a good example, as shown in the first molecular phylogeny of *Phrynus* from Puerto Rico and Dominican Republic which discovered numerous overlooked ‘cryptic’ species. Our work expands upon this phylogeny with samples from the remaining Greater Antilles as well as several of the Lesser Antilles, and Caribbean coasts of the Americas. We present preliminary results based on DNA barcoding with Cytochrome C Oxidase Subunit I for 402 specimens representing eight species from two genera of Phryniidae: *Paraphrynus* and *Phrynus*. Among the eight named species, we identify 40 clades separated by 5% or more sequence divergence. None of the densely sampled nominal species is monospecific, and many are non-monophyletic. *Phrynus longipes*, rather than representing a widespread species, is found to be a paraphyletic assemblage of multiple single-island endemics, while *Phrynus marginemaculatus* is identified as a monophyletic complex of at least five putative species. Short range endemism characterizes all groups both on islands and the mainland, with genetic variation showing strong geographic structure. In addition we see evidence of multiple colonization events to the Caribbean islands and subsequent radiation of multiple lineages within islands. Clade divergences are structured by geologic barriers within islands, notably among cave systems, in support of the “islands within islands” hypothesis.

Keywords: Amblypygi, barcoding, Caribbean, biodiversity, cryptic radiation

Student - oral presentation

Systematic revision of genus *Crassicrus* Reichling & West, 1996 (Araneae: Theraphosidae)

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Since its description in 1996, the genus *Crassicrus* Reichling & West, 1996 had not been included in any phylogenetic analysis and the relationships between this genus and other Theraphosinae genera remain unclear. According to a previous taxonomic revision, it is possible that *Crassicrus* is phylogenetically related to some South American genera that share some characters of the morphology of the male palpal bulb of the male, so we considered very important to perform a systematic revision of the genus to confirm this. With the revision of material deposited in Colección Nacional de Arácnidos of Instituto de Biología, UNAM, Mexico, and the American Museum of Natural History, New York, USA, a morphological data matrix was built consisting of 16 taxa (five of the ingroup and 11 of outgroup) and 85 characters, which 71 were binary and 14 multistate. The phylogenetic analysis was made using the parsimony criterion and the outgroup principle to probe the monophyly of the genus adding new species. The analysis was conducted with equal weights and it was performed through the method of exact searches with implicit enumeration in the computational program TNT. In the analysis one most parsimonious tree (L= 176, Ci= 0.55, Ri= 0.69) was obtained. The genus *Crassicrus* proved to be paraphyletic, so it was confined to include six species, the type species *C. lamanai* Reichling & West, 1996, four species previously described and also *Aphonopelma stoicum* (Chamberlin, 1925). The monophyly of the genus *Crassicrus* resulted supported by six synapomorphies and high values of Jackknife (98) and Bremer (6). A new diagnosis of *C. stoicum* n. comb. was elaborated.

Keywords: systematics, morphology, taxonomy, Araneae, Mygalomorphae, Theraphosidae

Poster presentation

The physiological basis for delayed development in social huntsman spiders: Impacts on sociality

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Are there physiological traits that facilitate sociality in spiders? Perhaps! Prolonged sociality with has been found in three sparassid species within the monophyletic clade Deleninae, *Delena cancerides*, *D. lapidicola*, and *D. melanochelis*. These group-living huntsman spiders develop differently from all other known solitary delenine spiders—and, to our knowledge, spiders in all other families. Like other spiders, huntsman spiders remain in the egg sac during their 1st instar. After emergence followed by molting, 2nd instar spiderlings of 26+ solitary huntsman species actively forage. In contrast, 2nd instar spiderlings of all three social huntsman are non-feeding and retain 1st instar characteristics: abundant abdominal yolk, shorter legs, and fewer sensory hairs. Only in the 3rd instar do the social species morphologically resemble huntsman spiders and begin to eat. To determine the physiological basis of these ontogenetic differences, we compared differences in maternal investment (egg size, clutch size, and chemical composition of yolk), standard metabolic rates, and development time of the three social species and five solitary species within deleninae. Our results show that social species have larger eggs with more yolk, spend a longer period of time as non-feeders in 1st and 2nd instars, and maintain low metabolic rates during their non-feeding instars, all of which enable the social spiderlings to remain non-feeding. We discuss the implications of (1) how the timing of molting may be precipitated by the depletion of energy and (2) developmental heterochrony on the evolution of sociality in spiders.

Keywords: sociality, metabolism, development, physiology

Oral presentation

The sampled Red List Index of spiders

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The IUCN Spider & Scorpion Specialist Group (SSSG) promotes the assessment of extinction risk of arachnid species worldwide. All assessments follow the IUCN redlisting criteria and guidelines by quantifying extent of occurrence (EOO), area of occupancy (AOO), habitat decline, population trends, fragmentation, and extent of threats. By randomly selecting a given number of species for assessment, the Sampled Red List Index (SRLI) allows perceiving general trends, threats and needed conservation actions for entire groups from local to global scales without the need to assess every single known species. One-hundred and fifty species of spiders were selected from the global checklist for a first attempt at the global SRLI. Prior to this congress, a team of experts gathered and assessed many of these species. Distribution maps were produced, and EOO, AOO and threats quantified whenever information was available and it is now possible to have a rough idea on the status of the group as a whole. However, this is only a start and new tools are planned to facilitate and promote the assessment of many more species, including the release of an R

package for the semi-automated production of IUCN-compliant results and a unique way of publishing peer-reviewed assessments through the Biodiversity Data Journal.

Keywords: conservation assessment, endangered species, extinction risk, IUCN, population trends, threats

Oral presentation

Morphological constraints on sprint performance as drivers of anti-predator behavior in scorpions

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Optimal defensive strategies depend on the ability to perform different anti-predator behaviors. Variation in such performance may result from morphological differences, such as between sexes (for which reproduction may select for sexually dimorphic morphology) or among species (for which morphology may evolve for species-specific activities). I explored this in scorpions by examining sex and species differences in morphology, sprint performance (i.e., escape ability) and propensity to attack predators. First, in *Centruroides vittatus* scorpions, females were more likely to sting and stung at faster rates, and were slower sprinters. Female *C. vittatus* were relatively heavier than males, and heavier bodies were correlated with reduced sprint speed and increased stinging rates. This suggests that the heavier bodies of females (due to reproduction) reduce sprinting ability and that aggression towards predators is increased to compensate. The longer legs of males further improved sprinting performance. In a second study, I used modified assays with six species of scorpions. There was significant variation among species and sexes in size-adjusted mass and leg length. Intriguingly, relatively heavier bodies were associated with relatively longer legs, suggesting morphological compensation for the costs of increased body weight. Species and sexes also differed in relative sprint speed, but overall size (rather than relative weight), leg length, and gravity were the only morphological drivers of variation in sprinting performance. Species also varied in aggression, but there was no evidence this was related to

sprint performance. This work shows that while defensive strategies may be sensitive to morphological traits, the relationship is complex and inconsistent when considering multiple traits, different sexes, and different species.

Keywords: antipredator behavior, scorpions, locomotor performance, aggression, phenotypic integration

Student - oral presentation

Biogeographic patterns of Atlantic Forest pholcid spiders (Araneae: Pholcidae)

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The Brazilian Atlantic Forest (AF) is one of the World's most species-rich ecosystems, but also notoriously endangered and still in need of large-scale studies for many groups of organisms. For Pholcidae spiders, the AF is characterized by high local species-richness and species endemism. Aiming to propose areas of endemism of the AF Pholcidae spiders and to investigate the species composition variation throughout the AF, we gathered the information on specimens collected in 48 AF localities, together with literature data and museum records. This database includes 2,744 records of 263 pholcid species from all over Brazil (144 described and 119 undescribed species), 183 of them endemic to the AF. A geographical interpolation of endemism suggests the existence of eight main areas of endemism, with three in Northeastern, three in Southeastern and two in Southern Brazil. An empirical Bayesian kriging of the species composition followed by a cluster analysis based on likelihood reveals 15 areas with different pholcid species composition: six in

Northeastern, four in Southeastern and five in Southern Brazil. The mean geographic distribution area of Pholcidae species throughout the Atlantic Forest is spatially autocorrelated, with widely distributed species clustered in three areas, and narrowly distributed species clustered in three other areas; both types occur throughout the entire biome. The known absolute geographic distribution area of Pholcidae species from the Atlantic Forest is smaller than that of species from the Amazon Forest. However, the relative within biomes geographic distribution area is statistically similar. This analysis might be biased due to the lack of sampling in the Amazon Forest. These preliminary data suggest a complex distribution pattern of AF pholcid spiders, which will be further investigated regarding its phylogenetic beta diversity and beta diversity partition

Keywords: endemism; diversity; Brazil; species richness; species composition; spider; biogeography

Student - poster presentation

Revision of *Sinopoda* (Araneae, Sparassidae) of Korea

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Until now, study on Korean huntsman spiders, such as genus *Sinopoda*, have mostly focused on describing a physical variations and morphological mutation, disregarding taxonomical differences within each species. As a result, taxonomic diversity among this genus is being simplified in South Korea. The author has studied about this genus and especially classified some new species from existing species of Korea. *S. nocturnus* sp. nov., *S. vitrana* sp. nov., *S. jeju* sp. nov., *S. kimbyeongwoo* sp. nov., *S. hagsanenesis* sp. nov., *S. magnus* sp. nov., *S. keojedoensis* sp. nov., *S. littus* sp. nov., and *S. rubidius* sp. nov. are newly discovered from various fields of Korea. Jäger & Ono (2002) considered *S. stellatops* to exist in Korea, and yet, each of the specimens have different male palp and female epigyne. Thus I conclude none of them are accurately matched with holotype of *S. stellatops* and that the existence of this species in Korea is questioned. Keywords: Sparassidae, *Sinopoda*, Heteropoda, *Micrommata*, taxonomy, Korean arachnology

Student - poster presentation

From Gondwana to GAARlandia: biogeography of ogre-faced spiders (Deinopidae) mirrors geologic history

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Island biogeography continues to debate the relative importance of dispersal versus vicariance. Old lineages that do not readily cross oceanic barriers are especially important because they can reflect ancient and recent as well as global and local geological events. This multilocus phylogeny and biogeographical analysis of ogre-faced spiders (Deinopidae) tests the importance of vicariance events during the ancient breakup of Gondwana and the formation of present-day Caribbean islands. These data support vicariance and Gondwanan history as the best overall explanations of deinopid biogeographic patterns. In particular the 100 mya split between the Old and New World deinopid clades probably reflects the geological separation of Africa and America. Although a single, earlier dispersal to the proto-Antillean islands is possible, the Greater Antilles were most likely colonized from South America via the GAARlandia land bridge. *Deinopis* rarely disperse overwater, but our results indicate dispersal events from Africa to Madagascar, from South America to the

Lesser Antilles and a recent 'reverse colonization' from Cuba to North America. Our results reveal greater species diversity than is captured by current taxonomy, including radiations within islands previously not known to have *Deinopis*. Ogre-faced spiders are an old lineage of relatively poor dispersers whose phylogeny reflects global and local vicariance with rare dispersal events.

Keywords: *Deinopis*, ogre-faced spider, biogeography, GAARlandia, Gondwana, vicariance, dispersal, phylogeography

Student - oral presentation

The joint effect of predator and prey personality on foraging strategy but not success rate

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Consistent inter-individual differences in behavior (i.e. personality) of predators or prey alone is known to influence species interactions, but how personality and intra-individual variability (IIV) of both predators and prey jointly influence the foraging success of predators still remains largely unexplored. Here, we addressed this using a spider-eating jumping spider, *Portia labiata* (Salticidae) as a predator and a jumping spider *Cosmophasis umbratica* as prey. We examined the personalities of both *P. labiata* and *C. umbratica* in the laboratory and used their behavioral variation as predictors of foraging behavior. We found a joint effect of the predator and prey personalities on foraging strategy (i.e., number of attacks before capturing prey), but not on the time taken to capture prey and the prey- capture success rate. Bolder predators were able to capture prey when encountered bold prey with fewer attempts than when encountered shy prey. Boldness IIV of predators predicted the success of prey capture: more consistently bold predators were more likely to capture the prey. However, boldness IIV

of prey correlated with the time taken to catch the prey: more consistent bold prey survived longer. This study highlights 1) the importance of the joint effect of both predator and prey personality on their interactions; and 2) the intra-individual variability (IIV) also plays a part in a predator's foraging success and prey survivorship.

Keywords: boldness, intra-individual variability, jumping spider, predation

Student - oral presentation

Investigating resource contests with the amblypygid *Phrynus longipes*

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Behavioral researchers using Amblypygi have noted the regularity at which species engage in agonistic interactions. Despite this, why agonistic interactions occur and how they are resolved is unknown. I conducted paired interactions of the amblypygid *Phrynus longipes* in Puerto Rico to understand the dynamics of agonistic interactions. Through a series of analyses, I found that agonistic interactions are territory contests common across the demographic range of the species. Further, I decoded the strategy that opponents use to negotiate contests, and used resource contests to explain the peculiar pattern of cannibalism that this species exhibits. I used these results to build an evolutionary simulation model of contest strategies, with novel predictions for the evolution of unintuitive contest tactics. Further, I identified variation in contests and other behavioral phenotypes across cave and surface populations. Last, I discuss current work on understanding the genetic mechanisms that maintain this behavioral variation across environments. This research broadens theory of resource contest evolution and behavioral variation by investigating phenomena in a non-model study system.

Keywords: behavioral ecology, territoriality, resource contests, Amblypygi, population genetics

Oral presentation

Comparison of dragline silk gland morphology and silk genes in two spiders

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Spiders spin an exceptional diversity of functionally distinct silks, including silks for adhesion, egg-case construction, and prey capture. An individual spider can produce multiple task-specific silks from specialized abdominal glands. Among araneomorph (true spiders) species, silk glands can be grouped by morphology and production of a unique silk type. For example, the Entelegynae have major ampullate silk glands, which are named for their size and ampule-shape. Major ampullate glands produce the proteins for dragline silk, and the glands can be subdivided into three regions with different functions and cell types. The Haplogynae also have ampule-shaped glands that produce dragline silk proteins, but whether the glands have differentiated regions is unknown. Major ampullate gland spigots are defined by their location on the anterior lateral spinneret, and the number of major ampullate silk gland spigots among entelegyne and haplogyne lineages suggests a complicated evolutionary history of major ampullate gland gains and losses. Functionally, ampullate glands from entelegyne and haplogyne spiders manufacture dragline silk proteins but as with the spigot evidence, the relationships of ampullate silk proteins suggests a complicated evolutionary history with multiple origins. Here, we study ampullate silk glands from the entelegyne *Latrodectus hesperus* and the haplogyne *Holocnemus pluchei*. Using histology and immunohistochemistry, we investigate the cells of *L. hesperus* major ampullate and *H. pluchei* ampullate glands. We expect that these glands will have three regions with different cell types, suggesting that the cellular structure of dragline silk glands is homologous and conserved. We also identify *H. pluchei* silk protein genes using deep sequencing and determine their relationship to other silk genes.

Keywords: black widow, cellar spider, dragline, major ampullate silk glands, morphology, silk proteins, spider silk

Oral presentation

Do all spider genital components respond to sexual selection?

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Genital evolution in animals with internal fertilization is thought to be under sexual selection and correlated between the sexes. Prior studies on selected spiders, for example, demonstrated that both male and female genital sizes exhibit low allometric slopes, which indicates that their evolution is driven by cryptic female choice. However, it is unclear whether such pattern also holds at inter-specific levels. Furthermore, it may be possible that genital components respond independently to selection. A recent comparative study in nephilid spiders showed that different parts of male genitalia, i.e., intromittent and non-intromittent organ, may be under different evolutionary pressures. While sexual selection may play an important role in male intromittent genital size evolution, the size evolution of non-intromittent part may relate to the selection pressures that act on male body size. Because our understanding of the independent evolution of different genital components is very preliminary, more comparative research on genital evolution is needed. Here, we report on comparative tests of these hypotheses in a female-biased sexually size dimorphic spider clade, genus *Argiope*. We first examined allometric patterns and evolutionary rates of body and genital sizes, then investigated size evolution of different genital components. Finally, we explored the relationship between sexual size and genital size dimorphism. Our preliminary analyses failed to detect any negative allometry in either male or female genital size evolution, discovered that male genital size was only correlated to female external but not internal genital size, and found no relationship between sexual size and genital

size dimorphism. These findings reveal a complicated nature of genital evolution in spiders, and do not unequivocally point towards sexual selection as its main driver.

Keywords: *Argiope*, sexual selection, genital size evolution, sexual size dimorphism, sexual genital size dimorphism

Poster presentation

Global phylogeny and biogeography of Argiopinae (Araneae: Araneidae)

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The araneid subfamily Argiopinae currently includes three genera: *Argiope*, *Gea* and *Neogea* totaling 100 species. Renowned for pronounced sexual dimorphism, unusual mating behaviors, and web decorations, among other traits, argiopines have been subjected to a wealth evolutionary research. Nevertheless, their systematics and biogeography remain unresolved. We present an updated time-calibrated phylogeny using three nuclear and three mitochondrial genes for 64 out of 100 argiopine species, and use it to clarify argiopine systematics and to reconstruct their biogeographical history. Our analyses support a major subdivision of this 40 million year old clade into *Neogea* + *A. trifaciata* + lobed shaped *Argiope* from Africa and Americas on one hand and *A. bruennichi* + *A. aurantia* + *Gea* + all other Old World *Argiope*, on the other. Phylogenetic evidence refutes the monophyly of current genera and rather suggests all are best placed in *Argiope*. However, a new argiopine genus will accommodate an unusual species of *Argiope*. Estimations of ancestral areas suggest Indomalaya + America (or alternatively, Indomalaya) as argiopine origin, from where they dispersed to Africa, Australasia and Western Palearctic around 20 to 30 million years ago. Around 10 to 20 million

years ago, argiopines dispersed repeatedly to Madagascar, Eastern Palearctic and Australasia, but such long distance dispersal events were rarer in the recent 10 million years, a time of extensive within continent diversification.

Keywords: Argiopinae, biogeography, *Argiope*, *Gea*, *Neogea*

Oral presentation

The diversity of long-jawed spiders (Tetragnathidae) in Thailand

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Spiders are considered one of the effective predators, attacking several small animal especially insect pests. This predator is typically found in many places, e.g., paddy field, orchards, forests, and agricultural plantations. The genus *Tetragnatha* is the most important predatory spider in paddy fields. Despite the fact that this spider plays a vital role in the control of *Nephotettix virescens*, the potential insect pest in paddy field, none of these studies have been conducted in Thailand. The distribution survey and collecting were implemented in 18 provinces across the country from October 2011-September 2014. The identification and taxonomic study were carried out under microscope and specimens were preserved in the 75% ethanol. The result revealed that 15 species in five genera were found including *Dyschiriognatha dentata*, *Leucauge celebesiana*, *L. decorata*, *L. tessellata*, *Opadometa grata*, *Orsinome vethi*, *Tetragnatha ceylonica*, *T. hasselti*, *T. javana*, *T. mandibulata*, *T. maxillosa*, *T. nitens*, *T. vermiformis*, *Tylorida striata* and *T. ventralis*. The spider local database was also established at Department of Agriculture (DOA), Thailand. The results can be extrapolated to the integrated pest management (IPM) strategy as well as biological control program to control insect pests in Thailand in the long run.

Keywords: long-jawed spider, Tetragnathidae, diversity, Thailand

Student- poster presentation

Behavior-driven range expansion in the colonial tentweb orbweaver, *Cyrtophora citricola*

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Given the drastic ecological and economic costs of biological invasions, identifying population traits and underlying mechanisms of colonization success is crucial to understanding range expansion processes. The range expansion of a species is dependent on individuals dispersing beyond current range limits at the leading edge. The spatial sorting hypothesis predicts that, like frontrunners of a race, phenotypes linked with higher dispersal tendencies will tend to accumulate at the leading edge of an expanding range. This hypothesis provides an alternative explanation for landscape-level phenotypic distributions besides local adaptation and is particularly relevant for dynamic populations such as invasions. In this study, the range expansion of the invasive colonial tentweb orbweaver, *Cyrtophora citricola*, is used to test the spatial sorting hypothesis on behavioral traits linked to dispersal tendency. Spiders were collected across their invasive range in Florida and assayed both in field and laboratory settings for putative traits of boldness, aggression, activity, and exploratory tendency. Preliminary analyses suggest that a behavioral cline exists at the range-level, with bolder spiders found preferentially at the leading edge of this invasion. This provides evidence of behavior as a driving factor of range expansions.

Keywords: animal personality, Araneidae, biological invasion, boldness

Student - oral presentation

Diversity, mapping and ecological aspects of cave spiders from Brazil (Arachnida, Araneae)

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The diversity of spiders that occurs in caves in Brazil is poorly known. Little is known about the diversity of species and their distribution and, ecological aspects as behavioral characteristics (e.g., maternal behavior, the webs architecture) and the relationship of these species with the cave environment are even less studied. In this study, we intend to map the diversity of spiders in caves in different karst regions in Brazil, as well as to record and analyse ecological characteristics of these species. Our study is based on a data-bank (still being update, 2009–) with information from more than 3,100 caves, based on standardized sampling. So far, we identified 35,674 adult spiders from 51 families distributed in 391 spp. Among these, 43 species, distributed in the families Ochyroceratidae, Tetrablemmidae, Oonopidae, Prodidomidae, Symphytognathidae, Caponiidae, Hahniidae, Corinnidae, Pholcidae, Ctenidae, Microstigmatidae, Dipluridae and Theraphosidae, have characteristics that indicate preference or isolation in the hypogean environment. This information has been ordered and will be presented in an analysis of guilds. We also evaluated the richness and abundance of species and related it with environmental variables (e.g., different lithologies). Among the results related to the ecology, species that carry their egg-sacs with them seem to be particularly abundant in caves communities. All information of distribution, taxonomy and ecology of cave species of Brazil are being organized to be available on a website still under construction.

Keywords: cave spiders, mapping, diversity and behavior

Student - poster presentation

Autotomized *Prionostemma* harvestmen have equal mating success than intact individuals

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By studying sexual behavior in animals, biologists can understand how particular morphological and behavioral traits have evolved. Furthermore, the importance of certain defensive strategies associated with mating can be addressed, for its impact on reproductive success. Autotomy –the voluntary releasing of legs– is a common strategy used as an anti-predator defense mechanism among arachnids. Although it may ensure immediate survival, it may convey long-term costs in courtship and individual fitness. This would be especially relevant for arachnids with behaviorally complex courtship that involve using their legs. For instance, some species of Sclerosomatidae harvestmen interact by doing leg-wrappings during courtship, which is known to be crucial for the male's mating success. Many species of Sclerosomatidae have high frequency of autotomy. For example, in a currently undescribed species of *Prionostemma* in the Neotropical rainforests of Costa Rica we observed that 61% of individuals, including males and females, were missing at least one leg. Therefore, we tested the hypothesis that leg condition (intact or autotomized) had an effect on the sexual behavior and consequently, mating success particularly of males, when compared to females. We conducted 144 lab mating trials using either autotomized males or females, or both. Overall, we found no major differences in courtship behavior nor mating success between autotomized and intact individuals (mating success average $38 \pm 3\%$). We also found a similar pattern for mating interactions when compared with field observations. We also described for the first time in Neotropical harvestmen the details of the mating behavior. Compared to temperate zone Sclerosomatidae, *Prionostemma* sp. males did not wrap the females' legs with their own. These findings suggest that autotomy does not interfere with mating success, potentially explaining why it is so prevalent in in this genus. However, this mechanism remains to be studied.

Keywords: Opiliones, sexual behavior, mating success, daddy-longlegs, Neotropical harvestmen

Oral presentation

DNA barcode data accurately identify higher spider taxa

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Most spider species are undescribed. Can DNA barcodes accurately assign an unidentified species to genus or family? We built a carefully chosen test library of CO1 sequences from 49 families, 313 genera, and 816 species of spiders to assess the accuracy of genus and family-level assignment. We BLASTed each sequence against the entire library and retained the top ten hits (PIdent, range 75-100%). Generic identifications were accurate (less than 5% errors) at PIdent > 95 and families at PIdent ≥ 91. More species/genus and genera/family in the library increases accuracy: above five genera per family and fifteen species per genus all higher taxon identifications were correct. The quality of the underlying database is important; many outliers in our dataset could be attributed to taxonomic and/or sequencing errors in BOLD and GenBank.

Student - oral presentation

Scorpion tail strikes: a trajectory shape analysis

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Whole-organism movement provides insights into how animals perform ecologically vital tasks. In scorpions there is a unique biomechanical challenge: the metasoma (the “tail”, a continuation of the body rather than a true tail) when used defensively, is capable of reaching speeds up to 2 m/s, shifting the center of mass position abruptly and requiring large reaction forces; it can also represent 25% of the total body weight. In this work, we quantified performance differences from 179 defensive strikes produced by 23 individuals. Using high-speed videography, we calculated anatomical and kinematic variables as well as the 3D shapes from the stinging trajectories. Scorpion morphology and kinematic variables exhibited a significant association across species after taking phylogeny into account. Moreover, the multivariate association between traits indicate that not only shape and kinematic variables are correlated but also that open (unfolded) trajectories present higher velocities. In other words, this indicates that certain strike trajectory shapes allow for faster strikes than others. Understanding how the scorpion defensive system operates can provide new additions to stability under perturbation models.

Keywords: scorpions, trajectory shape, defensive strike, comparative kinematics, functional morphology

Student - poster presentation

Characterization of the Venom Proteome for the Wandering Spider, *Ctenus hibernalis* (Aranea, Ctenidae)

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Spider venom is a rich multicomponent mixture of neurotoxic polypeptides. The venom of a small percentage of the currently classified spiders has been categorized.

We constructed proteomic data from crude venom of the wandering spider *Ctenus hibernalis* using HPLC paired with LTQ XL ion MS, to determine what venom proteins are expressed in this species. We found 1,238 proteins that closely matched the sequences of other venom proteins of several species of spiders. Our results suggest that the venom proteins of *C. hibernalis* contain several proteins with conserved structures similar to other species. Future work will further characterize the sequences of the proteins that did not have any matches within the database in order to further understand the proteomic makeup of the venom of this species.

Keywords: venom, ctenidae, proteomics

Student - oral presentation

Untangling evolutionary relationships of widow spiders (*Latrodectus*, Theridiidae, Araneae): *Latrodectus* phylogeny revisited

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The widow spiders (*Latrodectus* Walckenaer, 1805) are feared by the general public due to their neurotoxic venom and tendency to live near human habitations, but are valuable models for comparative study. *Latrodectus* species have been the focus of research on venom and silk evolution, behaviour, ecophysiology, plasticity, and invasion biology, but comparative studies are challenging because the group is taxonomically problematic. A previous phylogenetic analysis based on a single gene and 60% of the 31 currently recognized species failed to fully resolve species-level phylogenetic relationships. Here we present a new analysis utilizing ~200 *Latrodectus* specimens from 28 species (90% of valid species), and 20 outgroup taxa, based on data from two mitochondrial (COI and 16S) and four nuclear (18S, 28S, H3 and ALTX) genes. Phylogenetic

analyses were completed using Bayesian (MrBayes and BEAST) approaches. The widow genus, *Latrodectus*, was recovered as monophyletic (PP=1.0), and we confirm the previously-identified *mactans* and *geometricus* clades (PP=1.0). Within the *mactans* clade we recover species relationships that differ from previous hypotheses. For example, the clade including the South American widows is sister to the clade including the Israeli widows, rather than to the clade of species from North America. In addition, *L. dabli* (not previously included) is sister to the *mactans* clade in all analyses (PP=1.0). Our results show cryptic diversity within the widely-distributed western black widows (*L. hesperus*) and suggest a *L. hesperus* species complex. This well-supported phylogenetic hypothesis for the genus is an important new tool for comparative analyses of traits of interest to applied and fundamental researchers.

Keywords: macroevolution, molecular phylogeny, cryptic species

Student - oral presentation

Scorpions of the genus *Vaejovis* C. L. Koch, 1836: the *mexicanus* group, a morphological phylogeny (Scorpiiones: Vaejovidae)

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The genus *Vaejovis* has been on a huge debate over its diagnosis and the species included in it; since the phylogeny proposed from Soleglad and Fet (2008) where they put in 28 species. Later, González-Santillán and Prendini (2013) in a revision on the family Syntropinae take several of the traditional species included in this genus to be included in several of the genera described in this work; this puts into question the monophyly of the genus *Vaejovis*, the species groups within and the species included. This analysis, on basis of morphological information, define the monophyly of the groups within this genus and characters that support this hypothesis; it also proves the validity of

several characters proposed as the setae present on the legs on this genera, setae on the metasomal keels, hemispermatophore structures and trichobothria on the pedipalp, additionally presents new characters as the vesicular glands and the subaculear serrations (LAS) on a phylogenetic analysis.

Keywords: high lands, systematics, speciation, endemism, biodiversity

Student - poster presentation

Display architecture across social contexts in the amblypygid *Paraphrynus laevifrons*

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Using a likely similar toolset for signal production and signal perception, conspecific animals communicate with each other across social contexts. In amblypygids (Class Arachnida, Order Amblypygi), previously studied species have been shown to use distinct ritualized displays in intra- and intersexual interactions. In this ongoing study, we explore how selection for effective intraspecific communication across contexts might facilitate and/or constrain signaling system architecture. Specifically, we examine, describe, quantify, and compare the behavioral repertoire of *Paraphrynus laevifrons* in intra- and interspecific contexts to assess display similarities/differences. Preliminary results suggest that adult males and females use distinct types of antenniform leg vibrations (ALV) in intra-sexual interactions, and that sex-specific ALVs are also employed in intersexual interactions. ALVs used by male *P. laevifrons* are additionally compared to signaling systems in other known amblypygid species. An assessment of juvenile interactions thus far reveals no similar behaviors, suggesting that the form of these displays may change over ontogeny in these relatively long-lived arachnids.

Keywords: Amblypygi, communication, signal evolution, social context

Student - oral presentation

Silk gene expression profiles of male versus female cob-weaving spiders

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Spiders have multiple types of silk glands that are specialized to produce an array of task-specific silks. Studies have shown that spider silks are largely composed of proteins encoded by members of the spidroin gene family. Most of these studies have been conducted on females; thus, little is known about silk production by males. To shed light on silk use by male spiders, we compared silk gene expression profiles of mature males and females from three cobweb-weaving species (Theridiidae). We de novo assembled male-specific as well as species-specific (male and female) transcriptomes for *Latrodectus hesperus*, *Latrodectus geometricus*, and *Steatoda grossa*. Based on the presence of silk spigots in both sexes, we expected gene expression for aciniform (dominant component of prey-wrapping silk), major ampullate (dragline silk), minor ampullate (web construction silk), and pyriform (attachment disc silk) spidroins in males and females. Furthermore, we did not expect males to express silk protein genes associated with egg-case and aggregate glue production. Because males desert their prey-capture webs and become cursorial to search for mates, we expected males to have a higher expression of major ampullate spidroin genes than other silk genes. Our expression profiling results show that both sexes express aciniform, major ampullate, minor ampullate, and pyriform spidroin genes, as predicted. The most highly expressed silk genes in females of all species were tubuliform, major ampullate, and aggregate spidroins. Counter to expectation, we found that the most highly expressed silk genes in *Latrodectus* males were the minor ampullate spidroins. In *Steatoda* males, however, major ampullate spidroins had the highest expression. These findings suggest that *Latrodectus* males use more minor ampullate silk than *Steatoda* males.

Keywords: differential gene expression, male spiders

Student - Oral presentation

Straightening out the pseudoscorpion backbone

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Over the last century there have been four main hypotheses proposed regarding the classification of groups within the arachnid order Pseudoscorpiones: Chamberlin, 1931; Beier, 1932; Muchmore, 1982; and Harvey, 1992. While these classification schemes are primarily concordant, especially in contrast to the multitude of ideas proposed in the 19th century, the placement of a few particular groups continues to be debated, notably the superfamily Fealloidea and families Cheiridiidae, Pseudochiridiidae, and Sternophoridae. Recently, molecular data have begun to shed new light on our understanding of pseudoscorpion phylogenetics, however relationships between some key families and superfamilies remain unresolved. We have generated de novo transcriptomic data from 23 species representing 18 of the 26 currently recognized families in order to infer the pseudoscorpion phylogeny using a variety of phylogenetic inference methods and models of evolution. This data will also be used to estimate divergence times within Pseudoscorpiones and to compare rates of molecular evolution between lineages. We will discuss our findings as well as the implications of a well-resolved and dated pseudoscorpion phylogeny that will provide the necessary backbone from which we can investigate the evolution of morphological characters including silk and venom, as well as mating and dispersal behaviors.

Keywords: phylogenomics, pseudoscorpiones, systematics, divergence dating

Oral presentation

Genetic mosaic among ecologically similar species within an adaptive radiation of Hawaiian spiders

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The interplay between isolation and time in the initiation of adaptive radiation is central to understanding the dynamics of rapid diversification events. The chronosequence of the Hawaiian Islands provides an ideal system to explore this fundamental process. Here, we focus on a radiation of long jawed spiders, genus *Tetragnatha*, to examine the genetic signatures of early events of speciation. Specifically we investigated how ecologically similar species have differentiated genetically in the course of an adaptive radiation. Using a transcriptome-based exon capture approach, we examined relationships between populations of three closely related species (*T. brevignatha*, *T. waikamoi* and *T. macracantha*) from the youngest of islands of the Hawaiian chain, Lana'i, Maui and Big Island. The data shows that the originally described three species could be separated in at least five genetic clades. A key finding is that

T. waikamoi, is widespread across East Maui, while the other species (juxtaposed with *T. waikamoi*) are localized and more closely related to populations on other volcanoes. Regardless the phylogenetic proximity there is no evidence of hybridization between these species. This result adds a new layer of complexity to recent allopatric speciation events in the context of an adaptive radiation.

Keywords: *Tetragnatha*, ecomorph, exon capture, phylogeography, speciation

Student - oral presentation

Broad species comparative meta-analysis of key amino acid densities and silk structural properties

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The presence and density of key amino acids (Alanine, Glycine, Glutamine, Serine, and Proline) is posited to provide spider silk with its distinctive properties of both strength and extensibility. Various hypotheses exist to explain the role of each amino acid in forming the distinctive properties and to outline a working molecular model of spider silk. Despite all these studies, we still have a poor understanding of how the different amino acids interact to provide different silk properties across different species. The main objective of this study was to determine the relative importance of amino acid composition and spinning processes in determining spider silk properties. We performed a meta-analysis comparing the amino acid composition, modulus, extensibility, strength and overall toughness of silk of 77 spider species (phylogenetically controlled) from 64 papers sampled from 1,680 publications. I will focus on discussing the relative importance of the various major amino acids on the material properties of spider silk and discuss the role of spinning processes in the final properties of the silk.

Keywords: silk, amino acid, mechanical properties, meta-analysis

Oral presentation

Extreme striking in *Selenops* (Araneae: Selenopidae)

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Many predators attack prey by ambushing, the success of which largely depends on high speed. However, given the tradeoff between speed and maneuverability, ambush strikes are typically constrained within a specific angular range and thus not adapted for attacking prey from an unlimited range of direction. This research shows that flattie spiders (Selenopidae) are capable of performing rapid strike maneuvers to capture prey approaching from an unconstrained range of direction, exhibiting one of the greatest rotational movements in animals. Additionally, radially aligned, long laterigrade legs act as a modularized system covering a wide range of direction, and each leg can readily drive the striking movement towards the prey. In particular, legs function as planar manipulators to direct the rapid turn-and-reach body motion. Using a generalized mechanical model, how controlled manipulation of long segmented legs enables rapid, efficient generation of body translation and rotation is revealed. Thus, leg manipulability can enhance maneuverability in multi-legged locomotion.

Keywords: biomechanics, flatties, locomotion, ambush predation

Student - oral presentation

Phylogenetic analysis of Stygnopsidae (Opiliones), based on three molecular markers and morphology

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Due to the relative highest diversity of the family Stygnopsidae (Grassatores: Gonyleptoidea), its unknown relationships and the increasing taxonomic works in the last years, we performed a phylogenetic analysis concerning this family. We produced four datasets: three molecular markers, partial ribosomal 28S, mitochondrial ribosomal 16S, mitochondrial protein-encoding Cytochrome c oxidase subunit I (COI), and 72 morphological characters. With these data, we performed three different phylogenetic analyses: Bayesian Inference with molecular data, and Bayesian and Maximum Likelihood using combined data. In our results we recovered the monophyly of Stygnopsidae, with two major clades within the family, considered and diagnosed as two subfamilies: Stygnopsinae and a new subfamily assignment. According to the results and due to the polyphyly of *Hoplobunus* and *Paramitraceras*, the following genera were redefined: *Stygnopsis*, *Hoplobunus* and *Serrobunus* stat. rev., also we detected a new genus to allocate *Hoplobunus spinoocolorum*. Additionally, the following taxonomic changes are proposed: *Serrobunus queretarius*, *Stygnopsis apoalensis*, *Stygnopsis mexicana* and *Stygnopsis oaxacensis* new combinations. Finally, we discuss the evolution of male genitalia and the importance of some homoplastic characters.

Keywords: Laniatores, taxonomy, new subfamily, homoplastic, male genitalia

Oral presentation

Late Ordovician chelicerate diversity - new insights from Manitoba Konservat-Lagerstätten

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Two recently discovered Konservat-Lagerstätte deposits in central and northern Manitoba are yielding many exciting new fossils. Some of these provide a compelling (and often confounding) record of emerging chelicerate arthropod

diversity in Late Ordovician (Richmondian) restricted shallow marine environments of central Laurentia. Biotic assemblages from the William Lake (Grand Rapids Uplands; Williston Basin) and Airport Cove (Churchill area; Hudson Bay Basin) sites both contain representatives of the early xiphosurid horseshoe crab *Lunataspis aurora*, including juvenile individuals revealing allometric growth of the prosomal shield and telson. Elements of unusual new eurypterid taxa have so far been identified from William Lake. It possesses a puzzling chimera-like combination of exoskeletal characters, including a novel swimming paddle morphology, setting it apart from all other described forms. The William Lake section, in addition, includes the first Ordovician record of a sea spider - the only known fossil occurrence of the rare and bizarre Pycnogonida in rocks of demonstrable shallow-water origin. Fragmentary remains of other non-biomineralizing arthropods found at both sites hint that other chelicerate groups, such as the 'synziphosurines' and chasmataspidids, may be present. These discoveries provide a unique window into the early radiation of the chelicerate arthropods and suggest that Ordovician marginal marine habitats may have been the setting for much of their initial diversification.

Keywords: fossils, marine, evolution

Oral presentation

Dual function of male genitalia in *Tetragnatha*-sperm removal and sperm transfer

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Male long jawed orb weavers of the genus *Tetragnatha* have several unusual pedipalp structures. The most striking is the elegant corkscrew-like spiral of the conductor, which guides the sperm releasing embolus to its final destination. We have demonstrated that this structure, in concert with other features, removes stored rival male sperm and biases paternity towards the last male in the species *Tetragnatha elongata* (Walckenaer, 1841). In addition to removing stored rival sperm, male *T. elongata*

scrape their pedipalps across the female's genitalia and inflate hematodochae without embolus insertion at certain periods during mating. These types of behaviors have been previously classified as "flubs". Here we describe a functional purpose of these behaviors: removing sticky masses of rival sperm that have been partially or entirely drilled out of the female but remain stuck to her ventral surface or to the conductor itself. In summary, *T. elongata* males bias paternity in their favor by removing internal amorphous mating plugs composed of rival male sperm.

Keywords: Sexual selection, sperm competition

Oral presentation

An Aristotelian view on trapdoor spiders

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Within the order Araneae, Mygalomorphae are generally considered a 'lesser' branch of the (spider) tree of life. In comparison with their putative sister clade the Araneomorphae, Mygalomorphae are less diverse, less common, less derived, less complex, less visible and certainly less well-known. Recent work however shows that Mygalomorphae are much more common and diverse than previously perceived. Most of the new knowledge on mygalomorph spiders is morphologically or molecularly based and obtained from the studies of collected and preserved specimens. Knowledge of the living mygalomorph spiders is very limited. This is particularly true for the numerous fossorial mygalomorphs that may loosely be indicated as trapdoor spiders. Trapdoor spiders appear to show a remarkable evolutionary conservatism expressed in their habits and general anatomy. Molecular work has shown that trapdoor spiders not only appear to be ancient, but actually are ancient in the sense that species ages have been estimated to exceed 30 million years. Such times for species survival indicate that trapdoor spiders make perfect models for studies of morphological stasis that will contribute to the ongoing debate concerning tempo and mode in evolution. The long term survival of species furthermore suggests a high level of adaptation that questions the

supposedly 'lesser' degree of morphological and behavioral specialization in trapdoor spiders. To appreciate the functional specializations in trapdoor spider morphology and behavior (and to correct some common misconceptions) the Aristotelian question 'what for?' is asked to provide the necessary background knowledge for hypothesis building and further research. This Aristotelian question will be discussed with respect to the functional morphology of the chelicerae and pedicel in burrow construction and of the appendages in prey handling and locomotion.

Keywords: functional morphology, evolutionary stasis

Student - poster presentation

Leg autotomy in the fishing spider *Dolomedes triton* and its effect on antipredator and locomotor behavior

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Phenotypic plasticity, the ability of an organism to alter its phenotype in the face of different stressors, is a phenomenon that is widespread throughout nature. Plasticity in behavioral syndromes (animal personalities), a topic that is steadily increasing in interest within animal behavior, falls under this umbrella and can have significant implications for an organism in terms of overall fitness. The six-spotted fishing spider, *Dolomedes triton* (Araneae, Pisauridae) is an intriguing model for studying antipredator behavior (boldness) across different contexts, due to predation pressures from both terrestrial and aquatic sources. Like most spiders, *D. triton* is able to autotomize a limb in order to escape from a predator or remove itself from another situation that could cause significant harm or death. This project aims to test the hypotheses that when an individual *D. triton*

autotomizes a limb, its boldness will decrease in concert with a decrease in sprint speed. To test this, the boldness, latency to attack prey and sprint speed across three different substrates will be measured for individual *D. triton* before and after the autotomy of one leg, which will be standardized across all individuals. Some individuals with one autotomized leg will subsequently have a second leg removed, which will serve to test a further hypothesis that boldness is a syndrome of sprint speed and will continue to decrease, until a point, as legs are removed. This experiment could provide significant insight into how an awareness of physical ability can affect an individual's behavior within a varying number of ecological contexts.
Keywords: autotomy, boldness, fishing spider, behavior

Student - oral presentation

Adaptive timing of predatory activity by a mosquito-specialist predator

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Evarcha culicivora is a mosquito-specialist salticid spider from East Africa that feeds indirectly on vertebrate blood by actively choosing blood-carrying mosquitoes as preferred prey and by actively choosing *Anopheles* as preferred mosquitoes. We consider whether specialization by this predator is also expressed in the timing of predatory activity. Our data from field sampling and from systematically observing *E. culicivora* under semi-field conditions show that predation tends to be concentrated in the early morning hours, this being when night-feeding anthropophilic anopheline mosquitoes tend to be resting while they digest blood meals acquired during the night. In experiments using living prey and other experiments using lures made from dead prey, *E. culicivora* was significantly more responsive to prey and significantly more inclined to choose its preferred prey in the morning than in the afternoon. We also show that response to prey odour

is significantly stronger in the morning than in the afternoon. Although *E. culicivora* is known to be attracted to mate, plant and human odour, we found was no significant diel pattern in response to mate, plant or human odour and no significant diel pattern in inclination to mate. These findings suggest that *E. culicivora* has an innate activity pattern specific to predation, this being a pattern that should facilitate encounters with its preferred prey.
Keywords: specialization, predation, *Evarcha culicivora*, *Anopheles gambiae*

Student - oral presentation

Population genomics and phylogeography of *Sclerobunus robustus* from the southwestern United States

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The integration of ecological niche modeling into phylogeographic analyses has allowed for identification and testing of potential refugia under a hypothesis-based framework. In this study we focus on a montane-restricted cryophilic harvestman, *Sclerobunus robustus*, distributed throughout the heterogeneous Southern Rocky Mountains and Intermontane Plateau (SRMIP) of southwestern North America. We identified hypothetical refugia using ecological niche models (ENMs) across three time periods, corroborated these refugia with population genetic methods using RAD-loci data acquired with double-digest RAD-seq, and conducted population level phylogenetic and divergence dating analyses. ENMs identify two large temporally persistent regions in the mid-latitude highlands. Genetic patterns support these two hypothesized refugia with higher genetic diversity within refugial populations and evidence for range expansion in populations found outside of hypothesized refugia. Phylogenetic analyses identify five to six genetically divergent, geographically

cohesive clades of *S. robustus*. Divergence dating analyses suggest that these separate refugia date to the Pliocene and that divergence between clades predates the late Pleistocene glacial cycles, while diversification within clades was likely driven by these cycles.

Keywords: sky islands, southwestern United States, landscape genomics, isolation by environment, refugial persistence, ddRAD-seq

Student - oral presentation

Population genomics and mitochondrial-nuclear discordance in range expanding populations of *Argiope bruennichi*

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In the past decade, molecular markers have been increasingly employed to test various phylogeographic hypotheses. While resolving the geographic histories of many taxa, these methods can also be used to study the behavior of genetic markers such as mtDNA. Populations of *Argiope bruennichi* have exhibited poleward range expansion into Northern Europe in the past century. Mitochondrial and Nuclear genome-wide analyses of the range-expanding populations reveal the role of genomic admixture in enabling invasive populations to adapt to novel climatic conditions. These analyses also reveal an interesting difference between the mitochondrial and nuclear markers. While regions of the nuclear genome freely introgress between populations, mitochondrial genomes show high levels of structure between populations suggesting limited mitochondrial introgression. While various hypotheses such as sex-biased dispersal could lead to this apparent pattern, we propose the role of mitochondrial-nuclear incompatibilities in producing this discordance. These incompatibilities could serve as targets for selection and further pave the way for speciation. Such discordant patterns are most commonly observed in populations undergoing hybridization followed by a period of geographical isolation. The proficient

colonizing capabilities of spiders make them excellent candidates for testing these hypotheses and future studies in spiders should incorporate molecular methods to gain insight about the evolutionary processes that govern species delimitation and species hybridization.

Keywords: phylogeography, population genomics, mitochondrial nuclear discordance

Student - oral presentation

Dispersal, local density dependence, and population stability in social spider metapopulations

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In subdivided populations, local population stability may depend on dispersal occurring to prevent overcrowding and resource depletion. Social spider colonies constitute relatively isolated local populations forming part of a metapopulation. In the more highly social species, greater intrinsic rates of growth and lower dispersal tendencies may result in boom and bust colony and patch dynamics, whereas local populations may be more stable in the less social species with greater tendencies to disperse. We recorded the growth, dispersal, and stability of two co-occurring social *Anelosimus* spiders at Serra do Japi, Brazil. We found that in the transitional *A. jabaquara* per capita fitness was not affected by colony size, whereas in the more highly social *A. dubiosus* per capita fitness was maximum at intermediate colony sizes, but below replacement value in small and large colonies. The more highly social species thus exhibited both positive (Allee effect) and negative density dependence; the less social, did not. Dispersal and extinction were inversely correlated across species: the transitional *A. jabaquara* had consistently higher dispersal, but lower extinction rates, whereas the social *A. dubiosus* had the opposite pattern. These results are consistent with the hypothesis of dispersal as a stabilizing factor in local population dynamics.

Keywords: *Anelosimus*, group size, metapopulation, population persistence, sociality

Oral presentation

Developmental experience shapes life history, behavior, and web structure of black widows

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Developmental experience is known to affect life history and behavior, yet rarely, these are studied in together. As a result it is still unclear whether developmental experience affects behavior through changes in life history, or independently of it. Furthermore, the effect of developmental experience on life history and behavior may be affected by individual condition during adulthood. Thus, it is critical to tease apart developmental from condition-dependent effects. Here we manipulated food abundance during development in the western black widow spider, *Latrodectus hesperus*, by rearing spiders on either a restricted or ad lib diet. We separated developmental from condition-dependent effects by assaying adult foraging behavior (tendency to attack a prey cue) and web structure multiple times under different levels of satiation. Our results indicate that spiders reared under food restriction matured slower and at a smaller size than spiders reared in ad lib conditions. We found that restricted spiders were more aggressive towards prey and built webs structured for foraging, while ad lib spiders were less aggressive and built safer webs. The amount of individual variation in behavior and web structure varied with developmental treatment. Spiders reared on a restricted diet exhibited consistent individual variation in all aspects of foraging behavior and web structure, while spiders reared on an ad lib diet exhibited consistent individual variation in aggression and web weight only. Thus, developmental experience affected the average life history, behavior, and web structure of spiders, but also shaped the amount of phenotypic variation observed among individuals. Finally, developmental treatment affected adult trait

plasticity: when condition increased, restricted spiders built safer webs, but ad lib spiders reduced their aggression.

Keywords: developmental plasticity, web structure, foraging behavior

Poster presentation

Iranian spiders (Araneae) in the National Museum in Prague (Czech Republic)

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Most of the Iranian arachnids in the collection of the National Museum in Prague (NMP) were collected during three Czechoslovak-Iranian entomological expeditions organized by the NMP in 1970's. The spider material was collected by Bohumil Pražan at 18 Iranian localities during the third expedition (26 March–12 August 1977) and includes 217 specimens of spiders belonging to 50 species from 21 families: Atypidae, Dipluridae, Nemesiidae, Sicariidae, Eresidae, Oecobiidae, Theridiidae, Tetragnathidae, Araneidae, Lycosidae, Pisauridae, Oxyopidae, Agelenidae, Dictynidae, Clubionidae, Zodariidae, Gnaphosidae, Sparassidae, Philodromidae, Thomisidae, and Salticidae. Among them, eight species are new to the spider fauna of Iran: *Atypus muralis* Bertkau, 1890, *Steatoda bipunctata* Linnaeus, 1758, *Arctosa similis* Schenkel, 1938, *Wadicosa commoventia* Zyuzin, 1985, *Zodariidae* sp., *Trachyzelotes jaxartensis* (Kroneberg, 1875), *Thomisus albobirtus* Simon, 1884, and *Thomisus unidentatus* Dippenaar-Schoeman & van Harten, 2007. Older material deposited in the NMP is represented by a single *Lycosa singoriensis* (Laxmann, 1770) female collected by L. Král in 1944 in Karaj. Recent material, unfortunately, comprises only two sub-adult lycosid and sparassid females collected by P. Kabátek in October 1998. All arachnologists are invited to cooperate and study material deposited in the NMP. This work was financially supported by Ministry of Culture of the Czech Republic (DKRVO 2016/15, National Museum, 00023272).
Keywords: collection, expeditions, faunistics, Iran, new records

Student - oral presentation

Fossil spiders and ancient salt lakes

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Fossil spiders are relatively abundant in lacustrine deposits. This talk examines the diversity of spiders from several lacustrine deposits, and the information they provide about paleoenvironments. Fossil spiders from the Green River Formation of Colorado (Eocene) include specimens from the families Uloboridae, Hersiliidae, Selenopidae, and Thomisidae that have recently been described. The Florissant Formation (Eocene) has a similarly diverse fauna with several families represented including Lycosidae, Tetragnathidae, Thomisidae, and Gnaphosidae. Few fossils from the Crato Formation (Cretaceous) have been formally described but include mygalomorphs, araneids, nephilids, and an exquisite palpimanid. The diversity from these three deposits represents various life modes and habitats. Recently, it has been demonstrated that the leg flexure of spiders may serve as a proxy for the paleosalinity of ancient lakes. The typical pose of fossil spiders from the Crato Formation, for example, is legs tightly curled under the body, and is suggestive of hypersalinity. Fossil spiders from each of the three deposits were examined and compared to modern spiders drowned in varying salinities. Keywords: Araneae, taphonomy, paleontology, paleoenvironments, lacustrine

Oral presentation

Comparing araneoid biodiversity between high and low elevation Panamanian rainforest sites

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We used a Rapid Assessment Protocol to acquire comparable samples of ground-accessible spider assemblages from eight Panamanian rainforest sites during September and October, 2008. Our objectives are to obtain species-level data on clade Araneoidea in Neotropical rainforests; provide descriptions of the assemblages from four low elevation (70–135 m) and four high elevation (1181–2326 m) sites; and to determine what differences among sites are detectable using this Rapid Assessment data. 72 person-hours of sampling time yielded 309 adult araneoids (4.3/hour) belonging to 111 morpho-species (56% determined to known species) in 9 families. 75% of species were found at only one of the eight sites, and only six species were found in both low and high elevation sites. No species were found from more than half (four) of the sites. Theridiidae comprised nearly half of the adult Araneoids and 38.7% of the species. It was the numerically dominant family except at the two highest sites, which were dominated by Tetragnathidae. Tetragnathidae species richness was greater at higher elevation sites, whereas Theridiidae and Mysmenidae richness was greater at low elevation sites. Inter-site species similarity (Bray-Curtis) was largely a function of distance, but family-level similarity was uncorrelated with distance and is likely ecologically meaningful. Our data was useful for describing the assemblages, but most site pairs were not statistically distinguishable in richness or Simpson's diversity. Richness estimators yielded highly variable estimates, suggesting that more data is necessary for robust richness estimation.

Keywords: rapid assessment protocol, Neotropics, rainforest, elevation, Araneoidea, biodiversity, faunistics

Oral presentation

The beautiful behavior and morphology of how spiders find and grasp silk lines

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The morphology and behavior of the tarsi and claws are crucial in allowing spiders to find, grasp securely, and

release lines as they move in their webs. Some crucial aspects of tarsal morphology were elegantly documented long ago by E. Nielsen. Several recent advances on the behavioral side have been made possible by video recordings of behavior. The spider's legs routinely follow each other in various behavioral contexts, thus economizing on the exploratory behavior needed by more posterior legs to locate new lines. The short-distance searching movements made by a following leg are asymmetrical (prolateral for legs I and II, retrolateral for legs III and IV), and these orientations are appropriate to allow their asymmetrically placed median claws and serrate accessory setae to contact and grasp the lines that they encounter. And the tarsus itself (or, less likely its claw) is routinely twisted on its longitudinal axis to bring the median claw into a position perpendicular to the line, thus allowing the claw to clamp even those lines that are parallel to the spider's longitudinal axis.

Keywords: behavior, functional morphology, web spiders

Student - oral presentation

Control of signal alignment during the dynamic courtship display of a salticid

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Signals are often directional, meaning that they are best perceived from certain angles. Likewise, sensory systems often have directional biases. Thus, alignment of directional signals and directional sensors may often be critical for effective communication. However, we know little about how animals establish and maintain alignment during signaling. We analyzed the dynamic courtship dances of the jumping spider *Habronattus pyrithrix* to better understand how often alignment is achieved, and who is primarily responsible (i.e. male, female, or both). In this species, courtship consists of distinct long- and short-range phases. Males produce a forward-facing visual display that includes color, pattern, and movement. Females view this display with two types of eyes: color sensitive principal eyes with narrow fields of view, and colorblind secondary eyes with

wide fields of view. The combined inputs of these eyes create a visual field where colors and fine patterns of male displays can only be perceived by a female if the male is in front of her. We recorded relative positions and orientations of both actors throughout courtship to evaluate how consistently male displays are aligned with the female principal field of view, and who is responsible. Males always oriented their displays toward the female. When females were free to move, male displays were only consistently aligned with female color vision during the short range phase. When female position was fixed, signal alignment consistently occurred during both courtship phases, and maximal alignment during the short range phase occurred for a greater proportion of time. This suggests that normal female movements may reduce communication efficacy. In addition, when tethered females were rotated to face away, males rarely repositioned themselves to re-align their display. Thus, although signal alignment is a function of both sexes, males may rely on females for effective communication.

Keywords: communication efficacy, courtship signaling, signaling behavior, Salticidae

Oral presentation

Revision of *Misumessus* (Araneae: Thomisidae), with observations on crab spider epigynal hoods

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The previously monotypic genus *Misumessus*, type species *M. oblongus* (Keyserling, 1880), is found to consist of at least seven species distributed throughout most of North America, all of Central America, Bermuda, and the Greater and Lesser Antilles. Species are distinguished in the males primarily by the position of the embolus base and the length of the filamentous end of the embolus, with the embolus curling around the tegulum more than 360 degrees. In the females, differences are more subtle, but length and shape of the median epigynal piece, and differences in face morphology detail, can distinguish them. In addition, four of the species have other distinctive

somatic features that make them easily identifiable. The median epigynal piece, sometimes identified as a median septum, is better considered a scape, as its posterior end is separated from and directed away from the main part of the epigyne. Furthermore, the scape has a minute “hood” at its posterior end, very similar in appearance to that of *Misumenops* F.O. Pickard-Cambridge, 1900, which suggests that the two genera are related, contrary to previously published opinions. The epigynal “hood” of thomisids is considered misnamed, as it engages the retrolateral tibial apophysis (RTA), and is renamed the “coupling pocket” to conform with other RTA clade members. A hood is considered to be an epigynal outgrowth that partly encloses a depression that engages a structure on the palpal bulb rather than the palpal tibia.

Keywords: Thomisidae, *Misumessus*, taxonomy, new species, biogeography

Student - Oral presentation

From the mountains to the coast and back again: ancient biogeography in a radiation of short-range endemic harvestmen from California

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The harvestmen genus *Calicina* is represented by 25 short-range endemic species occurring in the western Sierra Nevada, Transverse and Coast Ranges of California. Our principal aim was to reconstruct the temporal and spatial biogeographic history of this arachnid lineage. We inferred a time-calibrated species tree for 21 of 25 described *Calicina* species using multiple genes and multilocus coalescent-based methods. This species tree was used as a framework for algorithmic biogeographic and divergence time analyses, and a phylogenetic canonical correlation analysis (CCA) was used to examine the relationship between morphological evolution and environmental variables. Species tree and biogeographic analyses indicate that high-elevation Sierran taxa are early-diverging in *Calicina*, with subsequent biogeographic “criss-crossing” of lineages from the Sierra Nevada to the Coast Ranges,

back to the Sierra Nevada, then back to Coast Ranges. In both the Sierra Nevada and Coast Ranges, distantly-related parapatric lineages essentially never occur in sympatry. CCA reveals that in both the Coast Ranges and the Sierra Nevada, distant phylogenetic relatives evolve convergent morphologies. Our evidence shows that *Calicina* is clearly dispersal-limited, with an ancient biogeographic history that provides unique insight into the complex geologic evolution of California since the mid-Paleogene.

Keywords: BioGeoBEARS, California, historical biogeography, multispecies coalescent, short-range endemism, vicariance

Student - Oral presentation

Behavioral response to environmental and dietary heavy metals by *Pardosa milvina*

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Heavy metal contamination driven by anthropogenic activity is a widespread environmental issue due to the myriad harms heavy metals cause. Due to the persistence of heavy metals in the environment, growing human population, and increasing industrialization of third world countries, concerns about heavy metals are projected to increase for the foreseeable future. Heavy metal contamination in the soil can have a large influence on epigeal invertebrate communities but little is known how it may influence the behavior of these animals that spend their lives closely associated with the soil. Indeed these invertebrates are exposed to heavy metals through contact and by contamination of their food source. While heavy metal uptake has been characterized in many herbivores and detritivores, there has been less work done on investigating how invertebrate predators respond to heavy metal contamination. In this study, we tested the hypothesis that exposure

to soil contaminated with heavy metals would affect the survival and foraging behavior of the wolf spider *Pardosa milvina*. Our experiment decoupled environmental exposure and dietary uptake. In a full factorial design we housed animals on contaminated or uncontaminated soil and fed them collembolans that had been reared on each soil type. Exposure to contaminated soils reduced survival especially for males. Both soil type and prey type affected prey consumption, but effects varied over time and between sexes. This study indicates a complex interaction between environmental and dietary contamination on behavioral responses for the wolf spider *P. milvina* and underscores the need for more studies of the manner in which anthropogenic factors influence natural food webs.

Keywords: behavioral ecology, heavy metals, toxicity, Collembola

Student - oral presentation

Kinematic consequences in locomotor performance after autotomy in *Prionostemma* harvestmen

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Animals face predictable challenges throughout their lifetimes. For instance, predation attempts are ubiquitous, and likely drive the evolution of adaptations to avoid predators. Some animals voluntarily release legs (autotomy) during predation attempts. While autotomy may secure immediate survival, animals can face long term consequences of limb loss, particularly in locomotor performance. Given this, strategies to compensate for damage are expected, for example making biomechanical adjustments in a running gait. We studied this in harvestmen (Opiliones) because autotomy is frequent and regeneration does not occur. We examined an undescribed species of *Prionostemma* (Sclerosomatidae) in the Costa Rican rainforest to test the hypothesis that compensation after losing legs occurs with changes in biomechanical kinematics of running over time. By controlling the time since autotomy and the number, type and asymmetry of legs lost, we quantified

changes in locomotor performance while running on a horizontal track over time using high speed video. We found an immediate decrease in the kinematics of running (velocity, acceleration, sinuosity of the trajectory, and stride length), as well as an increase in duty factor after autotomy. However, harvestmen did not recover initial performance after a 14-day period. Interestingly, one third of autotomized individuals performed different types of gaits (“pronking”, “bobbing”, or running), which seldom occurred in intact individuals. Our findings suggest that, along with kinematic, autotomy might impose prevailing challenges in the energetic balance and survival of harvestmen. Compensation seems not to be occurring at least in their general pattern of locomotion. Overall, this project outlines the potentially non-reversible locomotor consequences in harvestmen imposed by environmental damage. Future work could focus on behavioral plasticity or shifts in habitat use that harvestmen might use to alleviate the exposure to predators.

Keywords: autotomy, biomechanics, daddy long-legs harvestmen, running

Student - Poster presentation

Sensory shifts following autotomy in the golden orb-weaver spiders (*Nephila clavipes*)

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Arachnids possess many of their sensory organs on their appendages. However, the voluntary release of an appendage (“autotomy”) is a frequently used anti-predator strategy. Consequently, loss of an appendage could result in reduced locomotion, sensory abilities, especially relevant for prey (or predator) detection, location, and capture ability. Any reduction in prey capture or predator

avoidance, will result in energy loss, and a probable reduction in fecundity or possible injuries and death. Here we investigate the incidence of autotomy in *Nephila clavipes* in the tropical rainforest of Costa Rica. Additionally, in a repeated measures design, we test for behavioral plasticity of simulated prey capture events before and after induced autotomy (of one leg I) using a combination of MANOVA and behavioral sequence data. We found that 18 of 59 spiders observed at La Selva Biological Station had one or more legs missing (~31%) in the field, with leg II being the most frequently lost. We also found that *N. clavipes* altered their resting body position following autotomy, changing the angle of legs I (on the intact side), and legs II, and III on the autotomized side relative to the prosomal midline. In addition, autotomy appeared to significantly hinder the spider's ability to detect prey, with the odds of reaction being 7.8x less following leg loss. Taken together, *N. clavipes* demonstrated marked behavioral plasticity following autotomy in order to compensate for the loss of sensory perception organs during prey capture.

Keywords: autotomy, *Nephila*, behavioral plasticity

Oral presentation

Biogeography of Caribbean arthropods

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For the past 50 years the Caribbean has been a bastion for research on island biogeography. None the less, unifying patterns of biogeography for the region have remained elusive. A complex geologic history and the close proximity to major continental landmasses have resulted in a rich biodiversity, but one that is relatively understudied for terrestrial arthropods. This study synthesizes, for the first time, every published dataset on terrestrial Caribbean arthropods providing clarity into the mode and tempo of Caribbean diversification, clarifying the driving historical forces that have resulted in the incredibly diverse fauna present in the region today. Molecular datasets from insects and arachnids were used to generate time calibrated phylogenetic hypotheses of relationships. Various hypotheses of

dispersal and vicariance were then tested under an assortment of constraints based on various geologic scenarios. In elucidating the historic patterns and processes that have led to the present day diversity of the Caribbean biodiversity hotspot, we hope to inform future conservation efforts.

Keywords: Caribbean, biogeography, phylogeography, islands, vicariance, dispersal

Student - Poster presentation

Resolving deep relationships within jumping spiders

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Recent advances in cost-effectiveness of genome-wide sequencing has made feasible addressing long-standing questions of deep relationships among major spider groups. Within the 5800-plus species of jumping spiders (Araneae: Salticidae), we have yet to resolve relationships among basal lineages, we lack confident support of some large clades within the salticines, and we are still unable to discern placement of groups such as the agoriines and eupoines. Therefore, we used anchored enrichment (AE) sequencing to obtain hundreds of unlinked “anchor” regions throughout the genomes of 32 salticid species and one philodromid outgroup, yielding a dataset of over 90 kb and 400 loci. Our resulting maximum-likelihood phylogeny confidently supports the Hisponinae as sister to the Salticinae, reinforces the monophyly of the *Saltafresia*, succeeds in placing the agoriines within the *Saltafresia*, and resolves many relationships among the amycoids. We are

supplementing this AE dataset with previously published transcriptome data from representatives of the Dionycha and other RTA-clade members, to further resolve basal salticid relationships and explore which dionychan families are plausible sister groups to the salticids. We hope to not only improve the resolution of deep relationships among these taxa, but also gain a general understanding of how these different methods of genome-wide sequencing can be integrated in phylogenetic analyses.

Oral presentation

Unraveling the Chelicerata tree of life: phylogenomic resolution of chelicerate inter-relationships based on deep taxon sampling

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Chelicerates constitute the second largest branch of the arthropod tree of life and include several iconic lineages, such as spiders, scorpions, harvestmen or horseshoe crabs. For decades, scientific endeavors aiming to resolve the internal phylogeny of chelicerates have resulted in discrepant hypotheses, with different authors proposing discordant topologies based both on molecules and morphology. While considerable effort has been paid to resolve the relationships within several chelicerate orders, the backbone of the chelicerate tree of life remains unsettled, with several studies showing strong systemic conflicts in phylogenetic signal even after exhaustive analysis of several thousand orthologous genes. The open questions about how the main groups of chelicerates are related limit how we interpret the timing of the diversification of this major component of the arthropod biota. Building upon previous efforts based on transcriptome sequencing, we contribute to this discussion by presenting a large injection of novel Illumina transcriptome data for virtually all chelicerate lineages, including previously unsampled orders such as Palpigradi

and Opilioacarida, and a substantially expanded taxonomic coverage, especially for orders such as Pseudoscorpiones, Schizomida and Amblypygi. For this, we analyzed close to seventy transcriptomes of chelicerates and constructed an array of data sets to independently optimize gene number, gene occupancy, phylogenetic informativeness, or gene conservation and analyzed them using different phylogenetic methods and evolutionary models. In this contribution, we will discuss our findings in the context of previous phylogenetic hypotheses and explore the diversification timing of one of the oldest arthropod groups with a fossil record extending back to the Cambrian.

Keywords: Chelicerata, transcriptomics, systematics, phylogenomics

Student - oral presentation

Volatile chemical communication in female *Latrodectus* sp.

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Volatile chemical communication allows information transfer over long distances, and is important at many stages of spiders' life cycles. Volatile chemicals are important for attracting mating partners, and this has been well-studied. Although this communication pathway is likely also important for choosing nesting sites, we know very little about the use of this type of information in decision-making about web building sites. In this study, we tested the reaction of adult females to volatile cues of other females in two widow spiders (*Latrodectus hasselti* and *L. hesperus*). Other studies have shown that males can detect the feeding status, behavioral type and maturity of potential mates based on volatiles, so we assumed this same information would be available to adult females. We performed dual choice olfactory experiments in y-tubes in which we exposed adult virgin *L. hesperus* or *L. hasselti* females to controls (empty tubes) and a variety of volatile stimuli whose source (females) varied in terms of feeding

status (well-fed or poorly fed); behavioural type (bold or shy) and maturity level (juvenile or adult). In this paradigm, we eliminated visual or tactile cues, and so isolate the effect of volatiles. To characterize differences between chemical cues from different stimulus females, we also collected headspace samples (air surrounding the stimulus) of each spider stimulus group (N=15) and compared them with gas chromatography coupled with mass spectroscopy (GCMS). We found that *L. hesperus* avoid subadult and adult congeners, while *L. basselli* reacted only to adult ones. Both species also responded differentially to well-fed compared to food-restricted females, but there was no evidence the females react to the behavioral type of other females. Future work will examine female web establishment patterns and examine how these discrimination trials relate to free-ranging behaviour.

Keywords: chemical communication, female-female-interaction, behavioral biology

Student - poster presentation

Fact or myth: do natural substances repel invasive spiders?

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Arachnophobia is one of the most common irrational fears of the general public and some people invest considerable money and effort to avoid spiders. We searched the internet and identified the three most popular natural substances recommended as spider repellents (chestnuts, peppermint oil and lemon zest oil). We tested whether these substances were avoided by adult females of two invasive spider species: *Araneus diadematus* (European, invasive in North America) and *Latrodectus geometricus* (cosmopolitan distribution). We used a dual-choice paradigm in which free-walking females were released in one arm of a glass y-tube apparatus connected to an air pump. We tested the response of free-walking females to airborne chemicals released from whole chestnut, peppermint oil or lemon

oil, with each stimulus compared to an empty control. We found that neither species discriminated lemon oil from controls, but both *A. diadematus* and *L. geometricus* avoid chestnut and peppermint oil. Thus, we have verified two of the three most popular spider repellent myths. We complement this with an analysis of the 'headspace' of each substance using gas chromatographic detection coupled with mass spectroscopy to identify the airborne chemicals that might trigger this response and could be the basis of a synthetic repellent. Although *A. diadematus* is little more than a nuisance in locations where it is invasive, *L. geometricus* is neurotoxic and anthropophilic, so an effective repellent would be beneficial. Future work will focus on why the identified chemicals are repellent to female spiders, and the phylogenetic distribution of this response.

Keywords: pest control, repellence, behavioral ecology

Poster presentation

Sicariidae family (Araneae) in Colombia, new species and first records of *Sicarius*

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The genus *Loxosceles* Heineken & Lowe, 1832, commonly known as "brown" or "violin" spiders, currently includes 107 species distributed in the subtropical areas and tropics of Europe, Africa, Asia, Australia and America. Species of this genus may live in both natural habitats (under rocks, trunks, inside tree holes and caves) and inside houses. Only two species of *Loxosceles* have been registered for Colombia: *Loxosceles lutea* Keyserling, 1877 and *Loxosceles rufipes* (Lucas 1834). In addition, the genus *Sicarius* Walckenaer, 1847 (six-eyed sand spiders) currently includes 25 species found in the xeric environments of southern Africa and South and Central America, mostly in deserts and seasonally dry tropical forests. In the most recent study of *Sicarius* in South America, Magalhães

et al. 2013 described *Sicarius cariri*, *S. diadorim*, *S. ornatus*, and designated a neotype of *Sicarius tropicus* (Mello-Leitão, 1936). We present a new Colombian *Loxosceles* species that we include in the laeta species group due to the male's sub-oval palpal bulb, elongated embolus longer than the bulb's diameter, swollen palpal tibia at least two times longer than the tarsus. The female's blunt seminal receptacle lacks any globular lobes at the tip. We provide new records for *L. lutea* and *L. rufipes*, and we describe the first species of *Sicarius* known from Colombia. Keywords: Neotropics, *Sicarius*, *Loxosceles*, tropical dry forest, cave

Oral presentation

How can desert spiders dig their burrows in dry sand dunes?

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Two desert-living spiders, a sparassid (*Cebrennus*) and a lycosid (*Evippa*), were studied with respect to their burrow construction. Both spiders face the problem of how to transport dry sand and how to achieve a stable vertical tube. *Cebrennus* has many specialized bristles on palps and chelicerae which together form a carrying basket. Small balls of sand grains are accumulated below and then carried to the burrow entrance, where they are quickly dispersed. The lycosid (*Evippa*) has no such bristles and shows a different method for carrying sand: using a few sticky threads from the spinnerets it glues the loose sand grains together, then grasps them with palps and legs and carries them to the outside. Both spiders stabilize the developing tube on the inside by repeatedly adding silk rings, while digging down. Although both spiders live in the same environment (desert Erg Chebbi, Morocco), they use quite different methods to carry sand. We conclude that this is due to convergent evolution. Interestingly, certain desert ants also carry sand grains with specialized bristles on their mouthparts, in a structure known as a psammophore. However, these ants dig in moist sand, which easily forms discrete balls; these are

then deposited around the burrow entrance.

Keywords: functional morphology, desert spider, burrow construction, microscopy, sand transport

Oral presentation

Male mating success, locomotory performance, and metabolic rate in *Argiope aurantia*

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The relevance of male morphological attributes, such as body size and relative limb length, for efficiently locating sexually receptive females and for prevailing in competition with other males over access to females has been the focus of much recent research, especially in species with pronounced female-biased sexual size dimorphism (SSD). Nevertheless, results have been inconsistent and a number of studies have failed to find relationships between morphology and fitness proxies, such as climbing speed. Here we focus on a so-far neglected phenotypic attribute, resting metabolic rate (RMR), and investigate its importance for males in the contexts of mating and locomotion in the orb-weaver *Argiope auranti*, a species which exhibits extreme SSD. We performed three experiments: 1) In staged mating trials, two size-matched males competed to mate with a female. Males with higher RMR performed longer courtships, which translated into higher mating success. 2) In climbing trials, males with higher RMR achieved higher maximum running speeds on a vertically mounted rod, and RMR was more important than morphology for explaining running speed. 3) In endurance trials, RMR had no effect on the distance which males could run continuously, while average speed was

negatively related to distance run. We conclude that the metabolic “machinery” is important for the overall performance of males, independent of morphology, and discuss these results in the context of body size evolution in highly dimorphic spider species.

Keywords: sexual selection, sexual size dimorphism, performance traits

Oral presentation

The effect of elevation and time on mountain spider diversity: a view of two aspects in the Cederberg Mountains of South Africa

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Our aim was to test if long-term patterns in α and β diversity along an elevational transect on two aspects of a mountain are consistent through time using spiders as model organisms, quantify the role of elevation, time (seasonal and inter-annual) in explaining these patterns and partition the relative contribution of nestedness, species turnover and species loss in richness in explaining these diversity patterns. The transect is across the Cederberg mountains in the Cape Floristic Kingdom, South Africa and constitutes 17 sites with an elevational range of 1900 m on two aspects of the mountain (east and west) spider assemblages were sampled biannually (wet and dry seasons) over six years. Four replicates per site, each consisting of a 5×2 pitfall grid, were sampled for five days sessions. GLMM α - and β diversity (Jaccard dissimilarity β_{jac} and its partitioned components (β_{jtu} and β_{jne})) was used to model the effects of elevation and season on these two indices respectively. Spider alpha diversity had a hump-shaped pattern on the western aspect and U-shaped on the eastern aspect. However, season

interacted with elevation to produce more complex patterns during the dry season. There was no significant nestedness. Replacement accounted for 60–70 % of beta diversity between sites, and elevational distance decay in beta diversity was the result of increased turnover on the western aspect and increased species loss on the eastern aspect. Standardized patterns suggest that there are no effect of season on beta diversity except for a decreased rate of distance decay during the dry season on the western aspect. Large-scale predictors of spider alpha diversity explained a small amount of variation in spider diversity, pointing to the importance of local and stochastic processes. Regional turnover of spider diversity is mainly the result of niche processes, pointing to localized adaptation of taxa, this is supported by the lack of nestedness in assemblages.

Keywords: α -diversity, Araneae, β -diversity, Cape Floristic Region, epigeal, long-term

Student - oral presentation

Biodiversity survey of solifuge species within Big Bend National Park, Texas (Arachnida, Solifugae)

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Solifuges (Arachnida, Solifugae) are a wide ranging arachnid found in xeric and arid areas across the globe. Despite nearly 1,100 species of Solifugae having thus far been described within the 12 recognized families, there exists a lack of basic ecological and natural history data; in addition to much left to be learned about behavior, as well morphology and physiology. A wide ranged biodiversity survey of solifuges within the protected area of Big Bend National Park (BBNP), Texas was conducted over two field seasons. The goal of the study was to collect initial biodiversity and biogeographical data with which to build upon for solifuge research within the full range of the Chihuahuan Desert ecosystem. Wet pitfall traps- filled with propylene glycol-based anti-freeze were set up in arrays as the primary collection method. Seventeen species were found from the two North American families Eremobatidae and Ammotrechidae, with

over 1,000 identifiable solifuge specimens collected. Series of juvenile specimens collected can offer the potential of further insight into some species' life history. As well, difficulty found in identification work of some species speaks to a potential need of future taxonomic revisions being necessary. Keywords: solifugae; solifuge; camel spider; biodiversity; survey; Big Bend National Park; Texas

Oral presentation

The bizarre world of reproduction in leibunine harvestmen: the evolution of mating behavior

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Mating behavior and associated traits are very quickly-evolving aspects of phenotype in animals, and often highly divergent among closely-related species. I study North American leibunine harvestmen, commonly known as “daddy longlegs” (Opiliones: Sclerosomatidae). This group exhibits amazingly diverse, often bizarre, and largely undescribed mating behavior. During mating, males secure females in face-to-face ‘embraces’ by hooking their pedipalps behind the sensory legs of the female. I provide the first detailed descriptions and quantitative comparison of these mating interactions across several species of leibunine harvestmen. All species studied exhibited distinct pre-, peri-, and post-copulatory stages of mating interactions. However, species differed dramatically in how long each stage and the overall mating interaction lasted, levels of aggression, duration of copulation, and likelihood of multiple mating and re-mating. Many species also exhibited species-specific behavior, most notably including: sensory leg biting, violent shaking, and stroking the female. Finally, the morphological traits that determine mating success varied markedly among species. The high diversity in mating behavior and variation in the traits determining mating success suggests complex changes in selection have contributed to diversification of mating behavior.

Keywords: mating behavior, species comparison, Opiliones, Sclerosomatidae

Oral presentation

Exploring the chemo-textural familiarity hypothesis for scorpion navigation

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The navigation by scene familiarity hypothesis provides broad explanatory power for how bees and ants navigate from hive to distant food sources and back with brains the size of a pepper speck. The premise is that the visual world is decomposed into pixelated matrices of information that are stored and readdressed as the insects retrace learned routes. Innate behaviors in these insects (including learning walks/flights and path integration) provide the important goal-directed views to allow the initial retracing (i.e., the insect must learn the scene while moving toward the goal since everything looks different while moving away). Scorpion navigation may use a similar premise, with the chemical and textural features of the environment substituting for visual input. The pectines of scorpions support dense matrices of about 10,000 chemo- and mechano-sensitive units called peg sensilla, each containing at least 10 energetically expensive sensory neurons. We have long wondered why pectines have so many pegs and associated neurons. We chose desert grassland scorpions (*Paruroctonus utahensis*) to test the chemo-textural familiarity hypothesis because they emerge onto the sand from their home burrows at night to pursue insect prey and somehow find their way back to their burrows. We have preliminary evidence of learning walks and path integration in these animals. In addition, given the measured resolution of peg sensilla, sufficient information exists in sand's texture to enable scorpions to retrace previously experienced paths with little to no chance of confusion. We are developing behavioral and electrophysiological tests to explore the possibility that these animals are using a chemo-textural familiarity approach to relocate their home burrows and that pectinal complexity reflects the information content of the animals' environment.

Keywords: behavior, electrophysiology, homing, sensory

Student - Oral presentation

Decoration-building behavior in an orb-weaving spider, *Cyclosa octotuberculata*

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Many orb-weaving spiders add silk bands, silk tufts, egg sacs, prey remains or plant detritus so called 'web decorations' to their webs. Much attention has been paid to the functional significance of decorations and to silk decorations built mostly by a single genus, *Argiope*. By contrast, few studies have been conducted to investigate other types of web decorations spun by other groups of orb-weaving spiders and the materials and behavior used for decorating webs. Here, using *Cyclosa octotuberculata*, an orb-weaving spider that often decorates its web with prey remains, plant detritus or egg sacs called detritus decorations, as a model system, we investigated what cues *Cyclosa* spiders use to choose decoration materials with different color, texture, odor, size or weight. We also examined perception of different decoration materials (different colors, texture and size or weights) in eyes of predators. We found that the cues used by *Cyclosa* for choosing decorating materials were their capability and limits of webs other than visual cues, sensation experienced through touch and odor when vision is limited. Results also showed that predators preferred webs decorated with white and mix color detritus to webs decorated by the other detritus made up of different colors. We concluded that materials chosen by *Cyclosa* spiders to decorate their webs may attract or deter predators.

Keywords: web decorations, detritus, spider, *Cyclosa octotuberculata*, orb web

Student - oral presentation

Ultrastructure of chemosensory sensilla in *Argiope bruennichi* (Araneae, Araneidae)

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Chemical communication through volatile or contact pheromones is an important means of spiders, e.g., to attract and find mating partners and to assess their reproductive status. Assumed receptors for olfaction are s-shaped and blunt tipped sensilla with characteristically striated surfaces and terminal pores. As yet, only one electrophysiological analysis demonstrated that these sensilla perceive contact pheromones. The perception of volatile pheromones has not been tested yet and it remains to be analyzed if sensilla on different body parts differ in structure and function. To this aim we mapped the distribution of the chemosensory sensilla on legs and pedipalps of *Argiope bruennichi* males and females. It is known that male *A. bruennichi* are attracted by a volatile sex pheromone only emitted by virgin females. We explored the fine structure of tip-pore sensilla on tarsi of legs of *A. bruennichi* males by means of Transmission Electron Microscopy. Our results show that the sensilla possess a thick hair shaft and a double-lumen divided in three canals. More than ten dendrites are surrounded by a dendritic sheath. The cuticular hair shaft shows breakthroughs on the innermost cuticular sheath which may indicate that molecules can be transported from the outside to the innermost canal and not only through the tip-pore. The next step is to compare ultrastructural traits of these sensilla from different body regions.

Keywords: chemical communication, TEM, ultrastructure, tip-pore sensilla, Araneidae

Student - Poster presentation

Structure and distribution of different sensilla types in *Argiope bruennichi* (Araneae, Araneidae)

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Spiders use various sensory modes to interact with other individuals on an inter- and intraspecific level, and with their environment or to get kinesthetic information. Accordingly, the sensilla that perceive these signals can be mechano-, hygro-, thermo- or chemosensilla. Some sensilla types, i.e., trichobothria, tarsal organs or slit sense organs, are well known in spiders regarding to their morphology and fine structure, physiology and function. Their quantity and distribution is assumed to be species specific and can be used as taxonomic character. We investigated the structure, quantity and distribution of tip-pore sensilla, trichobothria, slit sense organs and tarsal organs on all walking legs and pedipalps of *Argiope bruennichi* females by means of Scanning Electron Microscopy. We chose *A. bruennichi* since this species has been intensively studied as to its mating strategies including the pheromone involved in mate attraction. We show that *A. bruennichi* females possess all mentioned sensilla types on all legs and pedipalps. Tip-pore sensilla that are suspected to be chemosensory organs never occur on the coxae and trochanter of the walking legs, but they are common on the metatarsi and tarsi. The mechanosensitive trichobothria are distributed on the distal part of the tibiae and on the metatarsi. Lyriform organs are always located next to the joints on the basal part of a segment, mainly on ventral and lateral sides, whereas single slit sensilla are distributed on all segments mainly in rows. All tarsi possess a tarsal organ on the dorsal side. Apart from providing a survey of sensory structures, our data pave the ground for electrophysiological studies and ultrastructural analysis of sensory organs and may lead to a better understanding of the sensory ecology of spiders.

Keywords: sensory structures, tip-pore sensillum, trichobothrium, slit sense organ, tarsal organ, Araneidae, SEM

Student - oral presentation

Widespread putative hygro-thermoreceptors in harvestmen (Arachnida, Opiliones): an everted tarsal organ?

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Most harvestman species are dependent on high humidity levels and amenable temperatures for homeostasis. While they are known to actively choose environments with these conditions, no hygro/thermoreceptor has yet been identified in the group. Using scanning electron microscopy (SEM) and transmission electron microscopy, we investigated the fine morphology of two hair sensillar types of the armored harvestman *Heteromitobates discolor* (Laniatores, Gonyleptidae): sensillum basiconicum (Sb) and apical-hood sensillum (Ahs). With SEM, we investigated their phylogenetic distribution in all four suborders: sampling 43 Laniatores (in 30 families), three Dyspnoi, two Eupnoi and five Cyphophthalmi. Both structures occur in small numbers on the body (Sb: 36 units; Ahs: four units) and are distributed on the distal parts of the legs. The Sb is innervated by 3-4 dendrites and has a sagittal slit that results in a shaft with two flaps, which probably allows evaporation of receptor lymph. The Ahs is innervated by two bundles of three dendrites and has two pore-like structures on its tip. Ahs and a pair of Sb form a triad on the distal-most parts of tarsomeres I and II, being highly conserved in Laniatores, present in Dyspnoi and Eupnoi and absent in Cyphophthalmi. Cuticular structure, putative evaporation of receptor lymph and innervation support a

hygro/thermoreceptive function for Sb, but the function of Ahs remains unclear. We discuss the specific morphological characteristics in support of these functional inferences, the adequacy of the evaporation system of Sb to specific hygroreception mechanisms and a putative homology of the triad to the pit-like tarsal organ of other arachnids.

Keywords: sensilla basiconic, hygroreception, transmission electron microscopy, sensory biology

Student - Poster presentation

Not so touchy after all: ultrastructure of chemoreceptive tarsal sensilla in an armored harvestman (Arachnida: Opiliones) and evidence of olfaction in 17 families of Laniatores

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Harvestmen (Arachnida, Opiliones) are especially dependent on chemical sensing, often being regarded as touchy animals. Information on harvestmen sensilla is scarce when compared with other arachnid orders, and even more so when concerning internal morphology. Using scanning

(SEM) and transmission (TEM) electron microscopy, we investigated tarsal sensilla on the distal tarsomeres (DT) of all pairs of legs of *Heteromitobates discolor* (Laniatores, Gonyleptidae) and surveyed (SEM) the sensilla on DT I and II of species from all main lineages in the suborder Laniatores (17 families). The DT I and II of *H. discolor* are equipped with wall-pored falciform hairs (two types), wall-pored sensilla chaetica (two types) and tip-pored sensilla chaetica, while DT III and IV are mainly covered in trichomes (non-sensory) and tip-pored sensilla chaetica. Ultrastructure supports an olfactory function for all wall-pored sensilla and a dual gustatory/touch function for tip-pored sensilla chaetica. Wall-pored sensilla occur in all Laniatores investigated, demonstrating the widespread occurrence in the suborder and highlighting the importance of both legs I and II as the sensory appendages of laniatorean harvestmen. Our results provide the first morphological evidence of olfactory receptors in Laniatores (2/3 of Opiliones species) and suggest that olfaction is more important for harvestmen than previously thought.

Keywords: olfaction; Goniosomatinae, wall pores; sensory morphology, chemoreceptors

Oral presentation

Genomic perspectives on the evolution of black widow and house spider venoms

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Venom production is a defining feature of spiders that enables their predatory lifestyle. As venoms are secretions largely composed of toxic proteins and peptides, these molecules provide a relatively direct link between ecologically important genes and their functional roles, and makes evolutionary studies of venom production especially suitable for genomic investigation. This presentation will provide an update on recent advances in spider genomics for understanding the evolution of theridiid venoms. Specifically,

we have investigated the diversity, expression and evolution of genes encoding venom proteins from the common house spider (*Parasteatoda tepidariorum*) genome that was made available through the i5k (5000 arthropod genomes) initiative. We analyzed the house spider genome in conjunction with high throughput gene expression data from RNA-Seq libraries made from venom glands as well as other tissues and proteomic data to determine this species' venom composition. These results were considered with recent transcriptomic and proteomic analyses of venom composition in the Western black widow spider (*Latrodectus hesperus*), which has revealed common features and major differences between these species in terms of venom protein diversity and abundance. We also investigated the phylogenetic distribution and expression of latrotoxins and latroductins, two protein families that are particularly abundant in *Latrodectus* venoms, as well as their homologs within and across genomes. This revealed contrasting mechanisms of venom gene family evolution and suggests that changes in gene expression may in part explain the extreme toxicity of black widow venom to vertebrates. Given the distant relationship of *P. tepidariorum* and *L. hesperus* within the large family Theridiidae, this work significantly advances knowledge of spider venom diversity and provides an evolutionary framework for identifying the key molecular features that make black widow venom medically hazardous.

Keywords: venom, evolution, genomics, transcriptomics, *Latrodectus*

Student - Poster presentation

Systematics and Evolution of Plectreuridae Simon, 1893

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The spider family Plectreuridae Simon, 1893 is one of the oldest of spider lineages, suggested to have radiated as early as the Middle Jurassic (~165 MYA). These eight-eyed haplogyne spiders represent a small relictual group that

typically live semi-sedentary lives with an affiliation for xeric habitats across the New World. The family is considerably well represented in the fossil record with four fossils to date and comprises 30 extant species (and one subspecies) that are split into two genera: *Plectreurys* Simon, 1893 and *Kibramoa* Chamberlin, 1924. Since Gertsch's revision of the family (1958), plectreurids have not been meticulously studied (despite a handful of species descriptions) and much regarding plectreurid evolution remains an enigma. Since plectreurids are an old group, with ample time to accumulate diversity, it is likely that the family's diversity is grossly underestimated. In order to address questions of diversity, the purpose of this study is to assess the extent of diversity in three widespread species (*K. guapa*, *K. suprenans*, and *K. madrona*) of *Kibramoa* that are described from the California Floristic Province (CFP)—a biodiversity hotspot.

Keywords: systematics, California Floristic Province, haplogynes, living fossil

Student - oral presentation

Investigating species boundaries in a trapdoor spider complex using anchored hybrid enrichment

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High-throughput sequencing methods increasingly provide high quality, low cost markers for investigating speciation patterns in non-model systems. We use anchored hybrid enrichment (AE), a high throughput genomic sequence capture method, to recover over 400 phylogenetically informative loci for a trapdoor spider species complex (*Aptostichus atomarius* complex, CA). Independent species discovery methods—multi-locus, population level phylogenetic analyses and SNP clustering methods—were combined with validation approaches (BPP, BFD) to evaluate alternative species delimitation hypotheses in this morphologically homogeneous group of

spiders. Cryptic speciation and genomic divergence levels were explored in an integrative framework, using existing genomic resources and newly sequenced AE markers.

Keywords: next-generation sequencing, anchored enrichment, species delimitation, population genomics

Oral presentation

Visual scanning by the principal eyes of freely moving jumping spiders

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The lenses of arthropod eyes are fixed to the exoskeleton. Thus, to change their direction of gaze to view objects of interest with the high acuity region of the retina, the animal must re-orient its eye stalk, head, or entire body. The principal eyes (AM) of jumping spiders (Salticidae) perform high acuity inspection and spectral analysis of objects. Unlike the condition in spiders of almost all other families, salticid AM retinas are attached to three pairs of muscles that can move the retina horizontally, vertically, and torsionally to change the gaze direction through the fixed lens. We have filmed (60fps) and quantified these retinal movements in the horizontal plane as transparent spiders (*Thiodina* sp.) walked freely in a blank arena, tracked a small (4.5o) horizontally moving (24o/s), high contrast target with retinal and body movements, and inspected a scaffolding to select an escape route from the arena. Retinal scanning movements occur independently or synchronously in the two eyes. Retinal movements may occur while the spider walks, but occur more frequently when stopped. The angular range of gaze movement is greater in the ipsilateral direction than into the contralateral visual field. Consequently, when a moving target approaches in the spider's peripheral visual field, the ipsilateral retina begins tracking the target first. As it passes into the contralateral field of view the other retina begins to follow the target more closely. When this retina reaches the end of its movement range, a body turn may occur.

Keywords: vision, predatory behavior, lab experiment

Poster presentation

Spatial cognition in jumping spiders: Assessment of path length to prey and vantage point

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Jumping spiders (Salticidae) of several species, including *Portia* spp. (Spartaeinae) and *Phidippus* spp. (Dendryphantinae), have been demonstrated to be able to plan routes to prey that they cannot jump directly on or walk straight toward. Salticid visual acuity is very good and such situations must often occur in nature as the spiders forage among shrubbery, recognize acceptable prey and then calculate a route through the vegetation to reduce the separation and bring the spider to a vantage point from which it can jump on to its prey. In laboratory experiments with spiders of several species in the genus *Phidippus*, we examined two aspects of the potential spatial cognitive planning that a jumping spider might employ when approaching prey. We used a binary choice protocol to test whether spiders prefer to take the shorter versus longer path to prey when both lead to prey. We tested a range of path disparities from 15%, which was a linear difference of 3.4cm, to 75%, which was a linear difference of 16.7cm. At smaller disparities spiders did not significantly choose the shorter or longer path, but as disparities increased the probability of a spider choosing the shorter path increased. In a second experiment, we offered the spiders a choice of two equidistant paths both leading to the prey, but one terminated above the prey and the other terminated at a similar separation below the prey. The majority of spiders chose the elevated path that would allow them to jump down on the prey.

Keywords: vision, predatory behavior, route planning, lab experiment

Student - oral presentation

Immune stress and sexual signaling in the wolf spider (*Schizocosa ocreata*)

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Having an effective immune system can be very costly, sometimes at the expense of other important life history traits, including reproduction. This tradeoff can be exaggerated in males of species that have costly sexual signaling, where condition-dependent components of the signaling system reflect the health status of the bearer. It is therefore vital for a male to be able to adequately balance the costs of activating the immune system successfully while also expressing high quality sexual signals. We examined whether static condition-dependent components of sexual signaling in adult males of the brush-legged wolf spider *Schizocosa ocreata* are indicative of health status (immune stress response), and whether female preference for these traits could be influenced by male or female infection. After infecting adult males with a bacterial pathogen, females were found to avoid chemical cues from an infected male. However, the vibratory and visual signaling modalities were not influenced by infection. As a result, females did not discriminate against infected males in a live mating context, and as a result, were infected through the sexual transfer of the pathogen from males during copulation. These results indicate that not all signaling modalities in this multimodal sexual signaling system are honest indicators of active infection, and while females appear to be able to tell whether a male is infected based on chemical cues, they do not always avoid mating with infected males.

Keywords: immune function, sexual selection, courtship, *Schizocosa ocreata*

Student - Poster presentation

Gene expression analysis provides new insights into the arachnid immune system

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Animals across a wide variety of species, including both vertebrates and invertebrates, have evolved effective innate immune systems to fight off parasites and pathogens. While much is known about vertebrate and insect immune systems, there is far less known about arachnids. Recent genomic evidence has shown that arachnid immune systems lack several integral components of insect immune systems, which suggests that there may be some novel mechanisms of innate immunity that can be learned from a functional study of the genes involved in arachnid immunity. We used the wolf spider *Schizocosa ocreata* to examine the immune response at the transcriptomic level, in order to evaluate changes in gene expression that occur during infection at different developmental stages. Previous studies in this species have shown that there is a measurable immune response after experimental infection with a bacterial pathogen, and that the infection can be cleared rapidly. After sequencing and assembling over 300 million reads, we found 49,316 unique protein-coding contigs, with over 1,000 genes being differentially expressed in infected males compared to controls. As expected, many of these genes are related to transcription, peptide synthesis, and cellular adhesion and recognition. This study will provide not only a reference transcriptome for this well-studied species, but also the first functional evaluation of an arachnid immune system at the transcriptomic level.

Keywords: Transcriptomics, gene expression, immunity, *Schizocosa ocreata*

Oral presentation

Diversity vs. disparity: contrasting patterns of adaptive radiation among Hawaiian spiders

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Ecological and evolutionary processes interact synergistically to determine biodiversity patterns. The

Hawaiian Islands are particularly useful for examining the ecological-evolutionary nexus because they display an age chronology that allows analysis of communities that are just starting to establish, to more mature, allowing insights into how early ecological processes give way to longer term processes of adaptation and species diversification. Focusing on different lineages of spiders, I use the island chronosequence to examine the interplay between ecological affinities and genetic differentiation in fostering diversification. I highlight the importance of fusion and fission in fostering diversification; variability upon which selection can act; and selection and genetic drift in generating diversity. I use genetic and genomic tools to understand microevolutionary change in different lineages of spiders. I couple these data with ecological metrics across the chronosequence to uncover community dynamics. Different spider lineages show different rates and patterns of differentiation. One lineage shows “non-adaptive” radiation, with multiple species in allopatry and diversity increasing with island age. Another lineage shows early diversification into different ecologically defined taxa, and subsequent general progression down the island chain of each species; here, species numbers are high even on the youngest island, and seem to level off quickly on the older islands. Other lineages show repeated evolution of similar ecomorphs within islands; here, species numbers increase early in the radiation, and then decrease. This work highlights the interplay between rates of ecological and genetic differentiation in shaping biodiversity.

Keywords: evolution, ecology, biodiversity, island biogeography, phylogeography, community ecology

Student - Oral presentation

What makes males red-hot: mate choice in the peacock spider, *Maratus volans*

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Jumping spiders have long been renowned for their

specialized visual systems and colorful ornaments. Surprisingly however, virtually no experimental work has examined the importance of color as females select among potential mates. We conducted experiments on the exceptionally colorful peacock spider, *Maratus volans*, to investigate the role of both visual and vibratory courtship signals. By manipulating the visual and vibratory sensory environments, we tested whether long wavelength and/or vibratory signals were critical for male mating success. Our results suggest that red ornaments are relatively more important than vibratory signals for successful mating. We discuss the evolution of red coloration in peacock spiders and complex multimodal signaling across the group.

Keywords: sexual selection, jumping spider, multi-modal, visual communication, color vision

Oral Presentation

The Opiliones Tree of Life: resolution of harvestmen relationships through transcriptomics reflects ancient regionalization of Pangea and multiple instances of temperate Gondwanan vicariance

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Opiliones are iconic arachnids with an ancient origin and a diversity that reflects ancient biogeographical patterns. Due to interest in their diversity, ecology, evolution and biogeography, their relationships have been thoroughly studied using morphology and PCR-based approaches to systematics. More recently, two studies utilized transcriptomics-based phylogenomics to explore their basal relationships and diversification, but sampling was limiting for understanding more recent evolutionary patterns, as

they lacked good taxon representation at the family level. Here we analyzed a set of the 14 existing transcriptomes with 44 additional ones, representing 82% of the extant familial diversity in Opiliones. Our phylogenetic analyses, including a set of data matrices with different gene occupancy and evolutionary rates and using a multitude of methods correcting for a diversity of factors in phylogenomic data matrices, provide a robust and stable Opiliones tree of life, where most families are precisely placed. Our dating analyses and biogeographic analyses using alternative calibration points, methods, and analytical parameters provide well-resolved divergences, consistent with two main scenarios. A pattern of Temperate Gondwanan groups splitting first from the rest of the taxa (Laurasia and Tropical Gondwana), before the breakup of Pangea, suggests ancient regionalization in Pangea. Other groups however show a more recent split between Laurasian and Gondwanan taxa, roughly coincident with the time of Pangean breakup, and thus being consistent with a hypothesis of Pangean vicariance. The integration of recent fossil taxa and our current geological reconstructions with broad taxonomic sampling of extant harvestmen demonstrates the broad utility of Opiliones lineages as models for examining ancient biogeographic processes.

Keywords: Opiliones, systematics, transcriptomics, phylogenomics, biogeography

Student - oral presentation

**A light in the end of the “funnel”:
preliminary results on the phylogeny of
Segestriidae (Araneae, Synspermiata,
Dysderoidea)**

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Currently, Segestriidae Simon, 1893 is composed by four taxonomically valid genera which comprises 120 described species: *Segestria* Latreille, 1804, *Ariadna* Audouin, 1826,

Gippsicola Hogg, 1900 and *Citharoceps* Chamberlin, 1924. Segestriidae is part of the Dysderoidea clade, together with Dysderidae, Orsolobidae and Oonopidae. Later cladistic analysis involving Segestriidae focused only on the Dysderoidea clade and the relationships among its families. We present the first results on the phylogeny of Segestriidae genera, also including representatives of the currently synonymized ones, aiming to test the hypothesis of monophyly of the family and its genera. The data matrix was built based on the codification of 119 morphological characters in 41 terminals belonging to Segestriidae, the other Dysderoidea families, and Caponiidae as the root. The analysis was performed by TNT 1.1 under parsimony and equal weights. We retrieved two most-parsimonious trees with 206 steps (CI = 69; RI = 88), with the strict consensus collapsing only one branch (207 steps; CI = 69; RI = 88). The results show Segestriidae as a monophyletic clade, sister group of (Orsolobidae (Oonopidae + Dysderidae)), differing from previous resolutions of the Dysderoidea clade. Within Segestriidae, we can identify two subfamilies: Segestriinae Simon, 1893, comprising the paraphyletic *Segestria*, *Gippsicola* and Segestriinae AFR sp. 1, and Ariadninae Wunderlich, 2004, composed by *Ariadna* (lato and strictu sensu), *Citharoceps*, and a clade with Ariadninae AFR sp. 1, Ariadninae AFR sp. 2 and Ariadninae AME sp. 1, representing a possible new genus. This study will continue with the future addition of more Segestriidae terminals, aiming to achieve a better resolution, mainly on the Ariadninae clade.

Keywords: cladistics, Haplogynae, morphology, systematics

Student - poster presentation

Male chemosensory scopulae in Segestriidae (Araneae): morphology and biological aspects in *Ariadna* Audouin species

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Chemoreception in spiders is well known to play an important sensitive role, mainly in the detection of prey quality and conspecific recognition for potential mates. The chemosensory setae are responsible for the contact chemoreception and are distinguished from other setae by having a curved morphology, a steeper insertion angle, and an opening near the tip. They are usually found on the tip of the legs, in the dorsal region of the cymbium, and tarsus of female palp. Previous studies described a concentration of chemosensory setae located in the ventral region of *Liphistius* Schiödte, 1849 and *Idiops* Perty, 1833 males, a feature that brings out the inference of possible female pheromone recognition for a potential mate choice. In this study, we present an accurate examination of these modified setae in males of eight *Ariadna* species, *A. corticola*, *A. maxima*, *A. araucana*, *A. boliviana*, *A. isthmica*, *Ariadna* sp. 1 (AUS), *Ariadna* sp. 2 (AFR-CONT), *Ariadna* sp. 3 (AFR-MAD), describing its morphology, and bringing up its possible importance to *Ariadna* biology. We detected five morphologically different types of chemosensory setae forming scopulae, type a–e, only in mature males. The occurrence ranges from species to species: in *A. corticola*, *A. maxima*, and *A. araucana*, it appears on the cymbium and tarsi I–IV, whereas in *A. boliviana*, *A. isthmica*, *Ariadna* sp. 1 (AUS), *Ariadna* sp. 2 (AFR-CONT), *Ariadna* sp. 3 (AFR-MAD) it only appears on the tarsi (and sometimes metatarsi) I–IV. The results presented here are the first record of chemosensory scopula on tarsi and metatarsi of an Haplogynae spider. The occurrence of the chemosensory scopula only on adult males of *Ariadna* can strongly suggest a female sex pheromone reception function, as described for *Liphistius* and *Idiops*, and maybe a possible relation with the tube-dwelling behavior, shared by those genera. Financial support: FAPESP.

Keywords: Haplogynae, sensory organs, pheromones

Student - poster presentation

Misbehaving on atrazine; an herbicide's impact on *Pardosa milvina* (Araneae, Lycosidae)

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Chemical signals play an important role in evoking appropriate behaviors in many arthropod species. While many come from natural sources such as feces and other excreta, anthropogenic chemicals could potentially cause a response or disrupt other cues. Atrazine is not overly toxic to arthropods in general, but there is little information regarding its impact on their behavior. *Pardosa milvina* (Araneae, Lycosidae) is a predatory wolf spider commonly found in agroecosystems where application of atrazine is prevalent. This species is known to use both air- and substrate-borne cues to locate mates and prey, minimize risk of predation, and to differentiate sex and mating history. The aim of this study was to investigate the effects a commercial formulation of an atrazine based herbicide has on the behavior and activity of *Pardosa milvina*. Multiple metrics of spider activity were documented in two types of arenas; they were lined with filter paper treated with either herbicide or water. The activities were combined using Principal Component Analysis. The first two components were significantly impacted by sex. Males traveled further, faster, and spent more time mobile than females. The presence of atrazine significantly influenced the activities that were captured by the second principal component. The exposure to herbicide decreased the distance that spiders traveled and their velocity, while it increased the frequency with which they changed their mobility state. These data suggest that males are more active than females, and that atrazine alters the behavior of these spiders and therefore could have impacts on mating, foraging, and survival.

Keywords: *Pardosa*, atrazine, info-disruption, agroecosystem

Student - oral presentation

Assessment of Ctenizidae monophyly

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Comprising the tarantulas, purse web spiders, trapdoor spiders, and their kin, mygalomorphs have long been a source of intrigue and frustration for many arachnologists. Many groups remain problematic in terms of their systematics. Ctenizidae is one such family. At present, the nine ctenizid genera (*Bothriocyrtum*, *Cteniza*, *Conothele*, *Cyclocosmia*, *Cyrtocarenum*, *Hebestatis*, *Latouchia*, *Stasimopus*, and *Ummidia*) remain in a state of phylogenetic uncertainty with respect to their placement, though it seems clear that the family is not monophyletic and warrants closer inspection using modern molecular phylogenetic approaches. We used anchored hybrid enrichment (AE), which is a high-throughput, probe-based genomics technique that can capture hundreds of phylogenetically informative nuclear loci. Using an AE probe set specifically designed for Araneae and a combination of supermatrix and gene tree/species tree approaches we constructed a molecular phylogeny of the Ctenizidae along with a number of groups which have historically fallen among the ctenizid taxa in previous studies (Idiopidae, Actinopodidae, Euctenicidae, and Migidae).
Keywords: phylogenetics, systematics, ctenizidae, Anchored Enrichment

Student - Poster Presentation

Sampling protocol and processing of orb-web spiders. Insights towards conservation strategies

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Spiders are among the most abundant and diverse group of Arthropoda after insects. Due to their wide distribution, relatively well-known taxonomy and other biological characteristics, spiders may be useful for ecological studies, including biodiversity conservation and management strategies. In this study, we sampled spiders in three different types of vegetation including forest, coffee plantations and pastures, in two differentiated vegetative strata (aerial and lower), in three localities of an important productive and conservation area in Cundinamarca, Colombia. We propose an improved methodology for sample collection in the field and taxonomical identification that includes immature and adult specimens with the aim to guarantee better use of collected material. We present a diversity analysis of two orb-web families, Araneidae and Tetragnathidae, which includes richness estimates, rarefaction curves and species similarity for the three localities. We found differences in richness and diversity among the studied localities and types of vegetation. We registered strong statistical difference in spider density between both strata. We collected a total of 2052 specimens organized in 61 species: Araneidae (46 spp) and Tetragnathidae (15 spp). We found five new record species for Colombia: *Eustala scutigera*, *Leucauge acuminata*, *L. moerens*, *L. longimana* and *L. funebris*. Concurrently, we recorded five endemic species: *Hypognatha coyo*, *Mangora barba*, *Micrathena decorata*, *Chrysometa calima* and *C. carmelo*. To appreciate the potential usage of this type of studies for conservational purposes we present some insights that could contribute to the ongoing discussions and efforts concerning landscape conservation under the current environmental challenges in the Colombian territory.

Keywords: Araneidae, biodiversity conservation, spider diversity, Tetragnathidae

Student - Oral presentation

***Centruroides* as a model to understand the origin and evolution of venoms**

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The genus *Centruroides* is the second most diverse among North American buthids with Mexican species representing ca. 40 % of the diversity and 15 medically important species. The taxonomy of the genus remains contentious and there is scarce information on its phylogeny. Three species groups are recognized in Mexico, approximately corresponding to three out of four monophyletic clades recognized by Esposito (2011): 1) the striped group where all medically and some harmless species are grouped, 2) the non-striped group, and 3) the Thorelli-like group. Important aspects of *Centruroides* toxin biochemistry, pharmacology and diversity have been discovered in recent years. However, there has been little attention in integrating this information with other disciplines such ecology, population genetics and epidemiology, especially to investigate the evolutionary mode and tempo of toxicity in scorpions. Several competing hypotheses on the origin of toxicity at the molecular level have been proposed but they have not been validated by other disciplines. The most appealing hypothesis is that arthropod defensins and the most potent and lethal gated ionic channel inhibitor toxin family share a common ancestor. We contend that addressing the origin of toxicity requires simultaneous consideration of ecological backdrop, population genetics, behavior, and prey/predator biology. We are also convinced that epidemiology could potentially reciprocally illuminate the evolution of toxicity in scorpion and scorpionism, a worldwide health problem recognized by WHO.

Keywords: Scorpiones, toxic peptides, origin and evolution, multidisciplinary, transcriptome

Student - Poster presentation

Effects of dense taxon sampling, implied weighting and indels on total evidence analyses of subfamily Syntropinae (Scorpiones, Vaejovidae)

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A total evidence phylogeny of the North American vaejovid scorpion subfamily Syntropinae, based on dense taxon sampling, is presented. Comprising 462 terminals and 4273 aligned nucleotides of the mitochondrial 12S, 16S and COI genes and the nuclear 18S and 28S genes, 45 continuous, and 206 discrete morphological characters, this is the largest matrix ever assembled for scorpions. The analysis was rooted on *Smeringurus grandis* and other taxa representing the main clades of the family Vaejovidae. Using parsimony in the program TNT, the effect of several parameters on the matrix was compared with a previously published matrix for the subfamily, comprising 145 terminal taxa. Both matrices were analyzed with equal weights and implied weights with different values of the concavity constant ($k = 3, 10, 15, 30, 60, 100, 110$). The effect of indels used as missing data or as a fifth state was also investigated. Tree topologies were compared and symmetric resampling and relative Bremer support calculated, for each analysis. Denser sampling and differing values of the concavity constant values both influence the topology and support. The monophyly of taxa was more frequently recovered and support values slightly greater in the analysis with denser sampling. More monophyletic groups were retrieved when indels were analyzed as a fifth state than as missing data. In summary, adding an approximately four-fold increase in the density of taxon sampling, resulted in a more consistent topology, with increased support. The benefit of analyzing gaps as a fifth state was also demonstrated.

Keywords: Total evidence, Syntropinae, taxon sampling, implied weights, monophyly, support, indels

Oral presentation

Spiders attending sentinel egg masses prefer landscapes comprising native not exotic plants

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There is heightened interest in effects that the provenance of plants in the landscape has on animals inhabiting them. There is an increasing body of research on insect herbivores, but less attention has been paid to arthropod natural enemies. This question is of great interest for designers of urban ornamental landscapes, which tend to be mosaics of native and exotic plants. Many commonly grown exotic woody plants were missing from eastern North America for millions of years prior to the arrival of Europeans. We present the hypothesis that due to the lack of a recent co-evolutionary history with these plants, native natural enemies will be less well able to utilize the resources—architectural features and nutritional supplements—provided by exotic plants than they will those of native plants, and hence will be less numerous and diverse in landscapes dominated by exotic plants. To test the hypothesis, we designed a replicated experiment comprising 0.08 Ha plots planted to congeners of 16 genera of woody plants from either Eurasia or North America. Spiders attending egg masses of the brown marmorated stink bug, *Halyamorphba halys*, emplaced on leaves of a subset of plant species known to be attacked by this pest, were statistically less abundant in the exotic plots, supporting the hypothesis.

Keywords: Anyphaenidae, predation, salticidae, urban ornamental landscapes

Poster presentation

Morphology of setae on coxae and trochanters of spiders Theraphosinae: preliminary results

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Theraphosidae spiders, known as tarantulas, present a homogeneous morphology. They have a diversity of cuticular structures, such as stridulating, sensory and adhesive setae that are used for systematics purposes. Many genera of Theraphosinae are diagnosed by the presence of stridulating apparatus, which can be formed by distinct types of setae. These structures have never been examined in a comparative approach in the subfamily. We aim to describe, using SEM images, the diversity of setae, located on coxae and trochanters of theraphosinae spiders, as well as propose a terminology regarding the morphologic variants. The presence of stridulating setae on prolateral face of coxae I and II in spiders of the genus *Lasiadora* is documented. These stridulating setae are characterized by a smooth base, mid region sparsely covered with thin and long barbs and a spiniform apex. We found the same plumose setae in the close related genera *Vitalius*, *Nhandu*, *Proshapalopus*, *Pterinopelma*. These setae were recorded on all coxae and trochanters, and they are more numerous in males and on the front legs. Unlike of the plumose setae of the group above, spiders of the clade *Acanthoscurria*+*Cyrtopholis*, possess a stridulating clavi-form setae, characterized by having a bulky appearance, a smooth base, wide mid region densely barbed and a spiniform apex. Moreover, in some species of *Acanthoscurria* (*A. paulensis*, *A. natalensis* and *A. juruenicola*) we also recorded the stridulating plumose setae, similar to those in *Lasiadora* and closely related genera. Note that in *Acanthoscurria* these setae occur only on the front legs and are more numerous in males. Other theraphosine genera were examined and only covering body setae were found. Some other genera for which a stridulating apparatus has been reported, such as *Pamphobeteus*, *Grammostola*,

Theraphosa, *Phormictopus*, *Hemirrbagus*, will be examined towards a better knowledge of stridulating setae types for the whole subfamily.

Keywords: stridulating, tarantula, Theraphoside, Mygalomorphae

Oral presentation

Evolution of tarsal structures in Mygalomorphae

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Mygalomorphae comprise a monophyletic group that includes trapdoor spiders, funnel web spiders, tarantulas. They are considered a primitive group as they retain several plesiomorphic spider features. In the present work, we studied the tarsi of representatives of all 16 mygalomorph families under Scanning Electron Microscope (SEM) and recorded each distinct cuticular structure found. We recorded 10 distinct types of setae: (1) striated setae, characterized by longitudinal marks and with varying amounts of barbs, found in all families and Lisphistiomorphae; (2) covering setae, located only on lateral faces of tarsi and distinguished from the other types by the bent base and varying texture among the distinct families, recorded in all Crassitarsae and some Dipluridae; two kinds of adhesive setae, (3) claws tufts, synapomorphic of Theraphosidae+Barychelidae, and (4) scopula, common to all Crassitarsae, plus Euctenizoidina and some Dipluridae, (5) apical tarsus setae, similar to adhesive setae, but differ by the long and thin apex, are present in all families in varying densities, (6) epitrichobothrial setae, short, with many small barbs and always located interspersed with trichobothria, synapomorphic of

Theraphosidae+Barychelidae, (7) filiform, and (8) clavate trichobothria, both inserted in a distinct bothrium, (9 and 10) sensory setae, recognized by the diagonal marks and distinguished in two types: one of them is usually very long with a tapering apex, present on both sexes and all surfaces of the tarsi (as well as other parts of the spider body), and another type of sensory setae is exclusive of males, located on the ventral surface of the tarsi. Regarding these last three setae (7-9), the distribution and density throughout the legs and families are phylogenetically informative. Along with other features such as tegumentary texture and tarsal organ, we defined 13 new morphological characters, some with strong phylogenetic signal.

Keywords: Mygalomorphae, scopula, seta, phylogeny, morphology, tarsus

Student - poster presentation

Spider form and function: foraging guild, morphology and performance

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Spiders are often the most abundant and diverse predators in terrestrial ecosystems. They employ a variety of hunting strategies in different environments. We are examining ecomorphology of spiders to better understand which traits are adaptive in each environment. When variation in traits leads to increase in spider performance, those individuals with advantageous morphologies may have differential reproductive success, leading to natural selection on morphology. Here we examine the adaptive morphology of 23 families within several clades of Araneomorphs to test two main objectives: (1) Use morphological measures and multivariate statistics (i.e. DFA) to attempt to distinguish among spider foraging guilds based on morphology. (2) Test the association between organismal performance and morphology of traits indicative of guild membership. Spiders within the same foraging guild have similar morphologies, independent of phylogenetic relatedness. Morphology was more varied among foraging guilds. We

used burst speed as a performance measure to determine if unrelated taxa of spiders within the same functional group perform in a similar way, thus elucidating how morphology helps shape the fitness landscape of spiders. Results suggest that performance is similar within functional groups, therefore, revealing convergence among guilds. Keywords: morphology, ecomorphology, performance, guilds, ecology

Oral presentation

Biology, behaviour and physiological adaptations of the termitophagous spider genus *Ammoxenus*

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The spider genus *Ammoxenus* (Araneae: Ammoxenidae) is endemic to southern Africa. Research since the 1970s has shown these spiders to feed on termites, although their degree of dietary specialization has, until recently, been unconfirmed. *Ammoxenus* are often very common in grassland and savanna habitats in South Africa where harvester termites are locally abundant. *Ammoxenus* have various morphological and behavioural adaptations to feeding on termites, including rastellate chelicerae, pseudosegmented tarsi, and high speed running and digging behaviour. The presence of a sandy substrate, particularly

areas with soft sand, are critical for the effective capture of termite prey and subsequent digging to feed. A pitfall survey in grassland showed that *A. amphalodes* activity density was strongly correlated to that of *Hodotermes mossambicus*, but not to *Trinervitermes trinervoides*. Although narrowly associated with *H. mossambicus* as prey, *A. amphalodes* also utilize sand mounds of other organisms, including ants and moles, for retreat construction. Recent studies using next generation sequencing showed that 99.8% of sequences extracted from the guts of *A. amphalodes* belonged to *H. mossambicus* termites; this in spite of the presence of other termites (*Odontotermes* sp. and *T. trinervoides*) and arthropods in the study area. Juveniles had a significantly greater diversity of prey sequences than adults, although both males and females continued to feed on *H. mossambicus* as adults. Analysis of venom protein profiles shows that *A. amphalodes* possesses a much more limited number of proteins when compared to euryphagous spiders, providing evidence supporting a stenophagous diet on termites. We briefly describe several future studies that will investigate other aspects of *Ammoxenus* biology to support the evolution of stenophagy in this group of termitophagous predators.

Keywords: Diet, termite, stenophagy, burrowing, feeding, phenology, NGS

Poster presentation

First records and potential range of invasive *Badumna longinqua* in South Africa

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Badumna longinqua (Araneae: Desidae) is a web-building spider indigenous to eastern and southern Australia, but has been introduced to several countries in South America, as well as the U.S.A. (California and Hawaii), Germany, Japan and New Zealand. In this study we review the occurrence of the species from South Africa, from which it was recently recorded for the first

time in 2010, based on recently collected specimens and photographic records. The species has only been recorded from the southern coastal areas (Eastern and Western Cape Provinces) and from the central Free State Province to date, with the vast majority of records associated with synanthropic urban habitats. However, a predictive model shows that the latter localities are very unsuitable for establishment, which we explain on the basis of climatic conditions, while the southern coastal areas represent highly suitable habitat.

Keywords: Introduced, Australia, synanthropic, MAXENT, distribution

Student - oral presentation

Phylogenomics and taxonomic revision of the tarantula genus *Aphonopelma* within the United States

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This systematic study documents the taxonomy, diversity, and distribution of the tarantula spider genus *Aphonopelma* Pocock, 1901 within the United States. By employing phylogenomic, morphological, and geospatial data, we evaluated all 55 nominal species in the United States to examine the evolutionary history of *Aphonopelma* and the group's taxonomy by implementing an integrative approach to species delimitation. Based on our analyses, we now recognize only 29 distinct species in the United States. We proposed 33 new synonymies, seven nomina dubia, and 14 new species. Based on Anchored Enrichment phylogenomic data (581 loci, 334,436bp), our species tree delimits five major lineages: a monotypic group confined to California, a western group, an eastern group, a group primarily distributed in high-elevation areas, and a group that comprises several miniaturized species. Multiple species are distributed throughout two biodiversity hotspots in the United States (i.e., California Floristic Province and

Madrean Pine-Oak Woodlands). By conducting the most comprehensive sampling of a single theraphosid genus to date, this research significantly broadens the scope of prior molecular and morphological investigations, finally bringing a modern understanding of species delimitation in this dynamic and charismatic group of spiders.

Keywords: biodiversity, phylogenomics, molecular systematics, DNA taxonomy, spider taxonomy

Oral presentation

House spider venom and silk gland transcriptomes reveal a complex transcriptional landscape

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The venom and silk glands of spiders are both ecologically critical, being involved in prey capture and predator defense, and a key factor in the evolutionary success of spiders. The application of high-throughput technologies can have an important role in understanding the maintenance and function of these tissues, by characterizing their transcriptomes, including the prevalence of alternative splicing of transcripts. While the proportion of loci with alternatively spliced transcripts and the number of transcripts produced varies among taxa, detailed estimates from arachnids are generally lacking. Alternative splicing augments proteome complexity through the production of many different mRNAs (and coding regions) from pre-mRNAs derived from individual gene loci. The production of alternatively spliced transcripts can play a role in development, disease, and response to stress, as well as in defining tissue specific functions. We have leveraged deep RNA-Seq data to identify transcripts expressed in the venom and silk glands of the Common House Spider (*Parasteatoda tepidariorum*), and to identify thousands of novel splice variants of transcripts. These new forms greatly expand the catalog of such variants in *P. tepidariorum*, and reveal a complex transcriptional landscape, with variation in 5' and 3' splice sites, skipped exons and retained introns, as well as more

complex features. These findings suggest the potential for alternative splicing to have a critical role in the maintenance and operation of venom and silk glands.

Keywords: venom, silk, gene expression, transcriptome, alternative splicing, *Parasteatoda*

Oral presentation

Phylogenetic relationships of the Australian open-holed trapdoor spiders (Nemesiidae: Anaminae): a multi-locus molecular analysis resolves generic classification

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The spiders of the mygalomorph family Nemesiidae occur in many different parts of the world. Past morphological and molecular studies suggest the family is not monophyletic and that the subfamily classification is unstable. The most diverse nemesiid group in the Australasian region, the subfamily Anaminae, is currently represented by 12 valid genera, but the status of some, such as *Chenistonia*, has vacillated in different taxonomic treatments. Using a wide selection of specimens from Australia and New Zealand, we evaluate the relationships of the Australasian members of Anaminae using two different analyses. The first added several new 18S and 28S ribosomal RNA and Elongation Factor 1 gamma (EF-1 γ) sequences to a previously published dataset; the resulting tree showed that most Australasian Anaminae formed a monophyletic group, but that the genus *Stanwellia* failed to group with

this clade. The second analysis recovered three major clades using mitochondrial (12S and 16S ribosomal RNA, and CO1) and nuclear (18S and 28S ribosomal RNA, and Histone 3) sequence data. The first clade comprised the taxa previously included in the Teylini (*Teyl*, *Pseudoteyl* and *Namea*), as well as *Merredinia* and *Chenistonia*. The second clade included species of *Kwonkan*, *Swolnpes* and *Yilgarnia*, as well as the anomalous *Aname turrigera*. The third clade comprised the highly diverse genus *Aname* and a new genus. The results of the study are used to stabilize the generic classification. The New Zealand exemplars of *Stanwellia* analyzed for this study are nested deeply within the taxa from Australia, strongly suggesting that their presence in New Zealand is the result of transoceanic dispersal, not continental vicariance.

Keywords: systematics, molecular phylogenetics, biogeography, generic relationships, Gondwana

Poster presentation

The genus *Chenistonia* (Mygalomorphae: Nemesiidae) in southern Australia and revalidation of the genus *Proshermacha* Simon, 1908

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Recent molecular investigations of the mygalomorph family Nemesiidae in Western Australia have clarified the generic status of a number of known species including species of *Aname* L. Koch, 1872 and *Chenistonia* Hogg, 1901. The limits and composition of the genus *Chenistonia* has changed over the past three decades, either as a synonym of *Aname*, or as a distinct genus. A multi-gene analysis of the relationships of a wide range of Australasian nemesiids has clarified the status of *Chenistonia* which is found to be very distinct from *Aname*. Furthermore, the sister group to true *Chenistonia*—those species with a short embolus on the male pedipalp—is a group of species with a long embolus that deserves to be recognized at the generic level, for which the name *Proshermacha*

Simon, 1908 is available. We also sequenced numerous specimens of *Proshermacha* and 20 distinct genetic lineages were detected. These lineages mostly correspond with morphological differences, and we therefore interpret them as distinct species. Their disjunct distributions display obvious patterning across southern Australia, ranging from the high rainfall south coast in to the transitional drier regions. Keywords: Nemesiidae; southern Australia; molecular; morphology; species distribution; rainfall patterns

Student - poster presentation

Quantifying non-consumptive effects of arthropod predators on agroecosystem pests

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Fear Ecology is an understudied subset of predator-prey population dynamics. We have yet to quantitatively assess the indirect and non-consumptive effects predators have on their prey. Diverse assemblages of spiders can act as buffers that limit the initial exponential growth of given prey populations in agroecosystems. As prey mitigate predation risk through the manifestation of adaptive traits, such as predator avoidance behaviors, there will be negative costs associated with these traits. Non-consumptive effects involve the assumption that prey cease foraging as a mechanism to avoid predators. Active avoidance minimally results in lost foraging time, can induce physiological stress, and may have significant effects on the generation turnover time of crop pests. I am looking at prey response to simulated, olfactory, tactile, and visual cues. Differences in prey feeding activity and development will tell provide some information as to the non-consumptive effects foraging spiders have on their prey.

Oral presentation

Amblypygids as a model for exploring links between sensory systems and behavior

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Our working knowledge of the relationship between brain structures, sensory integration, and complex behavior is surprisingly limited. Navigation, as a behavioral context, is particularly well-suited for providing insights into these relationships as it is arguably a tangible manifestation of higher cognitive ability. Traditional studies of navigation, however, have focused predominantly on a small subset of taxa that inhabit rather simple environments. Modernizing navigation research requires the identification of model species that display successful navigation in a structurally complex environment, possess higher-order processing centers putatively capable of multisensory processing, and are amenable to sophisticated behavioral and neural assays. We propose that amblypygids offer just such a system. Recent field research using the amblypygid *Phrynus pseudoparvulus* has documented successful homing behavior of displaced individuals in heterogeneous tropical rainforest understories. Manipulations of the sensory systems of displaced individuals suggest a reliance on olfactory cues and putative visual cues. Earlier work additionally provided evidence that amblypygids are capable of learning tactile cues, raising the possibility of mechanoreception being important in nocturnal navigation as well. This talk will summarize the current state of knowledge regarding learning, memory, and navigation in amblypygids and will discuss ongoing research aimed at linking sensory systems to complex behavior in this understudied arachnid group. Keywords: Amblypygid, navigation, sensory ecology, multimodal, learning

Oral presentation

Cryptic elevational zonation in the *Aliatyplus janus* complex (Antrodiaetidae) from montane California

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The spider genus *Aliatypus* includes fourteen described species, twelve of which are restricted to California. *Aliatypus* are stocky, medium-sized (6–20 mm) subterranean spiders that cover silk-lined burrows with a wafer-like trapdoor. These spiders are generally highly dispersal-limited with strong preferences for cool, moist microhabitats, and prior genetic studies have revealed geographically localized population genetic structuring and evidence for cryptic speciation. This study focuses on *Aliatypus janus*, which is phylogenetically allied with members of the *A. californicus* group. While most *Aliatypus* species occupy mid-elevation upland habitats and have relatively small geographic distributions, *A. janus* has an atypically large geographic distribution—populations occur in California Coast Range xeric canyons, to upper montane forests near the crest of the southern Sierra Nevada (>2400 m), to lower xeric habitats in eastern California and western Nevada. We reconstructed the phylogeographic history of the *A. janus* complex (plus close outgroups) using a mitochondrial COI and nuclear 28S sample of over 170 specimens from 102 geographic locations. Based on congruent recovery of multiple geographic clades for these gene regions, we gathered DNA sequences for six additional nuclear genes for a subsample of specimens, placing emphasis on paired low versus high elevation populations from the western slopes of the southern Sierra Nevada. Using this multigenic nuclear dataset we conduct multispecies coalescent analyses to explicitly test alternative riverine versus elevational gradient divergence hypotheses. Our results support an elevational gradient hypothesis, which is further supported by ecological niche modeling. Overall, this research is novel in providing evidence for cryptic, ecologically-mediated divergence in the southern Sierra Nevada, in a taxonomic group otherwise dominated by divergence via niche conservatism.

Keywords: molecular systematics, speciation, trapdoor spiders, elevational zonation

Oral presentation

The good, the bad and the ugly: the association between a bromeliad, an ant and a spider

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Many spider species live on tank bromeliads that host arthropods and many other organisms. In Quintana Roo, Mexico, the neotropical spider *I. caudata* (Dipluridae) frequently installs its web on the tank-bromeliad *Aechmea bracteata*. This bromeliad also hosts different ant species and *I. caudata* appears to be associated with not only the bromeliad but also with the hairy-panther ant, *Neoponera villosa* that also inhabits the plant. This association appears to be climate dependent as floods make the bromeliad a Noah's Ark for all spiders living in the inundated forest, while during the dry season the plants are an attractive but not obligatory host for arachnids. This association between the funnel web tarantula, bromeliad and ants also has consequences on the architecture of the web. We describe web size and damage when associated with *A. bracteata* in the presence of a *N. villosa* colony, when these ants are absent but other species of ants are present, and when the spider is not associated with the bromeliad. In association with the tank-bromeliad and the hairy-panther ant, spiders have bigger webs with less damage. This particular association between a spider, a bromeliad and an ant may be explained by a lower cost in terms of silk production and also due to the defensive capacities of the hairy-panther ant towards eventual spider predators. Such multiple associations may be implicated in the evolution of spider-ant associations.

Keywords: tank bromeliad, *Neoponera villosa*, funnel web tarantula, climate

Poster presentation

The use of tarantulas in traditional medicine on three continents

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Spiders are used in traditional medicine on all continents; however the use of tarantulas in traditional medicine has been reported on only two continents; in America and in Asia. In this work we present a synthesis of the knowledge about the use of tarantulas in traditional medicine throughout the world and new information for Mexico as well as a first report for Africa. In the state of Chiapas, the Tzeltal Maya ethnic group use tarantulas as a cure for tumors. The spiders are induced to bite the affected area. Furthermore, the Chol ethnic group uses the tarantula *Brachypelma vagans* for people who present an illness called tarantula wind that consists of asthma, chest pain and coughing. In Brazil, the “tooth” of a bird spider is used to treat an infection of the upper dermis; the fangs are also recommended for the treatment of toothache. In Brazil, people suffering from asthma, drink tea with bird-spider toasted powder. In Cambodia, tarantulas of the genus *Haplopelma*, are used for several medical conditions. Recently we discovered another unique use of *B. vagans* by the Maya people, for bathing eyes which improves sight. They also rear these spiders in their patio so as to have medicine within easy reach. In southern Mali, Africa, we observed people from the Senufo population using tarantulas as a traditional medicine to cure stomach illness. The tarantula identified as from the *Phoneyusa* genus, is fried with salt and then consumed. This is the first report of the use of a tarantula in traditional medicine for Africa.

Keywords: tarantula, traditional medicine, *Brachypelma*, *Phoneyusa*

Poster presentation

Population genetic structure of the bold jumping spider, *Phidippus audax*: Evidence for distinct “northern” and “southern” forms

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The bold jumping spider, *Phidippus audax*, is found throughout much of North America, from Ontario to Mexico, in a variety of climatic regions. While there are few obvious geographical barriers separating populations, and the spiders are abundant throughout their range, there is substantial morphological variation, and previous work has suggested that there may be distinct Southern and Northern forms. We collected samples from across the southern portion of the eastern half of the U.S., and sequenced 672 bp of the COI gene for 114 individuals. We also downloaded corresponding sequences, from Genbank, for 12 *P. audax* collected in Ontario, as well as sequences from *P. purpuratus*, and *P. clarus*. The average pairwise differences among the *P. audax* haplotypes was 4.31, compared to more than 40 differences in comparisons between species. A minimum spanning tree of the *P. audax* haplotypes revealed two clusters, separated by 6 mutational steps. These clusters were geographically distinct, with one cluster found primarily in south Texas (“Southern” population), and the other cluster common everywhere else we collected (“Northern” population). Our study included a single sample collected from a morphologically distinct Florida population, but it was not genetically distinct from other “Northern” spiders. These differences suggest that, while the populations exhibit meaningful differentiation, they are not different species. Differentiation may have arose as the result of historical isolation, for example, during the last glacial maximum, or, through the action of selection, perhaps as a result of local adaptation. We are collecting additional nuclear data to further characterize the pattern of differentiation, and to better understand the evolutionary mechanisms that led to the differences.

Keywords: genetic differentiation, speciation, Salticidae, molecular systematics

Student - oral presentation

Sexual behavior and mating plugs as a tool of mating choice in the Colombian orb-web spider *Leucauge acuminata* (Araneae, Tetragnathidae)

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Females of some species of spiders can bias male paternity through different mating strategies such as rejecting a mating, flushing out the sperm or selecting the sperm of one male over the other. In *Leucauge* orb web spiders, females produce a copulatory plug during or after mating that could be a useful tool to bias paternity. *Leucauge acuminata* is a very frequent spider in Cundinamarca, Colombia; however, the sexual behavior of this species is completely unknown. Our aim was to describe courtship and mating behavior of *L. acuminata*, record plug formation and test its correlation with male sexual behavior. We recorded individually the courtship and copulation of 20 virgin females. In 11 cases, the copulatory plug was present, even though all females mated. Male courtship behaviors during mating such as tapping the female—touching synchronically the female with forelegs ($z=2.048$; $p=0.04$), palpal insertions ($z=2.232$; $p=0.02$) and mating duration ($z=2.465$; $p=0.0137$) were positively related with plug formation. We observed six female cannibalism attempts during mating, which could be related to female choice based on male copulatory performance. We will discuss and compare our results with data available for other species of the genus and the cryptic female choice hypotheses.

Keywords: copulatory plugs, *Leucauge acuminata*, cryptic female choice, male performance.

Student - poster presentation

Effects of *Wolbachia* infection on aggression in a socially polymorphic spider, *Anelosimus studiosus* (Araneae: Theridiidae)

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The endosymbiont bacterium *Wolbachia* is well known for a variety of effects it can have on its host through cellular and reproductive processes, such as cytoplasmic incompatibility, parthenogenesis, feminization and male killing. It has also recently come to light that *Wolbachia* can have effects on the nervous system as well, including effects on olfaction and the mediation of octopamine levels. This project aims to investigate a potential proximate cause of social behavior in the socially polymorphic spider, *Anelosimus studiosus*. While most *A. studiosus* express an aggressive phenotype and tend to live in solitary colonies, a rarer docile phenotype is much more tolerant of conspecifics and is often found in multi-female colonies characterized by cooperative brood care and foraging. Recent work has shown that lower levels of octopamine in the docile phenotype are related to this social behavior, but the proximate causes of lower octopamine levels remain poorly understood. In this study we investigate a potential causal link between lower levels of aggression in *A. studiosus* and *Wolbachia* infection. In *Drosophila*, *Wolbachia* infection have been linked to lower levels of octopamine and a corresponding decrease in aggression. Moreover, *Wolbachia* may be inherited through ingestion when hosts are in larval or early developmental states. Juveniles of docile *A. studiosus* can be fed by multiple females via regurgitation during development, which could be a potential vector for horizontal transmission of *Wolbachia* infection. We will present results of quantitative genetic screening of aggressive and docile females for *Wolbachia* infection. Research which focuses on the effects of endogenous microorganisms on social behavior is novel and our results could potentially transform current understandings of key mechanisms in biogenic amine production.

Keywords: social behavior, endosymbionts, biogenic amines, *Wolbachia*

Student - oral presentation

Activity patterns and mating behaviors of an arboreal tarantula: *Avicularia laeta*

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Tarantulas are sit-and-wait predators that remain close to their retreat while hunting. Following an ultimate molt, mature males travel in search of receptive adult females and exhibit scramble competition, where males locate scattered females within a habitat and show little aggression towards each other. Little is known about their daily habits and behavioral ecology in their natural habitat; especially for arboreal species. We examined several aspects of the natural history of an arboreal tarantula including: mate searching behaviors by males and activity patterns of juveniles and adult females. Retreats were located and marked during the day based on the presence of web and we returned at night to determine if retreats were occupied. The diameter-at-breast height (DBH) and length of visible silk was recorded. Active adult female and juvenile retreats were observed nightly from twilight until daybreak. Body position relative to their retreat was recorded every 30 minutes. Wild-caught male tarantulas were radio-tagged and released and these individuals were re-located nightly and their position was recorded using a GPS. These data were used to calculate distances travelled per day and search areas. Adult females occupied trees with a significantly larger DBH and longer visible silk than juveniles. Both groups emerged from retreats around the same time suggesting that light levels instigate activity. There was no difference in body position and proximity to their retreats indicating similar daily behaviors. Several males were relocated nightly on the same tree of an active female suggesting that they remain within close proximity to sexually active females for extended periods. No aggressive behavior was witnessed between mature-males located on the same female retreat tree. The results of this study provide the first insight into arboreal mature-male tarantula searching behaviors and differences in retreat

site selection based on the size/age of an individual.

Keywords: tarantula, arboreal, mature-male, mating

Poster presentation

Social polymorphism in *Anelosimus studiosus*: a longitudinal comparison

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Anelosimus studiosus is a subsocial theridiid whose distribution ranges from the southeastern United States through South America. Previous studies have shown variation in social tendencies such that colony size and lack of aggression increase from southern to northern latitudes, not the typical pattern for social spiders. Riechert & Jones (2008) examined social behavior along a latitudinal gradient from southern Florida to central Tennessee and found that social tolerance and multi-female nests increased with latitude. Our study compared social tendencies of a population of *A. studiosus* in northwestern Louisiana to that found by Riechert & Jones at a comparable latitude. Using the same behavioral assays we found that the Louisiana population showed a significantly greater proportion of social versus asocial phenotypes, but a similar frequency of multi-female nests. This corroborates that social polymorphism is characteristic of *A. studiosus* and that it varies at the population level.

Keywords: subsocial spider, social polymorphism

Student - Oral presentation

Red list proposals of spiders for European countries and regions

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Only 11 of the 51 European countries have a national red list for spiders comprising between 25 and 100% of the national spider fauna. Fourteen countries have other lists like conservation, governmental protection

or expert-knowledge lists, containing only a few species. Assessors used different criteria and methods for their assessments, which make a direct comparison between threat categories of species difficult. While in an ideal scenario, we would know the exact degree a given species is threatened, this information is only available for a few well-known taxa, mainly vertebrates, thus, IUCN criteria are hardly applicable to invertebrates such as spiders. Nevertheless, there is a need to classify invertebrates with simple, taxon-specific criteria, which are applicable for all species in every country. Here we analyse in a top-down approach criteria which have been used to establish some national red lists of spiders for all European species. We tested traits against IUCN categories of red listed species to analyse for significant influence. Species with narrow distribution (endemics), preferred occurrence in rare or threatened habitats such as wetlands, xeric habitats, caves or rocky habitats are significantly more often assessed to be threatened, whereas body size and hunting manner had no influence on vulnerability. With these results, trait-based criteria have been suggested to nationally assess all European spider species. We propose complete national species red lists for all 64 European countries and regions, which can be adapted, verified and easier compared with each other. Keywords: conservation, extinction, threatened species, risk assessment, endemism, distribution, habitat

Student - poster presentation

A test of the utility of venom expressed genes for reconstructing taxonomic relationships using Haplogyne spiders

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Haplogyne spiders, including infamous members of the genus *Loxosceles* (brown recluse) and relatives, are a diverse set of families with a variety of venom toxins that

are of medical and pharmaceutical interest. The currently accepted phylogeny of Haplogynes is largely based on morphological characteristics, and has not been scrutinized with molecular data. Next-generation sequencing (NGS) provides cost-effective access to large amounts of data that can be used to revisit phylogenetic hypotheses based on morphology and/or molecular datasets with few genes. This project is an undergraduate thesis that is utilizing NGS (Illumina 3000) venom gland and whole body transcriptomes for 11 Haplogyne species to provide a molecular test of the family relationships proposed by morphological data, with a concentration on generic level relationships in the scytodoid superfamily. A secondary goal is to test the phylogenetic utility of venom-expressed genes by analyzing the degree of congruence between phylogenies created with datasets including only genes that code for venom proteins, datasets that include only non-venom genes, and all molecular data. With a few intriguing exceptions, phylogenies including all sequences resolve relationships that are largely congruent with relationships supported by morphology. Further analyses will test whether the relationships supported with the full dataset are congruent with those supported by analyses of the subset of the data that are in gene families that include representatives that are venom expressed, and subsets that are gene families that are not venom-expressed. These analyses improve understanding of relationships within Haplogynes and test the utility of venom genes in resolving relationships.

Keywords: next-generation sequencing (NGS), haplogynes, phylogenomics

Oral Presentation

A phylogenomic approach to resolve the relationships among the main lineages of araneoid spiders

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Resolving the interfamilial relationships of the ecribellate orbweavers (Araneoidea) has proved to be a recalcitrant phylogenetic problem. This lineage includes over a quarter of the described spider species and a remarkable diversity of foraging webs and life history traits. Understanding this diversity has been hindered by a lack of a robust hypothesis on the phylogenetic relationships of the main lineages of Araneoidea. Recent studies using both the standard target-gene approach (and extensive taxon sampling) and phylogenomic methods (albeit with a modest taxon sample) have refuted the monophyly of cribellate and ecribellate orb-weavers (Orbiculariae) and provided support for some interfamilial relationships, such as the clade that includes the families Mimetidae, Arkyidae and Tetragnathidae. Unfortunately, much of the phylogenetic scaffolding of Araneoidea has yet to be discovered. In this presentation we will report on our progress to address araneoid relationships through a transcriptomic approach, using a taxon sample that includes representatives of about 72% of the families of Araneae and about 90% of the families of Araneoidea.

Keywords: Araneoidea, Orb-weavers, Phylogeny, Systematics, Web evolution

Oral presentation

A myrmecophilic spider from West Texas with discussion of biology and taxonomy

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In the fall of 1999 a graduate student, Greg Broussard, found an unusual spider while conducting a survey of cursorial species. The location was the Dalquest Desert Research Station (DDRS) in the Chihuahuan Desert of the Big Bend area of Texas. The family could not be determined, so specimens were sent to taxonomic authorities for family placement, which has yet to be determined. In 2011 personnel from the University of New Mexico found this spider on the surface of an ant mound (*Pogonomyrmex rugosus*) 9.7 km S of Cuatro Ciénegas, Coahuila, Mexico. The DDRS is 335 km (208 mi) from the Mexico site. Concentrated pitfall collecting near a *P. rugosus* nests on the DDRS has increased the take of this spider. In the summer of 2015 four specimens were collected from chambers while digging up a *P. rugosus* nest. To date 127 spiders have been collected from the DDRS and include 51 ♂, 34 ♀ and 42 immatures. Details of the symbiotic relationship are unknown. The morphology of the eyes suggests that it belongs to a group of *Dionycha* having orthogonally oriented tapeta in the posterior median eyes, although the perplexing overall morphology makes it hard to place the species in any established family.

Student - oral presentation

Blue tarantulas and dancing rainbow spiders inspire new color technologies

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Many spiders exhibit vivid colors that are not produced by pigments, but rather by optical interference, diffraction, and scattering — structural colors. Traditionally, structural color research in nature focused on birds, butterflies and beetles. But the long evolutionary history and extreme diversity of spiders provide fruitful new territory. The repeated evolution of blue in large, nearly blind tarantulas and the diversification of sexual display colors in tiny

peacock spiders provide two striking examples. Here, we show how tarantula blue is produced using specialized hairs with complex hierarchical structure that greatly reduces iridescence—which has been a key obstacle to the production of synthetic structural colorants without the shimmering effects. On the other hand, the strikingly iridescent scales of the rainbow peacock spider (*Maratus robinsoni*) can produce every color of the rainbow, and may hold the secrets for future optical device miniaturization. We used an interdisciplinary biomimetic approach to investigate both questions by including techniques such as: morphological characterization (SEM/TEM), phylogenetic analysis, spectrophotometry, optical simulation, and rapid prototyping by 3D nano-printing. Particularly with the rapid prototyping capability, we can create engineering models to test biological hypotheses in a controlled manner that may not be feasible with the living systems. Hence, biomimicry is not only taking what we learned from natural systems to practical human applications, but it is also providing insightful feedbacks and ideas to deepen our understanding of the biological system subject matter during the process.

Keywords: structural color, biomimicry, Theraphosidae, Salticidae, *Maratus*

Oral presentation

Multiple convergences in pholcid spiders: problem and promise

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Based on our upcoming molecular phylogeny of Pholcidae (currently 380 species, 61 genera) we explore multiple convergences at three levels: ecology (microhabitats), ultrastructure (spinning apparatus), and sexual dimorphism (male ocular area modifications). In tropical forests, pholcid spiders occupy a wide range of microhabitats, such as the leaf litter, large sheltered spaces, and the

undersides of live leaves. Most species are restricted to one specific microhabitat, and most are adapted to their microhabitat in terms of body shape and coloration. Here we focus on leaf-dwelling which is often associated with conspicuous adaptations in morphology and behavior. Our results suggest that leaf-dwelling has originated ~30 times independently, mostly in the supposedly ‘modern’, humid tropical subfamilies Modisiminae (8) and Pholcinae (~21). The evolution of the pholcid spinning apparatus is characterized by multiple convergent losses of one specific set of spigots. Male ocular area modifications have evolved about 20 times independently in pholcids. Such multiple convergences are not only examples of ‘noise’ in phylogenetic analyses (the problem) but can guide future research on the macroecology, behavioral ecology, and functional morphology of the respective taxa (the promise).

Keywords: convergence, Pholcidae, microhabitat-shifts, leaf-dwelling

Poster presentation

Multiple convergent evolution of male sexual ‘head’ modifications in pholcid spiders

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Sexual modifications of the male ocular area (‘head’) occur in a wide variety of pholcid genera, in particular in the subfamily Pholcinae. These range from simple median or paired processes to exaggerated eye-stalks, conspicuous turrets, and curiously waxed brushes of hairs. As a first step towards understanding the evolution of these modifications, we summarize all known cases and map them on our current molecular phylogeny of the family (380 species, 61 genera). There is strong evidence that male ‘head’ modifications originated at least 20 times independently within pholcids. Similar to linyphiids, the copulatory position of pholcids is a likely explanation for this multiple

convergences; however, in contrast to linyphiids, gustatorial courtship does not seem to be involved in pholcids except for one single case (*Modisimus culicinus*). This leaves a wide range of possible functions, including intersexual as well as intrasexual scenarios that may explain the evolution of these structures. Obviously, this is a rich field for future observational and experimental studies.

Keywords: Sexual dimorphism, convergent evolution, Pholcidae, 'head' structures

Oral presentation

Species discovery in the Pilbara: the curious case of *Conothele*

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Many Mygalomorph genera harbor undescribed species diversity. In Western Australia, this was made evident in a recently published barcoding study, which found ~140 putative new species across seven families, defined by a 9.5% divergence threshold at CO1. For the genus *Conothele* (Ctenizidae), 13 putative species were revealed in that study. In a more comprehensive molecular dataset discussed here, we have revealed upwards of 30 lineages, based on that same criterion. These lineages suggest a complex evolutionary history for this genus in Australia, especially in the resource-rich Pilbara region of the north-west of the continent. Reconciling these genetic data with morphology faces some constraints. Adult males are required for adequate morphological species level description and diagnoses, but available collections have few adult male specimens that can be sequenced and linked to the phylogeny. Here we discuss avenues to reconcile these data, and explore the complex and incomplete biogeographic history of this genus in Australia.

Keywords: species discovery, systematics, phylogenetics, Mygalomorphae

Poster presentation

Species diversity of *Cybaeus kuramotoi*-group (Cybaeidae) in Japan and evolution of mating plugs associated with antagonistic coevolution between males and females

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The genus *Cybaeus* (Cybaeidae) comprises numerous species endemic to Japan. The number of described species of Japanese *Cybaeus* has reached 80 and there still remains undescribed species as many as described ones. They vary in body length with a wide range from ca. 3 to 15 mm, and a local species assemblage usually consists of representatives of different size classes. Each species of the assemblage often constitutes a closely related species group together with other similar-sized species. A series of the medium-sized species groups (approximately 5–7 mm in body length), such as the *kuramotoi*-group and the *ashikitaensis*-group, is most diverse in western Japan. The *kuramotoi*-group consists of more than 30 (including 7 described) species. The group can be also characterized by presence of the mating plugs, whose morphology are species-specific. The mating plugs are broken pieces of male's own palp derived from an apical element of conductor. After the copulation, it is inlaid to a crevice of epigynal plate of female to block a copulatory pore. Female internal genitalia of the *kuramotoi*-group are more developed than those of *C. ashikitaensis* in which the mating plug is absent. In particular, the *kuramotoi*-group has conspicuously elongated spermathecal bases in contrast to rounded spermathecal bases of *C. ashikitaensis*. As the late mate priority may be enhanced by elongated spermathecal base, it is considered that males producing mating plugs are adaptive if female's multiple mating and resulting sperm competition are the norm. Furthermore, when males have larger apical elements of conductor (= mating plug), females tend to have more elongated spermathecal bases. The sexually antagonistic coevolution hypotheses predict that female and male morphology will often coevolve.

Keywords: *Cybaeus*, *kuramotoi*-group, geographic differentiation, mating plug

Oral presentation

The dark side of climate change

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The fact that caves are semi-closed systems with an almost constant temperature makes them almost ideal sites where to study where to study the effects of the ongoing global warming on biological communities. In spite of that, the underlying mechanisms behind the response of specialized subterranean species to global warming are still largely undiscussed. By means of two years observations data, we characterize the thermic conditions of 33 caves in the Western Alps, and relate the hypogean microclimate to the occurrence of subterranean-adapted *Troglohyphantes* spiders. Regression analysis points out a specific response to temperature as well as a significant effect of the past Pleistocene glaciations on their present distribution. In a second step, we investigate the relationship between temperatures recorded in monitored caves and the corresponding external temperature. We emphasize the mechanisms for which the constant temperature recorded inside corresponds in good approximation to the mean value of the annual temperature outside and use this direct relation to extend the results to a wider dataset, including records from over 350 caves in the Western Italian Alps. Specifically, we employ Ecological Niche Modeling techniques to predict habitat suitability both in the Last Glacial Maximum and in future global warming scenarios. In light of IPCC's projections of global average temperature increases, we assess the general sensitiveness of our model species to future increase of temperature, pointing out a future decline for hypogean adapted species.

Keywords: Global change, subterranean spiders, alpine spiders, ecological niche modelling

Poster presentation

Threatening the giant: the response of *Vesubia jugorum* to climate change

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Human-driven climate deterioration is expected to cause altitudinal shifts in biomes. There is a concern for high alpine species that suitable habitats will be reduced, and populations of cold-tolerant species living on mountain summits will be increasingly fragmented. *Vesubia jugorum*, the giant Alpine wolf spiders, represents a typical example of such cold-adapted species, as it occurs exclusively on rocky lands above 2,300 m asl. The species is paleoendemic, reported exclusively from the Maritime Alps (NW-Italy), with a very reduced number of populations reported in literature. On the base of literature and new original data, we generated a dataset comprising 37 occurrence of the species that we employed to model potential present distribution of the species via Ecological Niche Modeling (ENM). On the base of the model results, we estimated the bioclimatic suitability of *V. jugorum* in the past (Last Glacial Maximum, Pleistocene) and in the future, by projecting the present-day model into different global warming scenarios predicted by the International Panel on Climate Change (IPCC). As expected, given the colder climatic condition in the Pleistocene, the potential past distribution of *V. jugorum* was found to be wider than today. Future forecasts based on different temperature scenarios showed a general declining trend of suitable areas all over the investigated area. We interpreted our results in light of the expansion–contraction model, which describes the response of species to the fluctuations in temperature during glacial-interglacial cycles. According to our results the giant Alpine spider expanded its distribution during cooler periods and contracted it during interglacials. Therefore, we hypothesize that the species is currently in a refugial phase, and we suggest that future warmer conditions might determine a further contraction of the range.

Keywords: giant alpine spiders, global warming scenarios, ecological niche modelling, endemic fauna

Oral presentation

Jumping spiders as a model for attention: integration of novel techniques for eye-tracking and neural recording in the brain

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Jumping spiders use their small brains to integrate information from eight different eyes. Of these, one pair, the principal eyes, have retinæ that move around to examine the visual field, whereas the other three pairs of eyes are non-moving. We present results from two unusual approaches to studying jumping spider perception. First, our eye-tracker enables us to record retinal position as a spider explores video images. Second, we are able to simultaneously record from the arcuate body region of the brain as the spider observes video stimuli. We will present the first data in which we record both retinal position and arcuate body firing from spiders as they observe different stimuli. We argue that we now have a powerful new model for the study of visual attention in invertebrates.

Keywords: salticids, gaze direction, attention, brain recordings, eyetracking

Poster presentation

Sampling terrestrial spiders: evaluation of sampling protocols and presentation of alternative methods

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The arthropod pitfall trap is the capture technique most commonly used in sampling spiders. However, this technique is not always used in long-term sampling, and consequently, the component in which the diversity of terrestrial spiders is studied is not performed. Our study presents an alternative sampling technique for terrestrial spiders (pitfall traps with drift fences; PTFD), and compares the species richness, relative abundance, and community structure perceived between this technique and the specific traps widely used for terrestrial spiders (pitfall traps; PT), and between the different designs, buckets sizes, and spatial parameters widely used for PTFD. Based on a great sampling effort in the Caxiuanã National Forest, Brazilian Amazonia, our results evidences similar species richness obtained by PTFD and PT, as well as patterns of species abundance and community structure. Among the different PTFD tested by us, both line and Y designs and buckets size (35l, 62l and 100l) did not influence the effectiveness of the sampling technique, with similar species richness, relative abundance, and community structure perceived by them. However, there was a complementarity in the spatial parameters analyzed, evidenced by the species abundance and community structure patterns perceived by the traps installed widely in the region, and by them installed concentrated in one area. Finally, the efficiency of the PTFD as sampling technique and component of the terrestrial spider protocol is evidenced, and this technique is considered by us as a complementary and/or alternative way to sampling terrestrial spiders in Amazonia.

Keywords: pitfall traps with drift fences, sampling protocols

Oral presentation

**From the proximate to the ultimate:
vertically-integrated research on the evolution of sociality in *Anelosimus studiosus* (Araneae: Theridiidae)**

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Anelosimus studiosus is unusual in that it forms both single-female subsocial colonies and multi-female social colonies. Because of this variation, and the underlying variation in individual personality, the species has proven to be an outstanding model for studies on the proximate underpinnings and ultimate selection for the evolution of sociality. This talk will review what we know about the ecology and neurobiology of aggression and sociality in this species, and present some new data illustrating vertically-integrated lines of inquiry. Results from a study exploring how abiotic factors influence the species' distribution suggest that both insolation and wind exposure affect both summer and winter colony survival. Another study found that exposure to sub-lethal levels of Cadmium significantly increases individuals' boldness and metabolic rate, without affecting overall coordination and activity. This latter study suggests that through behavioral modulation, Cadmium could move more quickly into the ecological food web.

Keywords: sociality, ecology, neurobiology, toxicology

Student - Poster presentation

Morphology of *Mundochthonius* (Pseudoscorpiones) in Western Oregon

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Three species of the genus *Mundochthonius* (Pseudoscorpiones, Chthoniidae) have previously been identified from western Oregon; however, our work with other chthoniid

taxa suggests this may be an underestimate of the actual number of species. This study attempts to identify distinct morphological forms and determine the total number of species of *Mundochthonius* present in western Oregon and nearby areas. Pseudoscorpions were collected from temperate wet forests in western Oregon, Washington, and California; 14 morphological features in 28 individuals were then examined and analyzed. Species were determined based on key taxonomic features, particularly coxal spine shape. Morphological features differed in their degree of variability: chelal dentition, serrula shape, and flagella shape did not vary, while overall color, male abdomen shape, eye shape, epistome shape, tergite chaetotaxy, coxal spine shape, intercoxal tubercle orientation, cheliceral dentition, chelal hand appearance, right chela length, and right palpal femur length varied among individuals. Coxal spine shape varies more than currently documented in existing species descriptions: spines often vary in teeth distribution and number and position of incisions between spines of the same individual. Updated species descriptions using alternative taxonomic features may be required to reflect observed morphological diversity.

Keywords: taxonomy, biodiversity, soil invertebrates, geographic barriers, morphometrics

Oral Presentation

Species diversity of the endemic genus *Annandaliella* in Western Ghats, India

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Annandaliella Hirst, 1909 is a primitive genus endemic to Western Ghats. The genus is established by Hirst (1909) to accommodate the new species *A. travancorica* Hirst, 1909 collected from Trivandrum. Later two more species are recorded from this genus: *A. pectinifera* Gravelly, 1935 and *A. ernakulamensis* Jose & Sebastian, 2008. It is very close to *Plesiophrictus* Pocock, 1899 but the presence of cheliceral spines on the proteral surfaces distinguishes it from related genera of theraphosids. The genus is presently known only from two states of India, indicating

its restrictive distribution. They are ground dwelling spiders found under rocks and boulders. Due to their secluded nature, data on these endemic spiders are very much limited. In this paper I rediagnose and illustrate two poorly known species based on new specimens collected from different parts of Western Ghats. One new species of *Annandaliella* is also recorded from Kerala. Photos and new data on their distribution, habits and morphometry are also provided. The new species *Annandaliella nigra* sp. nov. is collected from Maalippara, Ernakulam district, Kerala state, India. It can be separated from *A. travancorica* Hirst, 1909 by the presence of twin spermathecal lobes diverging from each other, distal end with club shaped lateral bud and three intercheliceral spines on the opposed surfaces of chelicerae. Regarding the known species *A. travancorica* Hirst, 1909, its presence in the northern district of Kozhikode is also reported along with diagnosis of the species. Similarly diagnosis and distributional records of *A. ernakulamensis* Jose & Sebastian 2008 is also provided. The primitive nature of these spiders makes them highly vulnerable to extinction due to land degradation and deforestation. Unless urgent measures are taken to study and protect these primitive spiders their existence will be at risk. Keywords: Taxonomy, Mygalomorph spiders.

Oral presentation

Intraspecific variation of pedipalp and epigyne morphology in *Plebs mitratus* (Simon, 1895) (Araneae: Aranedidae), with comments on the occurrence of mating plug in the genus

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Plebs Joseph & Framenau, 2012 (Araneae: Aranedidae) is an orb weaving spider genus distributed in Australia-Pacific region, South-East Asia, China, Japan, Korea and India and currently comprises 23 spp. *P. mitratus*, one of the Indian representatives of the genus, commonly prefers mountainous habitats. Specimens of *P. mitratus* were collected from three different tropical montane wet temperate

forests of Western Ghats in Kerala, India - Nayamakkadu shola (Eravikulam National Park), Chembra Peak and Aanamudi Shola National Park, all within a short geographic range of 150 km. Examination of the specimens revealed incredible intraspecific variation in the morphology of pedipalp and epigyne. Examination of four male and three female specimens revealed notable variations especially in the morphology of the basal arch of median apophysis, conductor, embolus, terminal apophysis, epigyne plate, spermathecae and copulatory ducts. Detailed examination of the epigyne also revealed the presence of mating plugs, which were hitherto unknown in the genus. The plug was found to be embedded in the copulatory opening and in the cleft between the posterior and lateral lobes of the median plate and covered the surrounding area of the epigyne. Either left or right or both copulatory openings were found to be plugged.

Keywords: distribution map, Shola, taxonomy, tropical montane wet temperate forest, Western Ghats.

Student - Oral presentation

Sexually dimorphic tarsal features in mygalomorph spiders

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We investigated tarsi I and IV of males and females representatives of all 16 families of mygalomorph spiders (except for Microstigmatidae and Paratropididae, for which only males were examined) to verify sexually dimorphic features regarding adhesive and sensory setae. A distinct type of sensory setae was found only in males, additional to those sensory setae that are present in both sexes. The male sensory setae, which are shorter and have a distinct apical end compared to the normal sensory setae, are located on the ventral face of tarsi. According to the relationship hypothesis based on total evidence for mygalomorphs, we can presume that adhesive setae probably appeared three times independently: in Diplurinae, Crassitarsae and Euctenizoidina. In Diplurinae and

Crassitarsae, males have the ventral tarsi covered with scopula (adhesive setae) and mixed with male sensory setae, whereas females have only adhesive setae (except for Cyrtaucheniidae, that the males have only the male sensory setae). The distinction between a scopula composed of adhesive or sensory setae is only possible when examined under SEM. In other families, Actinopodidae, Antrodiaetidae, Atypidae, Ctenizidae, Hexathelidae, Migidae, Paratropididae and representatives of Euagrinae (Dipluridae) male representatives have sensory scopula only, whereas females have just a few long setae. Moreover, in these families, plus Idiopidae and Euctenizidae, we observed differences in density of sensory setae of male scopula. The plesiomorphic state, as it is in *Liphistius*, where males have sensory scopula three times denser in hind legs, was observed in Actinopodidae, Hexathelidae and Paratropididae ($p < 0.005$), as well as in Antrodiaetidae, Atypidae and Dipluridae (Euagrinae). The apomorphic state, where sensory setae are denser in front legs, was observed in Bipectina: Cyrtaucheniidae, Idiopidae and Nemesiidae ($p < 0.001$). These results provides new data for phylogenetic and functional morphology approaches.

Keywords: Mygalomorphae, morphology, tarsus, seta

Student - poster presentation

Island hideouts of thieves and assassins; biogeography of Indian Ocean Argyrodinae spiders

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The diversity of arthropods inhabiting Indian Ocean islands is estimated to be high but remains poorly known. Argyrodinae spiders (Araneae: Theridiidae) are found on all of the major islands and are notorious for their unusual foraging strategies such as occupying webs of host spiders to steal resources (kleptoparasitism), and preying on other spiders (araneophagy). Despite their ubiquity, however, the historical biogeography and dispersal patterns of Indian Ocean argyrodines as well as the evolution of these

foraging strategies (in the subfamily in general) are not well studied. The aims of our study are to 1) test biogeographical hypotheses of Indian Ocean argyrodines and 2) to understand the evolutionary history of their foraging strategies. Here, we construct a preliminary molecular phylogeny of western Indian Ocean argyrodines using mitochondrial (CO1) and nuclear (ITS2) genes to infer the biogeographical history of argyrodines and the phylogenetic relationship between kleptoparasites and araneophages. Our phylogeny complements a previous study done by Su & Smith (2014), and we use it to test the hypothesis that kleptoparasitism evolved from araneophagy (which itself evolved from a free-living ancestor). Our study furthermore sets the stage for future co-phylogenetic analyses of argyrodines and hosts to determine their interplay.

Keywords: biogeography, Argyrodinae, phylogeny, kleptoparasitism, araneophagy

Student - oral presentation

Systematics of the Australasian araneid *Phonognatha* and evolution of orb-web leaf retreats

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The phylogenetic relationships at the base of Araneidae are either contentious or poorly known. Two early diverging lineages within Araneidae are the Australasian genera *Phonognatha* Simon, 1894 and *Deliochus* Simon, 1894. Members of these genera have been placed in Araneidae, Tetragnathidae, and Nephilidae over the course of the past 150 years. Neither genus has been revised, and 11 species and subspecies are described between them. Some of these taxa are biologically interesting for reasons including curling a leaf in the orb-web to use as a retreat, male and female cohabitation prior to mating, and reversible color change. Recent analyses place them in the araneid subfamily Zyiellinae, which is either sister to Nephilinae at the base of Araneidae, or sister to all other araneids. Morphological examination of more than 2,000 specimens

and our own fieldwork indicates there is one undescribed *Phonognatha* species, and multiple new combinations and synonymies with taxa previously described as *Araneus*. Preliminary phylogenetic analyses including the Queensland endemic *P. melanopyga* (L. Koch, 1871) are equivocal with respect to the reciprocal monophyly of the genera. This could suggest the leaf curl and incomplete orb-web of *Phonognatha* were lost secondarily, but all taxa retained the non-sticky temporary spiral in the final web.

Keywords: Araneidae, Australasia, leaf-curling, systematics, taxonomy, Zygiellinae

Oral presentation

Honoring Herbert W. Levi: studies on *Phoroncidia* and an interdisciplinary project based on spider biodiversity in Grand Teton National Park

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In 2014, arachnology lost a major figure in Herbert W. Levi. Throughout the course of his career, first at the University of Wisconsin and then as curator of arachnology at Harvard's Museum of Comparative Zoology, he described 1,254 species of spiders and authored over 200 scientific publications. His scholarly and taxonomic contributions are well known; less obvious yet equally important were his interests in conservation and stewardship influenced by his early studies with Aldo Leopold and brought to fruition through his and his wife Lorna's dedication to local conservation and education efforts. This presentation will pay tribute to Herb by highlighting two areas of my research and how this work was influenced by his mentorship. Firstly, I will discuss my taxonomic research and investigation of structural color in *Phoroncidia* stemming from Herb's publication "American Spiders of the Genus *Phoroncidia*" in 1964. Secondly, I will describe my study of spiders of Grand Teton National Park retracing Herb and Lorna's historic invertebrate survey from 1950 and the resulting interdisciplinary project in celebration of Herb and Lorna and the centennial of the National Park Service.

Keywords: Herbert and Lorna Levi, *Phoroncidia*, structural color, biodiversity, Grand Teton National Park

Student - oral presentation

Individual behavioral differences influence patterns of social interactions and bacterial transmission dynamics

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Despite the importance of host traits for the likelihood of the transmission of microbes from exposed to susceptible individuals, inter-individual variation is seldom considered in studies of wildlife disease. Here, we test the influence of host behavioral phenotypes on social network structure and the likelihood of cuticular bacterial transmission from exposed individuals to susceptible group-mates using female social spiders (*Stegodyphus dumicola*). Based on the patterns of contact between resting individuals of known behavioral types, we assessed whether individuals assorted according to their behavioral traits. We found that individuals preferentially interacted with individuals of unlike behavioral phenotypes (i.e., contact networks are behaviorally disassortative). We next applied a GFP-transformed cuticular bacterium, *Pantoea* sp., to individuals and allowed them to interact with an unexposed colony-mate for 24h. We found evidence for transmission of bacteria in 55% of cases. Though, the likelihood of transmission was influenced jointly by the behavioral phenotypes of both the exposed and susceptible individuals: 69% of the instances where we detected bacterial transmission were cases where the exposed individual was bolder than its susceptible colony-mate. Indirect transmission via contaminated silk took place in only 15% of cases. Thus, bodily contact appears key to transmission in this system. These data represent a fundamental step towards understanding how individual traits jointly influence larger-scale

social and epidemiological dynamics.

Keywords: behavior, bacterial transmission, social network analysis, social spider

Student - oral presentation

Riparian tetragnathids rely heavily on aquatic subsidies in a tropical urban watershed

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Some taxa of tetragnathid spiders are considered specialists of aquatic ecosystems and are major consumers of emerging aquatic insects. However, little is known about how urbanization may have indirect effects on riparian spider assemblages due to changes in prey communities along urban stream gradients. We predicted that due to the loss of terrestrial primary productivity in more urbanized areas there will be less terrestrial prey available and riparian tetragnathids would rely more heavily on aquatic insects as a major energy source. Six study sites were selected along the Río Piedras watershed that flows through the center of San Juan, Puerto Rico. These six sites represent individual subwatersheds and form a gradient of increasing urbanization according to percent vegetation in each subwatershed. To conduct stable isotope dietary analyses, we collected samples of basal resources for aquatic and terrestrial food webs, primary consumers and two species of tetragnathids (*Leucauge argyra* and *Tetragnatha boydi*). *T. boydi* are generally nocturnal and are known to be aquatic ecosystem specialists, while *L. argyra* are more diurnal and are not exclusive to aquatic ecosystems. Utilizing Bayesian mixing models we found that the proportion of aquatic insects in the diet of riparian tetragnathids increased along the urban gradient from ~50% in the less urbanized areas of the watershed to ~95% at the most urbanized sites. There was not a large difference in the diets of the two species, although *T. boydi* overall was found to consume greater proportions of aquatic insects. These findings support our prediction that in heavily urbanized areas riparian tetragnathids

rely more on aquatic insects as their primary food source. Therefore, impacts to urban stream ecosystems could have strong indirect effects on riparian spiders, such as changes in insect prey abundance and diversity, along with the possible bioaccumulation of aquatic contaminants.

Keywords: dietary analysis, riparian tetragnathids, stable isotopes, urbanization

Student - Oral presentation

Next generation sequencing of gut content to study niche ecology in spiders

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Dietary studies in spiders have historically been difficult due to the infrequency of observing predation events; the fact that spiders consume prey in liquid form, leaving no parts for morphological identification; and the limitations of traditional barcoding methods, which have not always been able to distinguish spiders from their closely related arthropod prey without the use of blocking primers. However, recent methodological innovations and advances in sequencing technology have enabled powerful and detailed studies of spider gut contents using metagenomics. We developed a protocol for extracting, amplifying and sequencing high yields of prey DNA from spiders' guts using an Illumina platform and without the need for blocking primers. Using the agelenid spider *Hololena adnexa*, we tested several variables in the extraction process and used the results to create an optimized protocol. This protocol recovers prey DNA at a higher proportion of the total yield than has been previously obtainable. It also addresses the problem of secondary predation by substantially decreasing the detection of secondarily consumed prey. The assemblage of prey we recovered from *H. adnexa* closely resembles the findings of previous observational studies, supporting

the accuracy of our method. We are now using this approach to measure the trophic niches of spiders in the Hawaiian *Tetragnatha* radiation in order to elucidate the role of diet in the rapid diversification of this lineage.

Keywords: gut content, metagenomics, trophic niche, barcoding

Student - poster presentation

Stable isotopes illuminate niche ecology in an adaptive radiation of Hawaiian spiders

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Stable isotopes offer valuable information on organisms' niche ecology. Used in the context of adaptive radiation, these data can provide fascinating insights into the processes by which lineages evolve. Carbon and nitrogen isotopes have proven especially useful in food web studies, as they tend to increase incrementally with successive trophic levels. Isotopes also reflect the chemical stoichiometry of an individual's habitat, as isotopic signatures are passed from soil and water to plants, and on to consumers. We used C and N stable isotopes to measure niches of spiders in the Hawaiian *Tetragnatha* adaptive radiation. *Tetragnatha* spiders of both the cursorial (Spiny Leg) and web-building groups were collected from sites of different geologic age and were tested for their isotopic signatures. *Ariamnes* spiders, which specialize on hunting other spiders, were also included, and foliar samples were taken as a baseline. We found a clear stepwise increase in $\delta^{15}\text{N}$ from plants to Spiny Leg spiders to web-builders to *Ariamnes* for all sites tested; furthermore, as substrate age increased, $\delta^{15}\text{N}$ increased in every category. These results suggest that 1) web-building *Tetragnatha* may occupy a higher position in the food web than their Spiny Leg congeners, and 2) *Tetragnatha* and *Ariamnes* spiders exhibit high site fidelity, reflected in their site-specific nitrogen

isotopes, which may promote speciation by isolating nearby populations from each other. Work is now underway to test for dietary differences among the spider groups using gut content metagenomics.

Keywords: niche ecology, trophic ecology, stable isotopes, adaptive radiation

Student - Poster presentation

Diversity and community structure of arboreal spiders (Araneae) in grassland-shrub systems

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Native grasslands are among the most imperiled ecosystems and with continued habitat alteration, we require greater understanding on the species potentially affected. An important component of the invertebrate community of these grasslands, are spiders. However, relatively little is known about arboreal species in grassland systems. For instance, temperature, humidity, and structural complexity of many perennials may allow spiders to segregate in these systems and be partially determined by these ecoregion effects. Thus, without including shrub habitat and its occupants in modern grassland models, we cannot clearly determine what ecological drivers within a landscape are crucial to these spiders survival and its implications for overall species distribution. The objective is to determine the responses of arboreal spider populations to habitat structure and landscape attributes of native grassland shrubs and how those patterns scale to define habitat use and niche width. To assess the factors responsible for diversity variation, I examined data collected for a multi-year biodiversity study within selected Colorado National Grassland sites. Preliminary data indicates that shrub species offer unique structural or temporal factors to spider communities in grasslands. To measure the responses to landscape variation, I examined how different spider species respond to broad-scale to fine-scale ecological gradients (elevation, vegetation density). In this

way, spider communities within grassland shrubs serve as a model system for habitat diversity, fragmentation, patch size, and other aspects of spatial heterogeneity.

Keywords: grassland, Araneae, spatial heterogeneity

Poster presentation

Database of South East Asian jumping spiders

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In 2001 I started to study the spiders (labah-labah in Malay) of Sabah, Malaysian Borneo. However, summarizing literature (field guides, handbooks) was lacking, and internet databases were still in their infancy. I started the compilation of a database with all the pictures (drawings, photographs) from the scattered literature referring to species or genera of jumping spiders (Salticidae) that may occur on Borneo (so: literature describing species from Borneo and neighbouring areas like Sumatra, Java, West-Malaysia, Singapore, Thailand, Southeast-China, Vietnam, Philippines). The database 'Labah-labah Sabah' was developed in such a way (MS Access, simple structure, pictures incorporated within the database), that it should be easy to use. It now contains about 10,500 pictures. Although a tremendous progress was made with internet databases, my database still has a few advantages. For example, pictures can be arranged in an 'atlas' of pictorial datasheets per species (a Southeast Asian jumping spider book!) or in overviews of similarly looking genital organs. Its major drawback is, of course, that it is restricted to Salticidae and to Southeast Asia. If it still may be a useful tool for you, I will be glad to provide you with a (free) copy of the whole database (1.95 GB) and/or a pdf of the atlas (150 MB).

Keywords: Salticidae, Southeast Asia database, identification

Poster presentation

Towards a spider photo guide of Xishuangbanna, Yunnan, China

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Reliable field guides with nice, colourful photographs of spiders, with their correct names, are not widespread in Southeast Asia. The oldest is a field guide to common Singapore spiders (1989), only to be followed by guides for Thailand (2001, citrus orchards only), Hong Kong (2007, jumping spiders only), China (2011, entirely), Brunei (2013), and Malaysia (2015). Most of the scientific literature describes how spiders look like in collections, after at least several years of preservation with consequent loss of colours. This all makes it difficult to interest the general public or even life science students in tropical arachnology. We need more field guides (printed, on the internet, or both) to show what magnificent creatures live in tropical rain forests, which are constantly under threat. In July 2015 the first steps were taken to prepare a field guide with photographs of live spiders of Xishuangbanna prefecture, in the very south of China, close to Laos. Here, expanding rubber plantations pose the greatest threat. Within three weeks, more than 750 specimens were photographed from various points of view. The spiders were collected by hand and by fogging, during day and night, by a team of four collectors. All spiders were anaesthetized and photographed against a white background, in such a way that important features will be well visible. Afterwards the spiders were preserved in 96% ethanol and transported to Beijing for proper identification and, in some cases, DNA analysis. A first Chinese version of the 'Xishuangbanna spider photo guide' with about 150 species is expected to be ready in 2017.

Keywords: identification, photography, field guide, South China

Oral presentation

Community assembly over evolutionary time: application of next generation sequencing for high throughput assessment of Hawaiian arthropod diversity

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Home to impressive and diverse adaptive radiations, the Hawaiian Archipelago is a biodiversity hotspot of global importance. In conjunction with its geographic isolation and well known geology, the island chain is also considered a natural laboratory for the study of island biogeography. Although much of the Hawaiian biodiversity is comprised of arthropods, very little is known about diversification and assembly of Hawaiian arthropod communities. In a collaborative project, we currently aim to understand the processes underlying Hawaiian arthropod community assembly. The emerging technologies of next generation sequencing now allow for unprecedented insights into the contribution of species interactions, abiotic factors and island geology, in shaping Hawaii's diversity. We have developed next generation sequencing based tools for rapid, cost efficient and large scale analysis of taxonomy, biogeography and species interactions. Here, we present results from the application of Illumina sequencing to:

- (1) Multi-locus phylogenetic and taxonomic analyses. By simple amplicon sequencing, we are building a comprehensive barcode reference library for Hawaiian arthropod taxa.
- (2) Metabarcoding of mixed arthropod samples. We have optimized barcoding protocols for qualitative and quantitative analyses of the species composition in communities.
- (3) Large scale population genetics. We have reestablished microsatellites as cost efficient markers for large scale population genetic studies across multiple species. We present an Illumina sequencing protocol for these markers and a simple software solution for data analysis.

Keywords: Illumina sequencing, Hawaii, metabarcoding, community analysis

Oral presentation

The hemolymph pressure pump of armored spiders (Araneae)

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Hemolymph pressure in spiders serves many functions, e.g., extension of leg joints. The hemolymph pressure pump is generally considered to be the prosoma that can be flattened by dorsoventrally running muscles. In many taxa of Araneomorphae, a peculiar sclerotisation of the body is seen, i.e. sclerotised prosomal pleurae being immovably connected to carapace and sternum, a sclerotised pedicel, and abdominal scuta. A functional-morphological analysis of the armored species *Comaroma simoni* (Anapidae), *Perania nasuta*, and *Indicoblemma lannaianum* (Tetrablemmidae) leads to the hypothesis of a hemolymph pressure pump in the opisthosoma (and not in the prosoma) of these (and presumably all armored) spiders. Armored spiders transformed the prosoma into a stiff, inflexible capsule by connecting carapace and sternum with a largely sclerotised pleura, show a strongly thickened opisthosomal cuticle, adaptations in areas of the opisthosoma where the cuticle has to be membranous for functional reasons (e.g., mechanosensitive organs), a pressure-generating specialized muscular "abdominal sac" and corresponding cuticular muscle attachments, a reduction of the prosomal musculi laterales, and a reduced number of extrinsic coxal leg muscles. By transforming the prosoma into a stiff capsule and by generating hemolymph pressure in the opisthosoma, armored spiders presumably protect their sensitive pleurae from predators (e.g., pompilid wasps) and save energy: the leg coxae move in a stiff frame provided by the hardened pleura, in this way making the striated and energy-consuming musculi laterales and a part of the extrinsic coxal muscles superfluous. Juveniles of armored spiders show no or only minor sclerotisation of the body and therefore presumably generate hemolymph pressure "normally" in the prosoma. This is explained by the need to retain membranous pleurae as long as the animals have to molt and it further explains why no armored species occur in Mesothelae and Mygalomorphae.

Keywords: functional morphology, hemolymph pressure, armored spiders, muscles

Oral presentation

The evolution of genital complexity and mating rates in size dimorphic spiders

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Genital diversity may derive from a sexual conflict over polyandry, where male genital features function to manipulate female mating frequency against her interest. Correlated genital evolution across animal groups is consistent with this view, but linking genital complexity with mating frequencies remains untested. In extremely sexually size dimorphic spiders (Nephilidae) males mutilate genitals to form genital plugs, but these plugs do not always prevent female polyandry. We tested, using phylogenetic comparative methods, whether male and female genital complexity coevolve, and how they relate with the evolution of monogamy and polygamy. We found a positive correlation between male and female genital complexity, and the prevalence of monogamy in species with complex male genitals, suggesting that male genital complexity increases to limit female mating rates. Perhaps complex genitals are required to facilitate breakage in which the genitals remain in the female. In turn, females may evolve mechanisms to evade sexual monopolization by males, including sexual cannibalism and genital simplification. These data highlight the close evolutionary links between post-mating sexual selection and sexual conflict.

Keywords: sexual selection, sexual size dimorphism, female gigantism, genital complexity, sexually antagonistic coevolution, *Nephila*

Oral presentation

Spider feet evolution: multiple acquisitions of distal articulations in homologous location

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Most of the interaction of spiders with the substrate where they live occur just on the tips of their legs. Because of that, the different lifestyles have a profound impact on their feet anatomy. Web builders and vagrant spiders with adhesive setae are just two exemplary lifestyles where the functional anatomy is relatively well known from a few exemplary species with mostly solid tarsi (i.e., without distal articulations), but there are many spiders with apical divisions in the tarsus. Recently it has been described eight exemplary configurations of feet from diverse clades with various lifestyles and ethological specializations, to illustrate the diversity of structures and shapes that occur in spiders. Here we present new data on the tarsal evolution of Caponiidae, cryptic vagrant spiders that live in the lift litter, which presents a simple foot configuration without suture but some genera may present a distal articulation, an enormously pretarsus, cuticular

cracks (or pseudosegments) or, unusual for spiders, an eversible fleshy arolium. Also, we focus on the evolution of raptorial feet, present in both web-builder and active hunters, which involves hyperflexion of the claws over opposing macrosetae in several distant taxa. Finally, we discuss the possible function of those configurations.

Keywords: morphology, anatomy, spider feet, homology, evolution, phylogeny

Poster presentation

Comparison of zinc-based fixatives for histochemical and histomorphometric analysis of arachnid tissues

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Producing good histological preparations of arachnid tissues is often quite problematic. Studies that require high-fidelity morphological preservation for histomorphometric measurements, or spatial localization of histochemical events, inconsistent or poor histologic preparations can render samples useless for light microscopy analysis. The underlying causes of this variability are not always clear-cut. However, choice of tissue fixative is a significant factor in determining the quality outcome of an arachnid histologic preparation. Zinc-based fixatives have proven to provide exceptional morphological preservation, retention of DNA/RNA integrity and antigenic properties of vertebrate tissue and some insect tissues. However, the application of zinc-based fixatives on arachnid tissues has been quite limited. This study compares histological preparations of select tissue types such as neuronal, ocular, digestive and reproductive from several arachnid orders including: Araneae, Scorpiones, Opiliones and Solifugae. Specimen samples were fixed immediately post-sacrifice with various zinc-based fixatives or with commonly used formaldehyde-based fixatives (zinc-free). Following fixation, all tissue samples were comparably processed, embedded and sectioned. Staining was either tinctorial or with an antigenic marker identifying a particular protein expression via immunohistochemical technique. The results illustrate

that zinc-based fixatives are very effective in maintaining high-quality tissue integrity for simple and complex histological investigations of a variety of arachnid tissues. Keywords: histology, histomorphometry, immunohistochemistry, microscopy

Oral presentation

Ultrastructure in phylogeny of Araneomorpha

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SEM-analysis of leg cuticle of araneomorph spiders revealed that the well known fingerprint and scaly types represent two phylogenetic groups. It is possible to confirm phylogenetic position of araneomorph taxa by study of ultrastructure. Type of cuticular ultrastructure is correlated to setal ultrastructure. Setae of groups with fingerprint type cuticle are plumose or feathery, while setae of groups with scaly cuticle are serrate or simple. Fingerprint pattern is plesiomorphic in Araneomorpha. Ultrastructure of basal trichobothrial plate and tarsal organ are useful in study of phylogenetic relationships. Fingerprint type cuticle is present in *Dysderomorpha* (including Hypochiloidea), Eresoidea, RTA-clade with related Deinopoidea, Lycosoidea, and Dionycha. Leg cuticle of Thomisidae is papular or smooth with remnants of fingerprint type, but their setal structure is plumose and sometimes modified to resemble the branched type in Stiphropodidae and Zodariidae. Scaly cuticle is present in all Araneoidea s.lat., Archaeoidea and Palpimanoidea s.str. (but not all Palpimanoidea sensu Platnick & Forster). Filistatidae with different ultrastructure in all of its structures must be excluded from Araneomorpha. Nicodamidae s. str. and Homalonychidae with their “scaly” cuticle remain with uncertain placing. Megadictynidae Lehtinen, 1967 is excluded from Nicodamidae. Fingerprint pattern is best preserved in basal plates of large spines. Araneomorpha has neither been evolved from any recent group of Mygalomorpha nor from Liphistiomorpha, but all four groups, including Filistatomorpha have

independently evolved from extinct groups with no living representatives.

Keywords: SEM, cuticular anatomy, taxonomy

Poster presentation

Spiders from the “LLAMA” collection in the Museum of Comparative Zoology

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List and photo display of spiders from the “LLAMA” collection (Leaf Litter Arthropods of MesoAmerica) in the Invertebrate Zoology department collections, Museum of Comparative Zoology, Harvard University.

Keywords: leaf litter spiders, museum collections

Student - poster presentation

Cladistic analysis of the genus *Sphecozone* O. P.-Cambridge, 1870 (Linyphiidae)

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The genus *Sphecozone* O. P.-Cambridge, 1870 includes 34 species and has *S. rubescens* as its type-species. Except for the North American *S. magnipalpis* Millidge 1993, all species of the genus occur only in the Neotropics. The monophyly of *Sphecozone* is supported by the loss of the paracymbium and the radical ridge, and the origin of the atrium. It has *Tutaibo* Chamberlin, 1916 as sister group, and is related to *Ceratinopsis* Emerton, 1882, *Dolabrator* Millidge, 1991, *Intecymbium* Miller, 2007, *Gonatoraphis* Millidge, 1991, and *Psilocymbium* Millidge, 1991 based on the absence or reduction of paracymbium, a structure present in the palps of males of the superfamily

Araneoidea. Despite previous studies, the internal relationship and monophyly of *Sphecozone* is doubtful, and hypotheses about a possible revalidation of *Hypselistoides* Tullgren 1901, and *Brattia* Simon, 1894, its junior synonyms, are also discussed. In this context, a new cladistic analysis of *Sphecozone* is in progress, and currently, is composed by 18 species of *Sphecozone* as the ingroup, one representative of *Ceratinopsis*, *Dolabrator*, *Intecymbium*, *Gonatoraphis*, *Psilocymbium*, *Tutaibo* and *Grammonota* Emerton, 1882, and two of *Moyosi* Miller, 2007, comprising the outgroup. So far, preliminary results show only one most parsimonious tree (L=169; CI=0.46; RI=0.57) and confirm the uncertainties concerning the monophyly of *Sphecozone*, and the possible revalidation of *Brattia*.

Keywords: phylogeny, parsimony, spiders, Neotropics, Erigoninae

Oral presentation

Jumping spiders as models for the study of animal coloration

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Coloration is one of the most striking phenotypic traits in animal kingdom and has evolved to serve a great diversity of functions including camouflage, mimicry, masquerade, aposematism, pollination, social, and sexual signaling. However, the increasingly complexities of reconstructing how the receivers (conspecifics, predators and prey) perceive, integrate and process spectral information present challenges that hamper accurate, biologically-relevant appraisals of animal coloration. This is particularly true in jumping spiders (Salticidae). Salticids are renowned for their intricate vision-guided predatory and sexual behavior, and particularly for the acute eyesight of their principal eyes, which also support color vision, including UV vision. Most salticids are diurnal predators that prey on various arthropods, including other spiders, thus predation pressure from salticids is one of potential selective force of the evolution of arthropod coloration. Many male salticids sport garish coloration and some have strikingly

iridescent markings that are used sexual selection. These make salticids exceptional models for the study of evolution of color communication, and of animal signaling in general. However, a lack of proper foundation on how salticids perceive, integrate and process colors from prey and conspecifics makes it difficult to develop the study of coloration of salticids and their prey arthropods in a rigorous and coherent manner. In this paper, we therefore review the state of current research, present the challenges, and urge for collaboration to develop a framework for the study of salticid coloration and sensory ecology.

Keywords: jumping spiders, vision, color, visual modeling, sensory ecology

Poster presentation

Autotomy and surface incline interactively affect movement in pholcid spiders

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Autotomy of limbs is a common trait across many arachnid taxa that allows animals to escape from dangerous situations. Isolating and identifying the effects of autotomy is often undertaken in the lab, but choosing ecologically relevant ways to measure these effects can be challenging. Building on previous studies of pholcid spiders, we examined the effects of autotomy on spiders traveling on surfaces at different angles. Using a repeated measures design, we examined maximum speed, stride length, stride cycle and duty cycle of both spiders with all eight legs intact and spiders with an autotomized leg. Speed declined with increasing angle of the surface and with autotomy. A variety of changes in stride kinematics were observed for autotomized spiders as compared to intact spiders, which we believe is likely due to compensation for a missing leg. Overall, our data suggest that the angle of the surface on which spiders move is an important part of the ecological

context in which autotomy occurs. The orientation of surfaces in natural habitats is likely to determine the ways in which spiders will react to the loss of a limb. While many spiders are able to regrow autotomized limbs, pholcids are not. The ability to compensate for limb loss may ameliorate selective forces that maintain regeneration in other spiders. Keywords: autotomy, regeneration, locomotion, kinematics, Pholcidae

Student - Poster presentation

How citizen scientists help scientists to do real scientific researches on arachnology?—A case of spider survey in Taiwan

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The information of species-richness and distribution from local to global is important for biodiversity conservation. However, to evaluate biodiversity status is difficult because that we must input large time and financial aid. Recently, we had an opportunity to overcome the difficulty by using a citizen science approach that could help scientists to address large-scale data and has made substantive contributions to ecological research and environmental management. Here we report on the citizen scientists who participated in the public project about a spider survey in Taiwan, how to facilitate spider investigation, specimen sampling and scientific education. We assembled records from citizen scientists using social network platform (Facebook group) and framed systematic investigation in regular sampling area every year. It helped us to accumulate great amount of data about spider diversity rapidly in large spatial and long time scale, to obtain specimens to help us to clarify taxonomic problem. The data is all public and shared according to principle of open data that made spiders have more attention by crowd. Notably, there are still some constraints and weakness we need to overcome in the future, therefore it should be cautious when using citizen science approach on Araneae studies.

However, since environment status decline and biodiversity loss increasingly, and “taxonomic scientist extinction”, cooperation among the amateurs, scientist and government become critical to contribute for scientific research on arachnology of taxonomy, species diversity, evolution and population tendency monitoring indeed.

Keywords: citizen science, monitoring, species diversity

Poster presentation

On the *Neohahnia ernsti* (Simon, 1897) (Araneae: Hahniidae): redescription and new records

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Simon described *Neohahnia ernsti* based on males and females from the West Indies. Afterwards, Petrunkevitch examined specimens from Puerto Rico. *Neohahnia ernsti* was originally assigned to *Hahnia* and transferred to *Neohahnia* by Lehtinen, who provided figures from male and female genitalia. Here, we redescribe and illustrate *N. ernsti*. The male palp retrolateral view and female epigynum ventral view are illustrated for the first time, SEM images were taken as complement to species description and new distribution records are provided. Males of *N. ernsti* resemble males of *N. chibcha*, for combination of the following characters: shape of cymbium rounded, the embolus curves clockwise direction around the bulbus in a complete circle and lying on a furrow on the tegulum, without median apophysis and the shape of retrolateral tibial apophysis long and curved but differs from males of *N. chibcha*, by embolous curves in little V-shape in cymbial furrow, RTA is thin semicircular and is directed against patellar apophysis which is also curved but with 1–3 hooks,

whereas in *N. chibcha* the embolus curves in S-shaped to the furrow at base of cymbium and RTA is directed towards the patellar apophysis which has a curved tip. Females of *N. ernsti* resembles females of *N. chibcha* for the simple epigynum, but in *N. chibcha* copulatory openings are rectangular, ducts are highly coiled, with loop laterally in irregular loops trajectory terminating in connecting with lateral surface of posterior spermathecae, fertilization tubes are small and lateral, whereas in *N. ernsti* the paired openings (or “pockets”) are very conspicuous, with copulatory ducts almost globular and small central fertilization tubes. Keywords: dwarf sheet spiders; Neotropics, Hahniinae, taxonomy

Oral presentation

Variation in morphology and organization of the secondary eye optic neuropils across the order of Araneae

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Although the relationship between behavior and the brain is well studied in insects, the brains of only a few of the some 40,000 spider species have been described and comparative studies of spider brain morphology are limited in scope. The current project uses a novel histological technique that allows for the rapid processing and imaging of whole spider cephalothoraxes. This approach improves our ability to accurately measure brain regions and places the brain within the context of other tissues, giving a more holistic view of spider neuromorphology. Nineteen species sampled from across the Araneae show striking variation in general brain morphology and the size of different brain regions. In particular, the organization and morphology of the visual processing pathway of the secondary eyes show four distinct conditions. These conditions vary both in the number of pre-protocerebral optic neuropils and in the connectivity pathways between the secondary eye retinas

and nerve tracts in the protocerebrum. The current study highlights the vast amount of variation found in spider neuromorphology and the potential for using brain variation to study visual processing in spiders.

Keywords: brain, vision, morphology, variation

Oral presentation

Systematics and biogeography of the Asian forest scorpions, genus *Heterometrus* Ehrenberg, 1828

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Asian forest scorpions of the genus *Heterometrus* Ehrenberg, 1828 include some of the world's largest scorpions, e.g., *H. swammerdami* Simon, 1872, reaching almost 180 mm in length. As their vernacular name suggests, the 36 species of *Heterometrus* are distributed throughout the tropical and subtropical forests of South and Southeast Asia, from Pakistan to Wallace's Line. All *Heterometrus* species are fossorial, rarely leaving their underground burrows and, consequently, their dispersal abilities are limited. We present the first phylogeny of *Heterometrus* and the first biogeographical analysis of Southeast Asian scorpions using both morphological and molecular data. The dataset comprised approximately 70 samples representing twenty-two ingroup species from across the distribution. Other genera of the family Scorpionidae Latreille, 1802 from Africa and the Middle East were included as outgroups. The origins and diversification of *Heterometrus* were tested using divergence time estimation and ancestral range estimation. Results of this study have implications for the systematics of Asian forest scorpions and for understanding the complex geological history of South and Southeast Asia.

Keywords: systematics, scorpions, biogeography, Southeast Asia

Oral presentation

***Brachypelma vagans*, a successful invasive species on Cozumel Island, Mexico: a molecular perspective**

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The Mexican redrump tarantula has shown its high potential as an invasive species through two successful invasions. One in Florida and a second which commenced on Cozumel Island (Mexico) in 1971, through the liberation of different animal species after the filming of a movie. The context for the tarantula in Cozumel is particularly interesting because the island has a protected area in the north and a highly perturbed zone in the center and south for the development of important touristic infrastructure. Using highly polymorphic molecular markers (ISSR; Inter Simple Sequence Repeats), we studied the genetic diversity and population structure of this protected tarantula at two localities on Cozumel island (invasive area) and two localities on the mainland (the Yucatan Peninsula being its natural distribution range) as a reference. At all localities, genetic diversity is high suggesting that the invasive population has not experienced the negative consequences of the founder effect. Tarantula biology and environmental conditions were invoked in order to understand why the invasions have been so successful. The genetic structure of one population on the island, within a conserved area in the north part of the island, presents a genetic profile similar to the original invasive populations, whereas the other population, in the tourism orientated south of the island, presents a mix of the original and mainland profile. These results suggest more recent introductions associated with the human activities on the island. Furthermore, we identify one mainland population that appears to be at risk of extinction, revealing how a species can be at risk in its natural range of distribution but a successful invader in new areas.

Keywords: population genetic, genetic diversity, invasion, conservation

Oral presentation

Surprising sisters among the salticids

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Much of the broad structure of salticid phylogeny has been resolved using morphology, a several-genes molecular dataset, and now a genome-wide dataset with a few hundred loci. Nonetheless, there is uncertainty deep in the phylogeny, most smaller clades have no phylogenetic studies, and many distinctive lineages remain to be discovered and placed. Field work in Australasia, Asia and South America over the last 10 years has uncovered several such distinctive lineages: sister groups to well-known lineages, each geographically or morphologically surprising. These include a larger-bodied sister group to *Neon*, a relative of *Myrmarachne* that is not ant-like, a far-away marpissine, and a deeply diverging lysomanine (finally). This talk will include a quick tour of salticid phylogeny, the field sites, the living spiders, and of course, their genitalia.

Keywords: jumping spiders, taxonomy, systematics, Herb Levi

Poster presentation

Phylogeny with introgression in *Habronattus* jumping spiders revealed by transcriptomes (Araneae: Salticidae: Harmochirina)

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The approximately-100 species of *Habronattus* are notable for their complex and diverse courtship displays, and frequent evolution of neo-Y chromosomes. The group's phylogeny has been reconstructed with morphology by Griswold and two genes by Maddison & Hedin, but poorly resolved areas remain that hinder interpretation

of character evolution. Hybridization and introgression among distant species, suggested by previous molecular data, may play an important role in the group's evolution, but its extent has been unclear. We assembled transcriptomes for 34 *Habronattus* and 2 outgroup species and conducted a concatenated phylogenetic analysis using Maximum Likelihood for 2.41 Mb of nuclear data and for 12.33 kb of mitochondrial data. The concatenated nuclear phylogeny was resolved with high bootstrap support (95–100%) at most nodes. Several instances of mitochondrial introgression are suggested by mitochondrial-nuclear discordance. Bayesian Concordance Analysis and Patterson's D and DFOIL statistics indicate introgression in the *viridipes/clypeatus/coecatus* group and the *americanus* group, some distant, with (for instance) one undescribed Mexican species showing about 20% of its genome introgressed from a different species group. Thus, although divergent branching dominates the history of genetic descent in *Habronattus*, reticulate evolution may have been frequent enough to play an important role in shaping the group.

Keywords: phylogenomics, introgression, incomplete lineage sorting, Salticidae, Plexippini

Student - Poster presentation

Do RTA-clade spiders possess the same suite of silk genes as orb-web weaving spiders?

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Key innovations are traits that promote speciation and the ecological success of a clade. Key innovations are verified through sister-group comparisons, which requires understanding when a trait originated and the relationships between groups with the trait and their sister groups, both of which are accomplished through phylogenetic analysis. For spiders, there are two conflicting phylogenetic hypotheses, however, which affect the classification of two key innovations in spider evolution, the orb web and aggregate gland sticky-glyce droplets, which must be resolved before we can begin to determine whether these

traits are key innovations. Until recently, the favored phylogenetic hypothesis included the clade Orbiculariae, which was composed of two groups that include orb-web-weaving spiders: Araneoidea and Deinopoidea. It implied a more recent evolution of the orb web. Under this hypothesis, the sister group of Orbiculariae was the RTA-clade, a megadiverse group named by the retrolateral tibial apophysis (RTA) structure of the male genitalia. The RTA-clade includes spiders that build sheet webs or that have abandoned web-construction altogether. Recent evidence, however, suggests that Deinopoidea is sister to the RTA clade, implying either an earlier, more ancestral evolution of the orb-web with multiple losses, or less likely two separate origins of the orb-web. Both of these hypotheses make mutually exclusive claims about the morphological and phylogenetic characteristics of the silk systems of these three clades. Our understanding of deinopoid and RTA-clade silk systems, however, is poor compared to those of araneoids. To approach this issue and add to our understanding of deinopoid and RTA-clade silk systems, we combined morphological, histological, and non-traditional phylogenetic (comparing silk genes as opposed to housekeeping genes) analyses of deinopoid and RTA-clade silk systems to test the claims of these two hypotheses and clarify the evolution of spiders

Keywords: RTA-clade, phylogenetics, orbweb

Student - poster presentation

Influence of age and environmental enrichment on tarantula (*Grammostola pulchripes*) personality

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Personality in arachnids is increasingly being studied, but the majority of work has been with social species within colonies. Tarantulas, which are traditionally thought of as solitary, have been studied in the context of personality even less. Our project examined the impact of environmental enrichment and age on tarantula personality. Personality was assessed on a spectrum of bold

to shy behaviors; measurements included latency to prey capture and exploratory behavior. Tests of these behaviors were performed three times over a six month period using arena prey capture trials and video tracking of exploratory behavior in a novel environment. Two age groups were used — spiderlings and juveniles — and split into separate environmental types: simple and enriched. The simple environments held only coconut substrate, and the enriched environments had the addition of artificial plants. Juveniles were found to be significantly more active in their explorations, and most likely to spend time away from the periphery of the arena, which corresponds with bold behavior. Surprisingly, no differences were found between tarantulas housed in the two types of environments. Similarly, latency of prey capture was alike between age and environmental groups. These results suggest that age may play an important role in personality, while environmental enrichment appears to have no effect.

Keywords: Tarantulas, personality, environment, age

Oral presentation

How far is far? Spatial variation in the structure of spider communities in the Udzungwa Mountains, Tanzania

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Understanding the mechanisms behind community assembly is no trivial task. One must consider processes such as adaptation, speciation and movement, and use data on the ecological and evolutionary relationships among

organisms, and on the interactions with their physical environment. Elevational gradients offer one powerful tool to disentangle the relative effects of these processes because the zones or bands along a gradient represent different conditions across which species composition and abundances vary. In our talk we will present a novel framework to investigate community assembly using spider communities as a model. By combining habitat-related physical and (functional and phylogenetic) community structure data we are looking into the way climate and geography, habitat use and dispersal all interact to determine how species are filtered into communities. We will show our first findings on the spatial changes in communities while introducing our model system: the Udzungwa Mountains, part of the Eastern Arc Mountains (EAM), Tanzania. The elevational range (300–2500 m) in the Udzungwa Mountains creates gradients in temperature and humidity, allowing for a variety of habitat types. From evolutionary and conservation points of view, the EAM are particularly exciting as they form an inland archipelago with a history at least as fascinating as that of the Galápagos Islands, and they contain some of the oldest and most stable forests of Africa and some of the most endemism-rich forests in the world.

Keywords: beta diversity, community assembly, Eastern Arc Mountains, functional structure, habitat, Udzungwa

Student - oral presentation

The ecological niche of subterranean spiders

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The geometry of the Hutchinson's hypervolume derives from multiple selective pressures defined, on one side by the physiological tolerance of the species, and on the other, by intra- and interspecific competition. The quantification of these evolutionary forces is essential for the understanding of the coexistence of top predators. We address this topic by investigating the ecological niche of three spider species showing different adaptations to subterranean

life (*Meta menardi*, *Pimoa* n.sp. and *Troglohyphantes vignai*), occurring syntopically in different hypogean sites of the Western Italian Alps. We surveyed different populations of our model organisms over one year, monitoring monthly their spatial and temporal dynamics in the caves and the associated physical and ecological variables. We quantified the ecological niche of the three species through multi regression techniques (GLMMs) and assessed interspecific competition by evaluating the overlap between their n-dimensional niche hypervolumes. We detected a remarkable overlap between the microclimatic and trophic niche of *M. menardi* and *Pimoa* n.sp. However, the former—being larger in size—resulted the best competitor in the vicinity of the surface, causing the latter to readjust its spatial niche slightly towards the internal part of the cave, where prey availability was scarcer. On the other hand, lacking true competitors in the inner sections of the cave, *T. vignai* realized its niche as a trade-off between optimal microclimatic conditions and trophic availability. With this work, we aim at providing new insights about the complex relationships among subterranean species, demonstrating that energy-poor environments such as caves maintain the potential for diversification of top predators via niches differentiation.

Keywords: autoecology, cave, Hutchinsonian hypervolume, interspecific competition, niche overlap

Student - Poster presentation

Ecology of *Argyroneta aquatica* in a small resurgence

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The water spider *Argyroneta aquatica* is the only known spider to conduct a wholly aquatic life. For this reason, it has been the object of an array of studies concerning different aspects of its peculiar biology such as reproductive behavior and sexual dimorphism, physiology, genetic and silk. On the other hand, besides some empirical observations, the autoecology of this spider is widely understudied.

We conducted an ecological study in a resurgence of the Po Plain (Northern Italy, Province of Vercelli) hosting a relatively rich population of *A. aquatica*, aiming at identifying the ecological factors driving its presence/absence at the micro-habitat level. By means of a specific sampling methodology, we acquired distributional data of the spiders in the study area and monitored physical-chemical and habitat structure parameters at each plot. We analyzed the data through Bernoulli Generalized Linear Models (GLM). Results pointed out a significant positive effect of the presence of aquatic vegetation in the plot. In addition, the presence of the water spider was significantly associated with areas of the resurgence characterized simultaneously by high prey availability and low density of predators.

Keywords: water spider, Po Plain, wetlands, binomial regressions

Oral presentation

Palaeartic and Nearctic versus Holarctic: how do spiders fit into zoogeographic regions?

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There are two alternative opinions about the biogeographic subdivision of the Northern Hemisphere. Many biogeographers recognize the Holarctic realm with two main subdivisions: the Palaeartic and the Nearctic, while some consider Palaeartic and Nearctic as separate biogeographic realms. In this presentation, I address the distribution of spider taxa in the northern Eurasia, northern Africa and North America and show how it corroborates different biogeographical schemes. A special emphasis will be given to the spiders distributed in the Boreal and tundra zones. Spiders of these zones are much better studied in both the Western and Eastern hemispheres than the spiders of other ecological zones.

Keywords: zoogeography, Holarctic, Palaeartic, Nearctic, boreal zone, tundra zone

Poster presentation

Spiders of the *Pardosa laura*-group (Araneae: Lycosidae) in the Far East Russia

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Pardosa laura-group is a group of small-sized lycosids occurring in Far East Asia (Japan, Korea, China and Russia). It encompasses six species by now: *P. baoshanensis* Wang & Qiu, 1991, *P. graminea* Tanaka, 1985, *P. hokkaido* Tanaka and Suwa, 1986, *P. laevitarsis* Tanaka and Suwa, 1986; *P. laura* Karsch, 1879 and *P. yamanoi* Tanaka and Suwa, 1986. Study of spiders from Primorskii Province of Russia as well as from Japan reveals that two species (*P. agraria* Tanaka, 1985 and *P. diversa* Tanaka, 1985) are valid and should be removed from synonymy with *P. laura*. The latter species most probably is an endemic of the Japanese islands and its records from Korea, China and Russia actually refer to *P. agraria*. One species (*P. graminea*) is found to be new for Russia. Finding of *P. hokkaido* from Bolshehekhtsirsky Nature Reserve in Russia is doubtful and its status remains unclear. Besides the structure of males and females copulatory organs, the following somatic characters were found to be useful for distinguishing species: sternum coloration, leg I coloration, leg I spination, male palp coloration, presence/absence of carapace lateral bands, presence/absence of white hairs at eye area, and number of cymbial claws.

Keywords: wolf spiders, Asia, Pardosinae

Oral presentation

Phylogeography and diversification of chthonid pseudoscorpions in the Pacific Northwest, USA

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The Pacific Northwest region of the United States has a complex geological history, which likely has influenced the distribution and differentiation of the taxa that reside there. Chthonid pseudoscorpions in this region primarily inhabit leaf litter in moist evergreen forests, and their distribution and differentiation may reflect the geological and biotic factors that have shaped current forest ecosystems. In this study we focus on analyzing the geographic distribution, genetic relatedness, and potential morphological variation among populations of taxa within the pseudoscorpion genus *Apochthonius* in western Oregon, USA. We recover multiple cytochrome oxidase 1 clades (albeit weakly supported) that correspond to geographic location, but that do not correspond to currently described species. *Apochthonius minimus* sequences form a monophyletic group within a much larger clade of *Apochthonius occidentalis* sequences. Despite high sequence divergence among *A. occidentalis* from different geographic regions, we so far have found no anatomical features that can be used to distinguish among these individuals. We suggest that *A. occidentalis*, as currently described, represents multiple cryptic species, and that to retain the species name *A. minimus* would require naming each of these separate clades.

Keywords: phylogeography, systematics, cryptic species, Pacific Northwest, pseudoscorpion

Student - oral presentation

A revision of the spider genus *Drassodella* Hewitt, 1916 (Araneae: Gallieniellidae)

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The genus *Drassodella* Hewitt, 1916 is one of four Afro-tropical genera of Gallieniellidae, following the recent transfer of *Toxoniella* Jocqué & Warui, 2002 to Liocranidae. *Drassodella* is presently represented by seven species, all endemic to South Africa. The type material of six of the described species has been examined: *D. melana* Tucker, 1923, *D. quinquelabecula* Tucker, 1923, *D.*

salisburyi Hewitt, 1916, *D. septemmaculata* (Strand, 1909), *D. tenebrosa* Lawrence, 1938 and *D. vasivulva* Tucker, 1923, while recent field work yielded a female of *D. purcelli* Tucker, 1923. A further 13 new species are recognised from museum collections and recent field work. Based on the genitalic structure, there appear to be two distinct species groups. The *melana* species group, which includes *D. melana*, *D. tenebrosa* and eight new species mainly distributed in eastern and northern South Africa, is characterised by very conservative genitalic morphology in both sexes. The *salisburyi* species group, distributed in the southern half of South Africa, includes the remaining 10 species, of which five are new. Females display considerable variation in the structure of the epigynal hoods, lateral ridges and spermathecae, while the shape of the male palpal embolus, median apophysis, conductor and tibial apophysis also varies considerably.

Keywords: endemic, ground-dwelling, new species, South Africa

Oral presentation

Comparison of rapid assessment protocol data from Panama and Congo Basin sites

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Since 2007, we have been developing a rapid assessment protocol (RAP), for efficient collection of statistically comparable samples of spiders and millipedes from different habitats. This method intensively samples randomly selected equal areas, facilitating comparison of fauna, and requires only low cost equipment and novice field personnel. We have collected samples from monodominant and mixed rainforest sites in Central Africa (DRC), and from younger and more mature rainforest types in Central America (Panama), in both wet and dry seasons. The spider faunas of these areas are species-rich but

poorly studied, and ongoing habitat alteration and human population expansion has created an urgent need to understand and begin to conserve this biota. Preliminary results show that spider in Central Africa are more abundant and diverse in monodominant than in the mixed forest. But on both continents, the same families (Theridiidae, Thomisidae, Salticidae, and Oonopidae) dominate (10–28% of communities) both ground and aerial samples. Rare families (less than 2% of the assemblage), including Anapidae, Clubionidae, Ctenidae, and Tetragnathidae, are rare in all our sites. Some families have medium abundance (2–10%) in all sites, including Linyphiidae and Gnaphosidae. A major result is that family-level spider diversity in our Central Africa samples (368 adult specimens collected, belonging to 25 families) is very similar to sites in Central America (265 adult specimens, 24 families). This similarity on two continents requires our attention, for conservation. Moreover, some families can be considered as indicators, because of their scarcity in the populations. But this research needs to be continued. This study has enhanced collaboration between our American and African institutions, and promises to open a new era of scientific exchange between us.

Keywords: rapid assessment protocol, Afrotropics, Neotropics, spider communities, biodiversity

Oral presentation

Assessment strategies in male-male contests of jumping spiders

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Animal contests are usually resolved when one opponent makes the decision to withdraw. This decision may be influenced by diverse sources of information available during a contest. Animals may reduce the costs of fighting by assessing the quality of their opponent and withdrawing when they determine that the opponent is superior (“mutual assessment”). However, as assessment itself may be costly

or difficult, animals may adopt an alternative strategy of persisting until they reach a cost threshold (“self assessment”). We conducted a series of experiments to examine the sources of information that influence decision-making during male-male contests of the jumping spider *Servaea incana*. We considered both maximum level of escalation and duration as measures of contest costs and also examined assessment strategies used at different stages within a contest. There is substantial variation in body size in *S. incana* males and body size was a strong predictor of contest outcome. Despite the high acuity vision of jumping spiders and their dynamic, ritualized, displays, we found little evidence that *S. incana* males assess the size of their opponents during staged contests. Smaller spiders were less willing to escalate, regardless of opponent size, consistent with a self-assessment strategy. Despite an apparent lack of mutual assessment during contests between live pairs, *S. incana* males did exhibit an ability to discern ‘opponent’ size in video playback experiments. The probability of displaying was determined by an interaction between the size of an individual and its video opponent. An additional set of experiments reveal that hunger also influences contest behaviour and may blur the distinction between “contests” and “predator-prey interactions” in jumping spiders. We discuss both the limitations of correlative studies in studying assessment strategies and why spiders may not use information about an opponent during live contests.

Keywords: agonistic signalling, animal contests, assessment strategies, body size, intrasexual competition, Salticidae, visual displays

Poster presentation

Relationships between whole-organism performance, morphology and behaviour in spiders

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Studies of whole-organism performance can assist in interpreting relationships between morphology and behaviour and how these in turn contribute towards

fitness. Traits such as locomotor performance and endurance capacity may determine an animal's success in tasks such as obtaining resources, evading predators and determining the outcome of intraspecific interactions. Morphological traits may potentially contribute towards, or impede, multiple performance traits. At the same time, variation in performance capacity between individuals may result in different individuals adopting different behaviours in order to achieve similar levels of fitness. Therefore, whole-organism performance capacity may be central to understanding why animals behave the way that they do. We will present the results of a series of studies examining different whole-organism performance traits in spiders and their relationships with 1) morphology, 2) other performance traits and 3) fitness related tasks such as mating success and predator evasion.

Keywords: whole-organism performance, locomotion, morphology, sexual selection, mating success

Oral presentation

Neural responses to airborne pure tones from the brains of jumping spiders, fishing spiders and net-casting spiders

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It has been known for over a century that spiders are very sensitive to acoustic stimuli such as substrate vibrations and airflow. We report neural recordings from the brains of jumping spiders (Salticidae), fishing spiders (*Dolomedes*) and net-casting spiders (Deinopidae). We present single unit recordings from the sound-processing regions of the brain in response to airborne pure-tone stimuli. These airborne pure tones were broadcast from a loudspeaker placed 3 meters from the spider, with neural units showing responses to amplitudes as low as 55 dB (SPL), and sensitivity to species-specific frequency bands between 50 and 5 kHz. These findings raise very interesting questions about the

sensory ecology of these species—especially regarding the sensory systems and cues used for the detection of predators and prey.

Keywords: neuroethology, recordings, acoustic, jumping spiders (Salticidae), wolf spiders (Lycosidae), net-casting spiders (Deinopidae)

Student - oral presentation

Investigating the complex relationship between female state and courtship in *Schizocosa ocreata*

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The courtship of male brush-legged wolf spiders (*Schizocosa ocreata* Hentz 1844) involves both visual and vibratory signals, which are initiated upon contact with cues in female silk. Studies have found that males appear able to assess a female's maturity, mating status, and feeding history from silk alone, and that variation in male response indicates differential courtship investment. However, these studies examined single factors, and males are likely to encounter multiple females with different combinations of states under natural conditions. In order to investigate how males might assess more complex aspects of female life history, males were exposed to silk from females varying in feeding history and mating status, and behaviors of these males were analyzed for indicators of courtship investment (rates of characteristic foreleg tapping and cheliceral strikes). Results suggest the presence of multiple factors and variation in the amount of experience with female cues may have an interactive effect on male behavior, with some combinations resulting in differentially reduced courtship. Additional results also show that females with varied feeding and reproductive states behave differently during male courtship, i.e., becoming less receptive or more aggressive, which suggests a relationship between male investment and female behavior.

Keywords: *Schizocosa ocreata*, sexual conflict, sexual selection, courtship

Oral presentation

‘Opening Pandora’s Box’—morphological analyses of the male reproductive system of goblin spiders (Oonopidae) revealed an extraordinary complexity in sperm structures

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Goblin spiders (Oonopidae) are among the most species-rich spider families. Despite this diversity, goblin spiders are understudied in many aspects and their phylogenetic relationships are not well resolved. As previously shown for numerous other spider groups, the male and female reproductive system bears many characters of phylogenetic relevance. Moreover, the diversity of sperm structures within spiders is astonishingly diverse and often taxon specific. In the present study, we analyzed the primary male reproductive system and spermatozoa of goblin spiders for the first time (Lipke and Michalik, Bull. Am. Mus. Nat. Hist. 396:1–72). We investigated 18 species of 13 genera representing the subfamilies Orchestiniinae and Oonopinae by means of light and transmission electron microscopy. We scored 44 characters from the gross morphology of the reproductive system as well as spermatozoa including four new characters for the male spider reproductive system. All investigated species transfer sperm as synspermia, a transfer mode that corroborates with the recently proposed “Synspermiata” clade unifying all ecribellate Haplogynae. Furthermore, goblin spiders show by far the highest diversity of sperm structures in spiders. In total, we recovered 30 unambiguous synapomorphies for different oonopid taxa. In a comparison of all other spider taxa studied to date, we identified the longest sperm (*Neoxyphinus termitophilus*) and longest sperm conjugates (*Orchestina*). Moreover and most remarkable is the presence of aflagellate sperm in *Opopaea apicalis*, which is the first report of the loss of a sperm flagellum in tetrapulmonate arachnids. These

findings are of high interest not only because of their phylogenetic implications, but also with regard to their contribution to our understanding of postcopulatory sexual selection in spiders.

Keywords: synspermiata, ultrastructure, reproduction, spermatozoa, genitalia, systematics

Poster presentation

The endemic New Zealand spider family Huttoniidae (Araneae)

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The family Huttoniidae is known only from New Zealand and the only described species is *Huttonia palpimanoides* O. Pickard-Cambridge, 1879. The description of this species was based on a single female specimen collected in the Dunedin area of the South Island. Huttoniids are a member of the superfamily Palpimanoidea, which also includes the families Stenochilidae, Palpimanidae, Mecysmaucheniidae and Archaeidae. The present study is based on material collected over almost five decades by comprehensive collecting programs. Our examination of the material revealed considerable diversity, which is distributed throughout mainland New Zealand, but appears to be absent in the outlying Chatham and Subantarctic Islands. Moreover, the disproportionate number of immature to mature spiders in Berlese samples suggest that adult huttoniids live above the forest floor. This is supported by collecting programs covering a full range of habitats that clearly indicate that most adult huttoniids were found in dried fronds of tree ferns. There are 13 new huttonid species, the majority in the genus *Huttonia* and possibly two new genera. Most of the species appear to be locally endemic.

Keywords: taxonomy, systematics, Palpimanoidea, endemism

Student - oral presentation

Effect of increased habitat complexity on pest suppression by winter-active spiders

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Increased habitat complexity often reduces intraguild predation (IGP) among the top-predator and meso-predator and consequently increases abundances of the latter. However, reduced IGP may not necessary translate to the increased predation pressure on a pest as the increased habitat complexity can also provide shelters for the pest. Moreover, increased abundances of the meso-predator may lead to increased intra-trophic level interference that decreases the per capita capture rate of the meso-predator. Here, we investigated whether the cardboard bands installed on pear trees in early winter improve the suppression of the pear psylla, *Cacopsylla pyri*, by winter-active spiders, *Anyphaena accentuata* and *Philodromus* spp. We also investigated the effect of abundances of philodromids on their functional response and their overall predation on the pear psylla. The trees with cardboard bands hosted less psylla than the control trees in early spring. The decrease in abundances of psylla can be attributed to the predation by spiders as the molecular gut-content analysis showed that 35% of spiders preyed on psylla. However, 58% of *Anyphaena* preyed also on *Philodromus*. There was an asymptotic relationship between abundances of winter-active spiders and the effect size of psylla abundances. In the functional response experiments, the per capita capture rate decreased with abundance of conspecifics. Consequently, the overall predation pressure on psylla was lowest at low abundances of philodromids but similar between moderate and high abundances. Our results show that installation of cardboard bands in winter contributes to reduction of psylla population. However, the effect of increased abundances

of winter-active spiders on overall predation pressure on psylla is not additive, which can be partly explained by an increased intra-trophic level interference.

Keywords: intraguild predation, food-web, biological control, pear psylla, winter ecology

Student - poster presentation

Alteration of predatory behavior of a generalist predator by exposure to two insecticides

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Predation pressure exerted by spiders on pests depends on their prey choice as well as predatory activity. However, both traits can be altered by exposure to pesticides. Possible influence of pesticides on the predatory activity of spiders is known for quite a few preparations and the predatory activity can be decreased as well as increased. However, the effects of pesticides on prey choice of natural enemies have not been studied yet. The prey choice in euryphagous spiders might be altered either by the blurred cognitive abilities or by increased voracity, which are sometimes connected to lower prey choosiness in euryphagous spiders. Here we tested the effect of two insecticides, SpinTor® (a.i. spinosad) and Integro® (a.i. methoxyfenozide), on the predatory activity and prey choice of spider *Philodromus cespitum* (Araneae: Philodromidae). We investigated the prey choice of *P. cespitum* between the pest *Cacopsylla pyri* (Hemiptera: Psyllidae) and spiders *Theridion* sp. (Araneae: Theridiidae). We evaluated the predatory activity as overall

number of killed prey of both prey types. We found that the philodromids in control treatment significantly preferred theridiids to psylla while the philodromids in both pesticide treatments did not show any distinct prey preferences. Although SpinTor has been shown to decrease the predatory activity of philodromids in previous studies, both pesticide treatments increased the predatory activity of philodromids in comparison to the control in this study. The results show that the application of pesticides can disrupt the natural ecological dynamics of predator-prey interactions, not only due to the changed predatory activity but also due to the altered prey choice.

Keywords: pesticides, prey choice, predatory activity, biocontrol

Oral presentation

An ontology for spider behavior

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For over two centuries, taxonomy has provided a vocabulary, controlled by an evolving code, for naming species and other groups. Ontologies are a more recent development in controlled vocabulary, which have been developed for a wide range of areas of knowledge, including many of interest to biologists. The Gene Ontology is probably the best known example of a biological ontology, but others exist for anatomy, biological chemistry, and ecology. Ontologies cover fields at a range of granularities. Some, like the Gene Ontology, cover processes and cell components relevant across all life, whereas others, such as the SPD spider ontology, focus on the anatomy of a particular group. All ontologies include a hierarchy of terms. Ontologies also include relations between terms. The most common relation is “is a.” Another common relation is between a whole and its parts. The relations, such as “is a” and “is part of” allow computers to use ontologies to do simple reasoning and to check logical definitions for formal errors. Ontologies should include human-friendly textual definitions of terms, so ontology designers and users can properly define and understand the relationships. This talk will describe an in-progress ontology of spider behavior, based on terms

collected from two well-known sources (Foelix 2010, Herberstein 2012). It intended to provide fine-grained coverage of spider behavior, while extending and relating terms back to the general behavior terms contained in other vetted ontologies (GO, NBO, ABO). This talk also is a call for community participation; ontologies are only useful when they represent a shared understanding of the field. Participation can include reviewing, suggesting missing terms, and developing definitions. Review and contribute at <http://arachb.org/ontology>.

Keywords: behavior, ontologies, informatics, synthesis

Oral presentation

Resolving the taxonomic impediment

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The genius of Linnaean nomenclature is to assign a unique identifier, a formal taxonomic name, to every known species on earth. This identifier then becomes the basis for accumulating knowledge about that species and distinguishing it from every other species. This includes physical characteristics, occurrence records, and interactions with other species. But the magnitude of biodiversity presents a two-part challenge for applying this knowledge: 1) organizing information about what is already known, and 2) incorporating species that lack formal names and thus a mechanism for aggregating knowledge. Our collective biodiversity knowledge is vast but unevenly accessible, incompletely digitized, and largely unstructured. Semantic enhancement of primary taxonomic literature using XML markup makes it possible to query taxonomic literature like a database. We contrast data issues and solutions for charismatic groups (e.g., Aves, a flagship taxon for conservation despite comprising a scant 10,000 species worldwide) with megadiverse groups (e.g., Araneae, Hymenoptera). A series of dashboard charts have been developed to convey at a glance critical information contained in one or many taxonomic treatments. Because

of their high richness and sensitivity to environmental variables, arthropods offer some of the finest-grained data with which to assess terrestrial biodiversity at individual localities (alpha diversity) and changes across landscapes (beta diversity). But because many arthropods lack formal scientific names, ecological inventories may refer to unidentifiable species using an informal name (e.g., a morphospecies designation). But unlike formal taxonomic names, informal names are rarely used as a basis for accumulating knowledge. By posting libraries of images and DNA sequence data for informal species concepts and assigning them a persistent unique identifier, we provide a basis for accumulating knowledge about a species regardless of whether it has a formal name.

Keywords: biodiversity informatics, cyberdiversity, cybertaxonomy, GBIF, XML markup

Poster presentation

A broad spectrum inventory of a small Caribbean island

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In October 2015, a team of researchers and students conducted a rapid inventory of Sint Eustatius, a 21 km² island in the Lesser Antilles. Eleven quarter hectare plots were established, each randomly placed within a different major vegetation zone. A sampling protocol was established targeting vascular and non-vascular plants, lichen, vertebrates, gastropods, and arthropods (focusing on Araneae, Coleoptera, Formicidae, and Heteroptera). The aim of the study is to investigate which taxonomic groups can stand as surrogates for others in conservation assessment based on the Species Accumulation Index (SAI). Ultimately, we will determine whether monitoring a subset of taxa can be used as a proxy for the island's biodiversity as a whole. For megadiverse groups, not all species will be determined using formal scientific names. Nevertheless, all will be assigned persistent identifiers linked to image libraries and DNA sequences as prescribed by the Cyberdiversity approach. The Caribbean presents challenges for determining which species are shared by which islands. Because this is a Cyberdiversity inventory, independent investigators will be able to use our image libraries and sequence data to compare the biota of Sint Eustatius with that of other Caribbean islands.

Keywords: biodiversity, conservation, species accumulation index, surrogacy

Student - poster presentation

Investigating the effects of fluoxetine on anti-predator behavior of orb weaver *Larinioides cornutus* (Araneae: Araneidae)

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Biogenic amines have been shown to regulate aggression-related behaviors in both vertebrates and invertebrates, potentially playing a role in the overall fitness of the animal. Being both predators and prey, spiders are an ideal model organism for studying such behavior in the laboratory and field. In orb-weaving spiders, a careful balance of aggression must be maintained to optimize foraging

while avoiding predation. Prior research in our lab has shown that experimentally elevating octopamine and serotonin alters predator wariness in the furrow orb-weaver *Larinioides cornutus*. We are now interested in modifying this behavior with antagonistic drug manipulations. Fluoxetine, a selective serotonin reuptake inhibitor which antagonizes 5-HT_{2C} receptors, was used to modify levels of serotonin. In order to quantify changes in aggression, the anti-predator behavior, called the “huddle” response, was scored 24 hours before and after drug manipulation. The goal of this work is to further understand the role of this neurohormone in spider behavior, and to develop tools with which behavior can be manipulated in the field.

Poster presentation

Seventy-two new spider distribution records and four undescribed species from Indiana forests

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Spiders are an integral part of many ecosystems, yet their diversity is understudied in Indiana. To uncover spider diversity within the state, we collected spiders from several ecosystems in many counties across the state. Moreover, we re-identified spiders within the collection of a former Indiana arachnologist, Thomas Parker. Herein we report sixty-five new state records for spider species and update seven species distribution records. Some notable discoveries include: 1) *Antrodiaetus unicolor*, *Cybaeus giganteus*, *Oecobius cellariorum*, and *Ummidia tuobita* represent species within four new families of spiders for the state (Antrodiaetidae, Cybaeidae, Oecobiidae, and Ctenizidae, respectively), 2)

Agyneta allosubtilis is not known from the Midwest and this record indicates a large southern range extension, and 3) *Dipoena nigra*, *Eidmannella pallida*, *Idionella rugosa*, *Neon nelli*, *Styloctetor purpureus*, *Paracornicularia bicapillata*, *Oreonetides beattyi*, *Larinia directa*, *Microneta viaria*, *Spintharus flavidus*, *Lepthyphantes turbatrix*, *Lupettiana mordax*, *Tapinocyba emertoni*, *Phylloneta pictipes*, *Ceratinopsidis formosa*, *Talanites exlineae*, and *Epiceraticelus fluvialis* represent species within 17 new genera for the state. Finally, we discovered four new undescribed linyphiids in the genera *Agyneta*, *Goneatara*, *Oreonetides*, and *Wubana*.
Keywords: Indiana, biodiversity, undescribed species, distribution record

Student - oral presentation

Revision and phylogeny of Charinidae Quintero, 1986 (Arachnida, Amblypygi) based on morphological and molecular data

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Charinidae is the most diverse family of Amblypygi with 84 described species from all tropical continents. Despite of being old and having disjunct distribution, the diversity of the family is relatively low and only three genera are currently recognized, *Catageus*, *Charinus* and *Sarax*. The goal of this work is to carry out a taxonomical revision of the family and to elucidate the phylogenetic structure of the family. The morphology of almost all known Charinidae species were studied and a morphological matrix created with 168 characters (of which approx. 140 are new) for 101 taxa (95 charinids and 6 outgroup taxa). The matrix was analyzed under parsimony. A molecular dataset was generated from a smaller set of taxa, since DNA quality

data was only available for a fraction of the species. This dataset include both mitochondrial (COI, 12S and 16S) and nuclear gene fragments (28S and 18S) for 39 taxa. This dataset was analyzed under Bayesian Inference, Maximum Likelihood and parsimony. The data support the monophyly of Charinidae, whereas the genera *Charinus* and *Sarax* are para- and/or polyphyletic. A new classification of the family is proposed, including establishment of new genera, and new diagnostic characters for the family is presented.

Keywords: diversity, DNA, morphology, systematics, whip spider

Student - oral presentation

Fossil and setae characters: the morphological phylogeny of the family Protoschizomidae (Arachnida: Schizomida)

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Family Protoschizomidae, endemic to North America, is currently represented by two genera and 15 species. Whereas most of the species are troglobite and distributed in caves in the Sierra Madre Oriental system; or in caves in the Sierra Madre Occidental system; others are epigeal (*Protoschizomus pachypalpus*, *Protoschizomus occidentalis* and *Protoschizomus rowlandi*). Recently, a new species member of this family was described from one cave in the Mexican Trans-Volcanic Belt, representing the bridge between both Sierras. Here, we revise the systematics of Protoschizomidae; we also propose the nomenclature for the pedipalp setae of the protoschizomids; and revise the phylogenetic status of family Protoschizomidae using 137 morphological characters

(including the proposed pedipalp setae) and 7 outgroup taxa (including one fossil taxa). Our selected topology, showed Protoschizomidae monophyletic, but its internal relationships were not fully resolved. Genus *Protoschizomus* was recovered paraphyletic due to the inclusion of genus *Agastoschizomus* (recovered monophyletic) and the fossil *Onychobelyphonus bonneri*. Biogeographical history hypothesis are hard to resolve given our results; nevertheless, a hypothesis was given and compared to a similar case found in Scorpiones. The intromission of these specimens to different caves can be a factor to discuss in the current distribution of this family.

Keywords: phylogenetics, cladistics, setae, morphology

Student - poster presentation

Tails or heads? Setae patterns and annuli in the female flagellum of micro-whip scorpions (Arachnida: Schizomida)

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Schizomid flagellum is consider one of the most important characters used to delimitate species, whereas the number of “flagellomeres”, in the female flagellum, is used to diagnose genera in both families. Despite the traditional use in schizomid taxonomy, the phylogenetic importance of these characters has been only tested in the systematics of family Protoschizomidae. However, our understanding in this pseudosegmentation of the flagellum, along with different “terminologies” proposed, and the relative position of certain setae, creates conflict in terms of homology assessments. In the present contribution, we present some homology hypotheses and the phylogenetic importance

of these characters across the two schizomid families. The analyses were based on 44 morphological characters and 22 schizomid species, and two thelyphonid species as outgroup. Parsimony, Bayesian inference analyses, and ancestral state reconstruction of the “annuli” characters were conducted. The resulting topology confirmed the monophyly of Hubbardiidae further divided into Hubbardiinae + Megaschizominae. However, Protoschizomidae was not recovered monophyletic. The ancestral state reconstruction of the number of annuli in the common ancestor of Schizomida suggested gain and loss of the different annuli at different hierarchical levels. Finally, the flagellum contains good taxonomic characters, but caution needs to be taken when used to diagnose genera, since the relative position of the setae presents a lot of variation.

Keywords: Schizomida, phylogenetics, Bayesian, parsimony, flagellum

Oral presentation

Are male copulatory structures in the order Scorpiones informative at suprageneric levels?

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The male sexual apparatus is widely used in arthropod taxonomy to diagnose species. In many organisms, however, it is considered to have evolved too rapidly to be

phylogenetically informative above the generic level. In scorpions, the male reproductive organs produce a pair of partly sclerotized structures, the hemispermatophores, that are eventually assembled when they exit the body to form a spermatophore. Surprisingly, in many genera of scorpions the hemispermatophores lack the interspecific morphological diversity observed in copulatory organs of other arthropods, suggesting that these structures may actually provide a stronger phylogenetic signal for suprageneric ranks than previously thought. A thorough reassessment of the morphology of hemispermatophores and spermatophores pre- and post-insemination across the whole order, as well as of the mechanisms of insemination, allows to recognize a complex of slowly evolving characters from which a series of basic bauplans are defined. In parallel, a phylogenomic tree was inferred with an emphasis on non-bothriurid Scorpionoidea, which comprises taxa with the most complicated hemispermatophores. The taxon sampling for this group covers all the families except one and about 65% of all genera. Ancestral states of the hemispermatophore bauplans were reconstructed on this new phylogeny, and compared with ancestral reconstructions on trees based on morphological data published earlier. A putative evolutive sequence is presented and the value of male copulatory structures in scorpion phylogenetics is discussed with regard to the reliability of the different phylogenies.

Keywords: hemispermatophore, spermatophore, bauplan, phylogenomic

Poster presentation

Nanoscale fibrillar attachment devices for the dry adhesion in the salticid spider *Plexippus setipes*

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The cuticles of the salticid spiders have the distinctive attachment apparatuses for adhesion on smooth dry surface without sticky fluids. It has been reported that the van der Waals interaction plays a dominant role of the dry

attachment by fibrillar adhesion system for smooth surface. Here, we have examined the whole tarsal appendages of the jumping spider, *Plexippus setipes* with using scanning electron microscope to reveal the fine structural characteristics of its dry adhesion system. All eight legs have the scopula with a pair of claw on the tip of feet. Each scopula is composed of two groups of setae that are capable of dry adhesion on smooth surface, however the hook structure of the claw is advanced to move on the rough surface. The setae distributed on the bottom side of the tarsal segment are densely covered by numerous setules. The contact area of each setule has a triangular shape, and cuticular surface of the contact area is fully expanded with aid of its elongated stalk. In addition, spontaneous self-adhesion between the numerous setules and the setae was effectively blocked due to the numerous microscopic hairs since these hairs were interspersed on the upper side of the setae.

Keywords: nanostructure, dry adhesion, salticid spider, tarsal appendage, *Plexippus setipes*

Poster presentation

Nanoscope structure of the silk spinning spigots in the cribellate spider *Nurscia albofasciata*

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The cribellar silk is considered as a quite different sort of catching silk with dry-adhesive properties. Here, we describe the functional significance of the cribellar silk spigots for capture thread production and its peculiar sieve-like structure in the titanocid spider *Nurscia albofasciata*. By our fine structural observation using the field emission scanning electron microscopy (FESEM), surface of the cribellum is covered by hundred of tiny spigots and its microstructure is quite different from those of the spigots on the spinnerets with respect to size. All of these spigots are composed of five segments, and are all approximately the same length (10 μm). These segmented and flexible structure enable to bent itself and conjoin together with adjacent other spigots to form congregate

bundles of spigots. Thus, the calamistrum of the spider draws silk fibrils from its cribellum and helps combine them with supporting strands to form a cribellar prey capture thread. Our fine structural observation support the hypothesis that physical interaction between cribellum and calamistrum is likely be attributed to electrostatic charging during the spinning of fibers on the nano-scale.

Keywords: silk, cribellate spider, nanofiber, *Nurscia albofasciata*

Oral presentation

Repeated evolution of color vision underlies rapid diversification of salticid male coloration

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A major goal of evolutionary biology is to understand the events that lead to rapid diversification of form in the living world. Sensory systems are likely to play an important role in the diversification of signals, particularly when major changes to sensory systems enable newfound sensory capabilities in specific taxa. We studied whether major transitions in color sensitivity underlie the rapid diversification of male courtship coloration in the Salticidae, or jumping spiders. In many species of jumping spiders, males perform elaborate courtship dances that involve visual signaling as well as vibratory songs. Courting males often showcase colored body parts during these dances. In the majority of jumping spiders, these male visual signals are limited to a restricted color gamut, typically blues, greens, blacks, whites and browns. However, several jumping spider taxa represent notable departures from this trend, exhibiting an expanded color palette that includes yellows, oranges, and reds. These jumping spiders present something of a conundrum, because data collected from closely related taxa suggest that their visual systems

should have limited color discrimination abilities based on a system of UV-green dichromacy, and should therefore lack the ability to discriminate long wavelength colors such as yellows or reds. Here, we present evidence for two independent, functionally distinct evolutionary origins of color vision in the Salticidae: filter-based trichromacy in the colorful *Habronattus* jumping spiders of North and Central America, and non-filter-based tetrachromacy in the Australian “peacock” spiders of the genus *Maratus*. Using a combination of microspectrophotometry, histology, and visual system modeling, we characterize the sensitivities of these novel color vision systems and describe how they might have enabled the evolution of a wider gamut of male courtship coloration in these two spider groups.

Keywords: visual ecology, color vision, sexual selection, speciation

Student - poster presentation

Effects of starvation on foraging behavior in the scorpion *Tityus serrulatus* (Buthidae)

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Starvation is known to affect foraging and sensory performance in animals. Under starvation conditions, animals may change their foraging strategy (wandering more), become more generalist, become risk-prone and increase their sensory perception. In scorpions, it has been shown that starvation affects the physiologic state, but few works have tested how this condition affects foraging behavior. We hypothesized that starved scorpions change from sit-and-wait to roving and that the threshold for prey detection is decreased. To assess changes in the foraging strategy, we divided an arena (45.3 x 33.3 x 13.3cm) in 12 quadrants of 11.3 x 11.1 cm and quantified the total number of quadrants used, the number of quadrant changes and whether the scorpion was walking or motionless in each sampling. No prey was present during the trials. We compared scorpions starved 30 days with scorpions fed once a week before the experiment. To assess changes in the threshold for prey detection, we measured the distance (ongoing analysis) and

latency to detect crickets. We also looked at differences in specific behaviors between treatments (ongoing analysis). We found no differences between treatments in any of the measured variables so far. Perhaps the starvation period was not long enough and/or differences appear in other behaviors that we did not measure, such as ingestion time.

Keywords: hunger level, prey detection, foraging strategy, sit-and-wait

Student - poster presentation

The importance of trichobothria in prey-capture success in the scorpion *Tityus serrulatus* (Buthidae)

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Arachnids often rely on substrate-borne vibrations and air displacement to detect prey. These stimuli are detected by organs such as slit sensilla and trichobothria. We tested the hypothesis that trichobothria on the pedipalps are important for capturing prey in scorpions. We predicted that scorpions with trichobothria removed would have a lower prey-capture success rate than control groups (other setae removed/no setae removed). We first anesthetized scorpions in the freezer and cut all trichobothria on the pedipalps except those of the inner region of the femur because these were difficult to access. We then released a scorpion and an immature cricket without legs III in a circular arena with suspended filter paper in the bottom. We measured prey-capture success as the number of scorpions that held the cricket for more than 2 s and, within the group that captured prey, the number of capture attempts. We also tried to find differences between the three treatment groups in the latency to detect prey, latency to the first attack and in the number of times each animal rotated to face the prey. We found no differences in any of the variables measured. Scorpions are known to possess other sensory organs (basitarsal compound slit sensillum and tarsal hairs) that allow them to detect prey by substrate vibration. These organs may have

compensated the lack of wind detectors (trichobothria) in our study.

Keywords: filiform hairs, predatory behavior, sensory organ, vibration, wind detector

Student - oral presentation

Social networks as a metric of sociality in spiders

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Sociality encompasses a wide range of social phenotypes and complexities. Beyond Wilson's eusociality threshold, based on reproductive division of labor, generation overlap and alloparental care, and other qualitative measures, recent papers have proposed to measure sociality quantitatively. Indeed, quantitative metrics that take into account various characteristics of sociality seem to constitute more useful tools for comparative studies of social behavior. Social network analysis (SNA) is currently used as a means to describe social structures in animals, and the network structure characteristics can be compared between groups of different composition and even species. Social spiders are good models to study social behavior because they present different levels of sociality in different taxonomic levels. In this context, we used association data between individuals to develop a social network approach in *Anelosimus eximius* colonies and describe their structure. In addition, since division of labor is an important feature of eusociality, one of the major transitions in evolution, we tested for the existence of clusters in their social organization through different social contexts. *Anelosimus eximius* doesn't seem to present consistent clusters in the colony across contexts, but specialists could be identified during the performance of specific tasks in the colony.

Keywords: sociality, *Anelosimus*, division of labor, metrics

Poster presentation

Preliminary description of defensive silk in *Latrodectus hesperus*

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Numerous studies have looked at the properties of spider silk from an ecological perspective. Of these studies, most have looked at how spiders use silk in a predatory context (prey capture) while comparatively few have looked at defensive silk use, with most of these focused on stabilimenta in orb weavers. To date, two studies have been published on defensive silk use in Western black widow spiders, but none have focused on the physical characteristics of the silk. In this study, we present a preliminary description of the physical properties of defensive silk produced by *Latrodectus hesperus* which, when sufficiently threatened, actively tries to apply this silk to its attacker. We found that, unlike the sticky globules used for ensnaring prey items which are small (median 0.004 nL; range 0.001–0.008), these viscous globules are often relatively large (median 1.46 nL; range 0.14–29.79). These globules also appeared to lack hygroscopic properties causing them to quickly desiccate after production and lose their adhesive properties. Rate of desiccation was dependent on size with larger globules taking longer to dry. Most globules completely desiccated in less than five minutes. We also show that this defensive silk forcefully contracts after production. When silk was suspended between thin wires the distance between wires was reduced by a median 2.88% (range 0.44–6.32). These properties may equip the defensive silk of this species to immobilize arthropod predators and allow the spider to escape.

Keywords: defensive silk, *Latrodectus*, viscid globule

Oral presentation

Ecological studies of spider fauna of Awka, Anambra state

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A twelve-month study of spider communities in farmland, fallow, marshy and forest habitats was conducted in Awka, eastern Nigeria. Pitfall trap, sweepnet and jarring methods were used and the influence of some abiotic factors investigated. Eight of the nineteen families found were new to Nigeria while only *Pochyta* sp., *Evarcha dotata* and *Baryphas* sp. out of the 24 species found have been previously recorded in Nigeria. Fallow habitat with 15 families and 337 individuals was the most productive habitat among the four, while the farmland showed the highest diversity index of 2.11. Lycosidae was the most dominant family, in terms of population, species diversity and distribution within and across habitats. All the four families recorded in the forest were also found in all the other habitats except zodariidae which was not found in the marshy habitat. Uloboridae was the only exclusive family to farmland, while fallow and marshy had 4 and 2 exclusive families each. ANOVA showed that there was no significant difference between the sampling methods effort, however Duncan test showed that there was a difference between pitfall trap effort and the other methods. Correlation coefficient showed significant relationship between sweep net, jarring methods effort and temperature. Spiders caught by pitfall trap from fallow and marshy showed significant relationship with rainfall. Lycosidae, Zodariidae, Theridiidae, Gnaphosidae, Eutichuridae, Uloboridae, Miturgidae and Nesticidae were the new addition to the list of the very little known Nigeria spiders. Lycosidae was found to be the most suited as biocontrol agent in the area. While all the methods were good, pitfall trap was the most efficient and the only method to collect zodariidae group. Rainfall and

temperature showed some level of influence on the population and distribution of spiders in marshy and fallow habitats particularly.

Keywords: habitat, sampling, pitfall trap

Student - poster presentation

A dated molecular phylogeny for *Austropurcellia*, short-range endemic mite harvestmen (Cyphophthalmi, Pettalidae) from the Australian Wet Tropics

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The Australian Wet Tropics in northern Queensland are heralded as a model region for studying the relationship between geological and evolutionary history. Mite harvestmen of the genus *Austropurcellia* (Opiliones: Cyphophthalmi: Pettalidae) have come to attention in recent years as a study system for understanding the biogeography of the Wet Tropics. The limited dispersal, excellent persistence, and ancient age of this lineage make it a particularly useful group for historical biogeographic study. Although phylogenetic relationships within this genus have been explored in recent years, previous studies did not achieve full taxonomic or biogeographic sampling across the genus. Using recently collected specimens from species and areas not represented in previous analyses, we inferred phylogenetic trees using Bayesian methods, and completed maximum likelihood analyses with bootstrap resampling. Molecular clock methods implemented in BEAST were used to determine divergence dates. We explore the relationship between the evolutionary history of *Austropurcellia* and the geological history of northeastern Australia, including Miocene aridification and Pleistocene glacial cycling.

Keywords: Australia, Cyphophthalmi, Pettalidae, molecular clock, Miocene, Pleistocene, Wet Tropics

Student - poster presentation

Scorpion's sexual behavior: a remarkable performance of *Megacormus gerstchi* Diaz Najera 1966 (Scorpiones: Euscorpiidae: Megacormiinae)

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Sexual selection, as a two sex coevolution process, has an important role in ornament and complex mating displays, as well as in female preference for certain phenotypes. All these processes result in individual differential reproductive success when competing for a mate. Historically, female choice has been neglected. Nevertheless, its relevance related to sexual selection force and direction, as well as the impact over male sexual traits, is under study using several animal systems. Some researchers have reported a particular male scorpion behavior, known as “sexual sting”, because it occurs during mating process. An educated guess is that this behavior results in the releasing of venom components, gaining some kind of sedative effect over female and reducing the chances of being hurt by her. We have successfully recorded eleven mating events with captive *Megacormus* couples. If female is receptive, pedipalpal grasp is allowed immediately. Sexual sting is performed during promenade a deux, with a clearly “submissive female” behavior over a period of 50 minutes in the longest sting. Considering that venom is a costly metabolic investment, it is of our interest to establish the costs and benefits potentially involved in this behavior for both sexes in terms of sexual conflict resolution, as well as the adaptive value(s) of this behavior.

Keywords: scorpions, sexual behavior, sexual sting

Oral presentation

Humidity affects insect retention by spider orb webs

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The viscous prey capture threads of araneoid orb spiders are smart biomaterials whose properties change in response to their environment. As these threads are hygroscopic, relative humidity (RH) has a significant impact on the performance of the glycoprotein glue core within each of a thread's droplets. In this study we test the hypothesis that humidity-mediated changes in *Araneus marmoreus* capture threads affect the time that actively struggling prey are retained. As RH increased from 37% to 55% to 72%, so too did the volume, contact area, and extensibility of a thread's glycoprotein cores, indicating that threads are better equipped to retain prey at 72% RH. To assess this, we collected capture threads from webs constructed by 14 *A. marmoreus* females. Thread strands from each web were placed at equal spacing on the parallel supports of insect retention assay samplers. Samplers were placed in 37%, 55%, and 72% RH chambers and an anesthetized housefly was placed on three thread strands. Each fly's struggle and escape was captured in a video and bouts of active escape behavior were summed. Houseflies were retained 12 seconds longer at 72% RH than at 37% or 55% RH. This difference is ecologically significant because the short time after a prey strikes a web and before a spider begins wrapping is an insect's best opportunity to escape from the web. The impact of environmental humidity on an orb web's ability to retain prey impacts spider fitness and may be the driving force behind inter-specific differences in viscous thread hygroscopicity and humidity related performance.

Keywords: biomaterial, capture thread, adhesion, prey capture

Student - oral presentation

Multilocus phylogeny of *Bonnetina* and related tarantulas reveals extensive morphological homoplasy

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Theraphosidae systematics has long been considered problematic. It has relied mostly on morphological features, which have proven to be relatively conserved and often homoplastic across the family. Several morphology-based attempts to clarify the phylogeny of the New World subfamily Theraphosinae, with more than 50 nominal genera, have been only moderately successful. Approaches based on molecular data have the potential provide better resolution with robust support in situations where morphological characters have proven problematic, thereby providing a phylogenetic framework for evaluating phenotypic evolution. Here we conduct a multilocus phylogenetic analysis of the Theraphosinae genus *Bonnetina* and related lineages, employing one mitochondrial (COI) and four nuclear (ITS1, EF1G, Mid1 and MRPL44) loci. We included all 17 valid *Bonnetina* species, as well as 26 additional species placed in 12 nominal genera and other undetermined lineages. Phylogenetic inference and divergence time estimation were performed using Maximum Likelihood and Bayesian methods. Central and North American tarantulas with only type III urticating setae, including *Bonnetina*, were recovered as monophyletic; this lineage appears to have undergone noticeable diversification in sexual features until the Middle Miocene. *Bonnetina juxtantricola* is grouped with *Schizopelma*. The remaining *Bonnetina* taxa form a monophyletic group with two morphologically divergent undescribed species. Morphological homoplasy is extensive across the phylogeny. For instance, one of the features that diagnose *Bonnetina* seems to be plesiomorphic for a larger group and have been lost in several lineages while retained in others; the other diagnostic feature seems to be homoplastic. Our results

challenge the reliability of morphological characters for phylogenetic reconstruction in *Bonnetina*, and indicate caution when interpreting Theraphosidae supra-specific classification in absence of a solid phylogenetic framework. Keywords: tarantulas, new markers, molecular phylogeny, morphological homoplasy, divergence time, Miocene

Oral presentation

Phylogeny and classification of ground spiders of the family Gnaphosidae (Araneae): historical and contemporary approaches

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The first complete classification of gnaphosids was presented by Eugene Simon (1893). He included these spiders in the family Drassidae, which contained four subfamilies. The subfamily Drassodinae, according to E. Simon, included nine groups, and four of them, Gnaphoseae, Laronaeae, Drassodea and Echemeae still belong to Gnaphosidae. To classify these spiders, Simon used two major characteristics: cheliceral dentition (keel, separated tooth, rounded lobe or the complete loss of any tooth or any projections) and the shapes of the labium and maxilla. In 1919, L. Berland described a new characteristic: preening comb in Gnaphosidae (*Zelotes*, *Camillina*) and eventually created a new large group with this characteristic. Ute Grimm (1985) in her book Central European Gnaphosidae divided the family into three subfamilies: Gnaphosinae, Laroniinae, and Drassodinae. Ovtcharenko (1989) used the structure of different setae to classify Gnaphosidae and included “tribe” as a new taxonomical rank in gnaphosids. In 1990, N. Platnick relimited the classification of Gnaphosidae on the basis of the structure of spinnerets and spigots of ground spiders and restricted Gnaphosidae to five subfamilies. Murphy (2007) eventually accepted Simon-Platnick classification and divided gnaphosids into 14 groups in order to simplify the identification process. An additional classification of gnaphosids was proposed by Wunderlich (2011).

He used the taxonomical rank of “tribe” and assigned all ground spiders to 10 tribes. In current research, use additional characteristics to classify ground spiders, including structures of covering setae, trichobothria, the tarsal organ, additional structures on spinnerets, and structure of male palps and female genital organs.
Keywords: phylogeny, ground spiders, Gnaphosidae

Poster presentation

Overview of cave spiders in Croatia - 150 years of research

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Cave spider research in Croatia goes back to 1862 when Keyserling described first troglobiotic species for Croatia, *Hadites tegenarioides*. Władysław Kulczyński described three and Josef Kratochvil, a famous Czech arachnologist, described 14 cave species, some of them with Karel Absolon and František Miller. Most recent explorer was Christa Deeleman-Reinhold who described six species. From the faunistic point of view, except for already mentioned authors, Paolo Marcello Brignoli also contributed. At the present time researchers from Croatian Biospeleological Society (CBSS) perform systematic work in this field. Of approximately 9000 explored caves in Croatian karst (prediction is three times as much), CBSS collection holds spider material from about 1000 of them. At the moment 115 hypogean taxa are recorded from caves in Croatia, 90 of which are true cave taxa (43 troglobionts, 47 trogloniles), 9 are subtroglophiles and 16 microcavernicolous. Most abundant families are Linyphiidae (46 species), Dysderidae (16), Agelenidae (13 and Lep-tonetidae (10). Thirty-five species are described from Croatia and 27 are endemic. Of 90 cave taxa, 23 (13 troglobionts) are probably new for science and waiting to be described.

Keywords: cave spiders, Croatia, troglobionts, faunistics, biodiversity

Oral presentation

Reproductive biology of scorpions: patterns and mechanisms of sexual selection

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In the last years, there was an increase in research oriented to sexual selection of scorpions. However, the knowledge remains partial and fragmented: 1) few global studies in a worldwide context, in particular in comparative analyses; 2) lack of long-term investigations on key topics such as mate choice, sperm competition, cryptic female choice, and sexual conflict. In the present talk, firstly, I will review the history of the study of reproductive biology of scorpions by means of a detailed survey. Secondly, I will show examples on presence of precopulatory and postcopulatory sexual selection, including morphological and ecological traits. In these two contexts, I will analyze our baseline knowledge and gaps on: a) patterns of intersexual communication; b) genitalia and mating plugs; c) links between precopulatory and postcopulatory mechanisms; d) rules and exceptions in reproductive ecology (sexual sting, sexual cannibalism). For example, some studies show that during the precopulatory phase, scorpion males appear to use luring rather than coercive behaviors when facing resisting females. In postcopulatory sexual interactions, as predicted by the sperm competition theory, testes mass increases with higher levels of sperm competition. The review ends with prospects for integrative studies on proximate and ultimate causes of sexual selection.

Keywords: reproduction, sexual selection, behavior, mating plugs, sperm competition, scorpions

Poster presentation

Level of polygyny and associated reproductive costs in a funnel-web lycosid

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A mating system that includes polygyny can involve benefits for males but also costs in mate searching and sexual performance during courtship and copulation. These costs could limit the number of copulations a male achieves and also generate changes in body conditions and physiological characteristics. In this study we focused on the atypical *Aglaoctenus lagotis*, a South American wolf spider who lives in funnel-webs. Polyandrous females has been reported for the species but nothing is known about reproductive dynamics of males. Here we evaluate, under laboratory conditions, the level of polygyny that males from *A. lagotis* are able to achieve and the behavioral and physiological changes involved. Nine males were sequentially exposed to virgin females, in their webs, every three days, until the male stopped copulating and courting, were cannibalized or dead naturally. Number of matings achieved by males were counted, and the characteristics of each sexual exposition, as well as body measurements of the individuals, were registered. We also counted the sperm in the spermathecae of the females the males copulated with, and the remaining sperm in male's pedipalps after all their copulations. Males performed an average of 6 copulations (range 11–3). The number of sperm transferred to the females decreases with successive copulations, as well as males weight. Courtships and copulations durations showed no relation with males' body conditions (size and weight). Four males were cannibalized by their mates during and after copulations, but were not those that had performed more copulations. Results suggest that *A. lagotis* presents a polyandrous-polygynous system. Details about other factors influencing these results, as males and female's sexual behavior and body characteristics, will be discussed by the light of the reproductive dynamics of the species.

Keywords: *Aglaoctenus lagotis*, sexual behavior, sperm transfer, copulation, polygyny

Oral presentation

Ransacking the incertae sedis opilionids: a new Indo-Malayan family of Grassatores

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Roewer established an artificial concept of Phalangodidae by lumping together members from several harvestmen families. However, over the years, many authors took the opposite approach and instead split Roewer's Phalangodidae to create, or revalidate, family groups. In this work, we continue to purge the Phalangodidae of poorly placed taxa and we propose that a distinct group of Indo-Malayan "Phalangodine" constitutes a new family. The new family belongs to the infraorder Grassatores and is sister to the Southeast Asian Epedanidae based on molecular phylogenetic evidence. Based on morphological data can be divided in two new subfamilies, one including the genera *Beloniscellus*, *Beloniscops*, *Belonisculus*, *Beloniscus* and *Kendengus* (all previously in Phalangodidae, although *Beloniscus* was originally in Epedanidae) and the other including the genera *Buparellus*, *Bupares*, *Buparomma*. The new family is endemic to Southeast Asia and thus far contains 38 valid species. Members of the family are distinguished from epedanids (and also from all other Grassatores) by a capsula externa with dorso-medial region rigid and forming a ditch accommodating the capsula interna. Male genitalia are characterized and detailed studied in representative species, including *Beloniscus quinquespinosus* Thorell, 1891 and *Beloniscus tricalcaratus* Roewer, 1949, from Indonesia and

Buparellus insolitus Suzuki, 1985, from Thailand.

Keywords: systematic, taxonomy, Opiliones, molecular phylogenetic analysis, genital morphology, Indo-Malayan Region

Oral presentation

Scopula, pseudoscopula and claw tufts in Mygalomorphae: morphology, evolution and experimental approach

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We studied the morphology of scopula, claw tufts and a scopula-like feature (pseudoscopula) of tarsi on representatives of all Mygalomorphae families. The taxonomic distribution of these features was mapped on a recent phylogeny of Mygalomorphae and the association of them with the lifestyles of the spiders was analyzed. Setae present in the adhesive features were described and some setal types characterized. The adhesive face of setae varied in the orientation in different parts of the tarsi, this variation is more conspicuous in the spiders which only have claw tufts or scopula. We confirmed the association of adhesive scopulae and claw tufts with burrower/cursorial or thin wafer lid trapdoor Mygalomorphs as suggested for cursorial spiders, but we found that the pseudoscopula is associated with some cork trap-door and some weavers Mygalomorphae. With the exception of some Diplurids (Diplurinae) most Mygalomorph weavers lack adhesive setae. The setal morphology of pseudoscopula suggest at first their sensorial function but the anterior-posterior gradation and sexual differences additionally suggest their contribution in copulation. The mechanism proposed to explain adhesion in tarantulas is anisotropic friction, where friction is higher when the leg pushes than when it pulls. However, previous studies of adhesion in theraphosids were performed using dead specimens. To test their ability to climb, we studied static friction of live theraphosid spiders on different surfaces and at different inclines. We also compared burrower with arboreal species. We found a complementary

participation of claw tufts and scopula of anterior and posterior legs when the tarantula climbs. The mechanics of climbing in association with the biological characteristics of the species are discussed. Supported by CSIC-UDELAR.

Keywords: scopula, claw-tufts, adhesion, locomotion

Oral presentation

Behavioral effects of octopamine across contexts in the wolf spider *Pardosa milvina*

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The biogenic amine, octopamine (OA) serves as an invertebrate homolog of norepinephrine. We compared the effect of ingested octopamine on boldness in the wolf spider, *Pardosa milvina* across multiple contexts. Using a within-between subjects experimental design, we quantified startle responses to a puff of air and a poke from a plastic pipette tip. We also measured male activity in the presence of predator cues, willingness to attack large prey, and court in the presence of silk cues from an unmated adult female. Spider behavioral responses across these contexts were measured before and after octopamine consumption. Males that ingested octopamine showed significantly shorter courtship latency and higher courtship intensity. They also showed shorter latency to attack prey, more prey attacks, and longer latency to flee from a disturbance. Octopamine generally increased boldness among spiders however we found no difference in antipredator responses among treatments suggesting some defensive behaviors are not strongly mediated by this neurohormone.

Keywords: ingested octopamine, personality, boldness, prey capture, courtship, predator avoidance

Oral presentation

The phylogeny of wolf spiders (Araneae: Lycosidae)

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We present the results of a project aimed at reconstructing the higher level cladistic relationships on Lycosidae, through a total evidence analysis. This work is the first phylogenetic analysis using morphological and molecular data that covers all the subfamilies of wolf spiders. We have collected morphological character data for a sample of more than 90 species of about 70 genera. The morphological dataset includes about 100 characters, covering those used in recent phylogenetic analyses of Lycosidae and Lycosoidea, including genitalic and somatic morphology. The molecular dataset includes mitochondrial (COI, NADH1 and 12S) and nuclear markers (28S, Wingless and Actin 5C) of more than 60 species distributed on more than 50 genera. Representatives of Trechaleidae, Pisauridae, Ctenidae, Oxyopidae and Thomisidae were included as outgroups. The analysis sheds light on the evolutionary history of biologically important characters for wolf spiders, such as changes of function in sclerites of the male genital bulb and their interaction with the female epigyne, the origin of the sheet webs, and the distribution of the knobbed setae on the female abdomen. The topology of the obtained tree generally agrees with previous hypotheses, except for the subfamilies Zoicinae and Wadicosinae, which are subsumed within Venoniinae and Pardosinae, respectively. Keywords: Lycosidae, cladistics, morphology, phylogeny, systematics, taxonomy

Student - poster presentation

The effects of habitat on the active space of two wolf spiders

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Habitat may place numerous constraints on animal communication. Two closely related lycosid species, *Schizocosa ocreata* (Hentz 1844) and *S. rovnerei* (Uetz and Dondale 1979), are almost identical in morphology, yet are reproductively isolated by courtship behavior and habitat. Male

S. ocreata exhibit multimodal courtship signals complete with visual and vibratory components, and occupy upland deciduous forests; male *S. rovnerei* are found in floodplains and use unimodal vibratory courtship signals. To explore differences in the active space of male courtship signals for these two species, we used female orientation as a bio-indicator of signal transmission in mesocosms representing each species' native habitat. Over two consecutive days, males of both species were randomly assigned to each mesocosm type. Females were restrained in a clear acetate ring at one end of the mesocosm, and paired with conspecific males (free to move about and court) for an hour or until the female oriented towards the male. No significant difference was found for orientation latency between mesocosm types for either species. However, female *S. rovnerei* had longer orientation latency and significantly shorter orientation distance. These results suggest that multimodal signals of *S. ocreata* have a larger active space.

Keywords: *S. rovnerei*, *S. ocreata*, vibration, courtship, sexual selection, ethospecies

Oral presentation

Beta-diversity and phylogeography of Opiliones across Brazilian Atlantic Rainforest

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The Brazilian Atlantic Forest (AF) is a humid forest formation located in the Atlantic coast from South to Northeast Brazil. Biogeographic hypotheses indicate a delimitation of the AF into 12 Areas of Endemism (AoEs) for harvestmen. To explore the environmental and historical factors underlying this pattern, we analyzed the diversity of harvestmen communities in the AF using a data bank with 528 species from 56 localities. We also investigated putative phylogeographic breaks among the AoEs analyzing the mitochondrial cytochrome oxidase I region of taxa

from the northern (*Pickeliana* spp. and *Pseudopucroliia* spp.) and southern (*Neosadocus* spp., *Promitobates* spp. and *Sodreana* spp.) portions of the AF. Richness ranged from 2 to 57 species (mean 17.8 ± 13.7 species) and was higher in sites near the coast in the Southeast region, decreasing towards the interior (with deciduous forest formation) and the Northeast region (especially northern of Bahia). Richness was positively related to humidity, and sites near cores of AoEs showed larger values than those more distant from them. Changes in beta diversity were intense and highly related with the AoEs, showing abrupt changes from one AoE to another and reflecting the high endemism level of harvestmen. Preliminary phylogeographic analyses revealed similar patterns for both Northeast taxa and corroborated the communities' diversity results, indicating higher genetic diversity near the core of the Pernambuco AoE and lineages' divergences between southern Bahia and other Northeast localities. In the Southern Atlantic Forest, *Promitobates* and *Neosadocus* exhibit genetic discontinuities in Ribeira de Iguape river valley region, which corresponds to the limit between two AoEs, while *Sodreana* presents a more complex pattern. Our results suggest that the predicted harvestmen AoEs may have acted as forest refugia, maintaining more species and higher genetic variability than less stable areas in the transitional regions between AoEs.

Keywords: beta-diversity, biogeography, Opiliones, phylogeography

Student - oral presentation

Ontogenetic shift towards stronger, tougher silk of web building Tasmanian cave spider

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The foraging efforts of trap constructing animals, such as web building spiders, tend to be confined within the limits of their trap, accordingly ontogenetic shifts in foraging are restricted to modifying their traps. While some web-building spiders vary their web's architecture through ontogeny, many spiders, such as the large-bodied Tasmanian cave spider *Hickmania troglodytes*, produce a nearly homogeneous web design throughout life history. We hypothesized that in order to meet the high-energy demands of its large body size, *H. troglodytes* enhances its webs prey-capturing abilities by adjusting the physical properties of the major ampullate silk (MAS); the web's primary prey stopping component and structural material. We collected samples of MAS from webs built in caves from 20 individuals of varying ontogeny and conducted tensile tests to measure the MAS physical properties. We found impressive strength and toughness (ability to deform and absorb energy) of the MAS that both increased significantly with both spider carapace width and body length. Our results are the first to show changes in the physical properties of spider silk through ontogeny, they also indicate that these spiders focus on building more resilient and structurally robust webs to catch disproportionately larger and potentially novel prey or to preserve web architectural integrity and function for longer periods of time. The gradual shift in silk production and use over the spider's lifetime should inevitably lead to improved prey capture abilities. Future investigation into the mechanisms responsible for these shifts in the physical properties of MAS may provide better insights into how spiders produce such strong and tough silk.

Keywords: major ampullate silk, ontogeny, spider web, cave spider, biomechanics

Student - poster presentation

Trophic cascades: the triangle of decomposition

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Litter decomposition is driven by multiple factors, including climate and soil organisms. In detrital food webs,

predators indirectly influence leaf litter through trophic interactions affecting decomposition rates. Numerous studies have shown wandering spiders (Lycosidae) can affect decomposition rates with varying magnitude and direction. It is hypothesized that spiders consuming Collembola has impacts on fungal communities, which drives the changes in decomposition rates. And so with changing abiotic environments and conditions, the fungal community health is a key factor in how spiders will impact this cascade. However, limited studies have investigated the fungal communities in response to spider presence or absence. Here I present the results of a laboratory mesocosm study, investigating the “triangle” of decomposition, measuring the spider-Collembola-fungus interactions. Mesocosm treatments were a factorial design of presence/absence of wolf spider (*Schizocosa*) and Collembola (*Sinella*). Decomposition rates were measured and fungal communities were assessed using phospholipid fatty-acid (PLFA) analyses and mass spectrometry. Keywords: Collembola, decomposition, fungus, phospholipid fatty-acid, *Schizocosa*

Student - oral presentation

Exploring behavior and neurochemistry in the polyphenic spider, *Anelosimus studiosus* (Araneae: Theridiidae)

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The importance of social behavior is evident in human society, but there are both costs and benefits associated with cooperation and sociality throughout the animal kingdom. At what point do the benefits outweigh the costs, and when do selective pressures favor sociality and colonization over solitude and independence? To investigate these questions, we have focused on an anomalous species of spider, *Anelosimus studiosus*, also known now as the northern social spider. Throughout its broad range, *A. studiosus* is solitary and aggressive, but recently, colonies of cooperative and social individuals have been observed at northern latitudes. This leads to two research questions: 1)

what characteristics differentiate the two variants behaviorally, and 2) how are they different physiologically? Colonies and individuals were collected from multiple populations throughout the Tennessee River watershed area and maintained in a laboratory environment for quantitative and qualitative assessment of behavioral traits as well as specific neurochemical analysis by high performance liquid chromatography with electrochemical detection. I looked at the influence of factors such as age, reproductive state, nutritional state, and time of day on behavior and neurophysiology. I found correlations between social behaviors and serotonin, aggressive behaviors and octopamine (invertebrate counterpart of norepinephrine), and several other compounds associated with an increase or decrease in aggression. These studies combine techniques from multiple disciplines to contribute to the greater understanding of the proximate control of social and aggressive behaviors as well as the factors influencing the evolution of sociality. Keywords: social behavior, neurochemistry, ontogeny, aggression, reproductive state, circadian rhythm

Oral presentation

Male polymorphism in bird-associated mites (Acariformes: Astigmata)

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Male polymorphism is common in mites from the cohort Astigmata. The best studied cases involve combat-related morphology in mites associated with stored products, such as *Sancassania berlesei*, in which some males have legs modified for attacking rivals (heteromorphs) while others have female-like walking legs (homeomorphs). In these free-living species, induction of the heteromorphic state can be environmentally or genetically determined. Polymorphism is even more commonly observed in astigmatan mites associated with birds. Male nest mites from the dust-mite family Pyroglyphidae can show strong variation in the degree of hypertrophy of their forelegs. Male feather mites from the superfamily Analgoidea often display homeo- and heteromorphic states, which can be further complicated by

right- vs left-handed asymmetries. To date, intraspecific variation in male form in these bird-associated mites has received attention only from a taxonomic point of view with little effort put into determining whether the variation is truly a distinct polymorphism (vs, e.g., continuous variation) and whether there are any environmental correlates associated with variation in male morphology. Here I investigate three distinct examples of variation in male morphology in bird associated mites: the nest mite *Sturnophagoides bakeri*, the pigeon feather mite *Falculifer rostratus* and the cormorant feather mite *Michaelia* sp. For the nest mite, there were no clearly distinct morphs, but rather a continuum of leg and body sizes. For *F. rostratus*, unlike in *S. berlessei*, there was no relationship between population density and propensity for expression of the heteromorphic state. Asymmetry of male *Michaelia* was strongly correlated with which side of the host bird they were found on. Future research could address the relationship between male morphology at a finer scale (e.g., per feather rather than per bird), and how the modified male structures are actually used by the male mites.

Keywords: sexual selection, male competition, asymmetry

Oral presentation

Uncharted diversity and evolutionary history of Neotropical samooiid harvestmen (Opiliones: Laniatores: Samooidea)

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The superfamily Samooidea is a diverse group of laniatorean harvestmen comprised of 212 species that were, until this work, divided into three families: Biantidae, Samoidae, and Stygnommatidae. The systematics of this lineage is investigated and, using an integrative taxonomic approach based on molecular and morphological evidence, a new systematic arrangement is proposed. Under the new arrangement, the African family Biantidae

is sister to a well-supported monophyletic group of Neotropical Samooidea comprised of five families: Samoidae + Hummelinckiolidae fam. nov. + Stygnommatidae + Stenostygnidae new rank + Neoscotolemonidae fam. nov. We present the first dated molecular phylogeny of the Samooidea and discuss the ways in which the shifting landscape of the Caribbean has shaped the opiliofauna of the region for more than 50 million years—with dispersal and vicariance both contributing to present day diversity and distributions. Of particular interest is *Neoscotolemon*, a genus that currently consists of only two described species although we have discovered more than 20 additional species during our work. This clearly indicates that the diversity of this genus is greatly underestimated—a pattern that we have observed to be relatively common for several genera of small litter dwelling harvestmen in the Neotropics. The inferred evolutionary history of *Neoscotolemon* illustrates the dynamic two-way interchange occurring between islands and nearby continents, in this case via dispersal. This phenomenon has recently gained the attention of many of those studying island biogeography, and lends support to the idea that islands can serve as both evolutionary museums and cradles of diversity.

Keywords: Opiliones, harvestmen, phylogenetics, systematics, Caribbean, biogeography, diversity

Oral presentation

Keystone individuals in spider societies: some pros and cons

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Many animal societies rely on highly influential keystone individuals for proper functioning. When information quality is important for group success, such keystone individuals have the potential to diminish group performance if they possess inaccurate information. Here, we test whether information quality (accurate or inaccurate) influences

collective outcomes when keystone individuals are the first to acquire it. We trained keystone or generic individuals to attack or avoid novel stimuli and implanted these trained individuals within groups of naive colony-mates. We subsequently tracked how quickly groups learned about their environment in situations that matched (accurate information) or mismatched (inaccurate information) the training of the trained individual. We found that colonies with just one accurately informed individual were quicker to learn to attack a novel prey stimulus than colonies with no informed individuals. However, this effect was no more pronounced when the informed individual was a keystone individual. In contrast, keystones with inaccurate information had larger effects than generic individuals with identical information: groups containing keystones with inaccurate information took longer to learn to attack/avoid prey/predator stimuli and gained less weight than groups harbouring generic individuals with identical information. Our results convey that misinformed keystone individuals can become points of vulnerability for their societies. Keywords: behavioral syndrome, leadership, learning, personality, social spider, temperament

Student - oral presentation

Efficiency of paternal care on egg protection in the harvestman *Poassa limbata* (Opiliones): do females help caring too?

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Parental care usually increases offspring protection against predators and pathogens. Although paternal care is widespread in harvestmen, only two studies have investigated the benefits of male care in terms of offspring protection. Here we tested the efficiency of parental care in the harvestman *Poassa limbata* Roewer 1943, whose males build cup-like mud nests used as oviposition sites. Given that some females stay for long periods in the vicinity of nests where they oviposit, we also tested whether

these resident females played a role in protecting the offspring. During four consecutive days we monitored 40 nests and recorded the presence of caring males and the position and behavior of all nearby females. We then removed the caring males from 24 nests and monitored all nests for the following four days. Predation events were observed only in nests without males, performed mainly by conspecifics and ants. Ten unprotected nests were adopted by other males. Three resident females occupied unprotected nests and no predation events were recorded while present. These results show that paternal protection is crucial for offspring survival and that resident females may take care of unprotected eggs if caring males desert or die. Additional information is required to assess whether this is the first case of biparental care in harvestmen.

Keywords: parental care, sex role reversal, sexual selection, mud-nest harvestmen

Poster Presentation

Weather conditions affect developmental decision in a common wolf spider species

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Cohort splitting is a unique life history characteristic of the Central European agrobiont wolf spider, *Pardosa agrestis*, and was suggested to be an adaptation to temporally variable environments by allowing the coexistence of parallel cohorts with differential success in given environmental conditions. We have tested whether the emergence of rapidly and slowly developing cohorts (due to the asynchronous development of first generation spiderlings) depends on environmental, in particular weather conditions during the season. We put forward three hypotheses regarding the effect of weather. The first proposed that weather conditions have no differential effect on the two cohorts or different life stages. The other two hypotheses devised that weather conditions may act as cues, based on which plastic developmental decisions of choosing rapid

or slow developmental pathways can be made. Our second hypothesis proposed an early, while the third allowed for later choice between the pathways. To test these hypotheses, we used long term collection and weather data of seven natural *P. agrestis* populations in Hungary between 1992 and 2000. Weather conditions indeed affect the number of individuals in late summer, as the number of adults in late summer (i.e., rapidly developing individuals) was significantly higher in years of optimal early weather, while the number of juveniles showed an opposing trend to that. Interestingly though, the between-year variation in late adult proportion did not correlate with early weather conditions. However, the proportion of late summer adults was higher in optimal late conditions. These results indicate that early weather do have considerable effects on developmental strategy, but at the same time, a later choice between the different developmental pathways (as proposed by our third hypothesis) might also contribute to the overall occurrence of rapidly developing individuals.

Keywords: developmental plasticity, cohort splitting, life history, unpredictable environment, agrobiont, wolf spider

Oral presentation

The phylogeny of dionychan spiders: a combined analysis of sequences and morphology

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The Dionycha comprise a large clade of two-clawed spiders and a tuft of tenent setae, including about 30% of the known spider species. Since the loss of the inferior claw and acquisition of adhesive setae is one of the most plastic syndromes in spider evolution, the phylogeny and precise demarcation of Dionycha are contentious. A recent morphological phylogeny produced novel synapomorphies for large dionychan clades, and the molecular

data (target gene and transcriptomic, published and in progress) are helping to define Dionycha and some of their main lineages, and disentangle morphological convergences. Both sources of data are illuminating and largely congruent, but also have important differences, due to different signal and unequal coverage. While morphological analyses are more sensitive to convergence syndromes, sequence data produce groupings without morphological synapomorphies, thus with limited prediction over the taxonomic diversity of spiders. By combining both data sources we provide synapomorphies for important dionychan clades, confirm the monophyly and placement of many families (e.g., the placement of crab spiders among lycosoids, the inclusion of viridasiids in Dionycha), and propose new higher rank-clades.

Keywords: phylogenetics, systematics, higher rank-clades, adhesive setae

Oral presentation

The visual ecology of anti-predator wing displays: a case study with jumping spiders

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Any species of tephritid flies (Diptera: Tephritidae) perform a wing waving display ('supination') to deter attacks from jumping spiders. This display, along with the dark bands on the wings, has been thought to deter spiders through a form of mimicry termed 'predator mimicry'. In a series of studies with jumping spiders and the Mexican fruit fly, we explored this interaction from a visual ecology perspective. Using a custom built eye-tracker that traces the movement of the retina in the principal eyes, we played videos of displaying flies and monitored the response. We describe the

patterns of retinal movement of jumping spiders in three treatments: during fly display, fly walking and a still fly. This study has implications for the study on signalling and visual ecology of jumping spiders.

Keywords: display, signalling, salticidae, retina

Poster presentation

Islands in the trees: A biogeographic exploration of epiphyte-dwelling spiders

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Epiphytic plants can be considered as tree-top islands. In this sense, a single tree represents a landscape where an archipelago of epiphytes influences ecological relationships dependent on geographic-spatial position, species-habitat size dynamics and species-isolation gradients. We studied these island-biogeographic relationships in spider communities that inhabit epiphyte archipelagos in a shade coffee plantation of Veracruz, Mexico. Spider diversity increased with epiphyte-island size. In contrast to other studies, our results showed no evidence of spatial position within the tree affecting diversity, but position relative to other epiphytes did affect diversity patterns. Thereby, direct distance (Euclidean) was more important than walking distance (along branches). This is the first study presenting evidence of species-isolation processes driving the diversity of epiphyte-dwelling spider communities. Tree architecture influenced the distribution of epiphytes and thereby also affected spider diversity. The three-dimensional archipelago structure and high biodiversity of epiphyte communities presents an excellent opportunity for further developing advanced island-biogeographic theory and testing the generality of existing predictions. Keywords: topology, structure, distance, 3d position, epiphytes

Oral presentation

How habitat and retreat limitation influence sociality in prolonged subsocial huntsman spiders

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Many aspects of group-living in spiders are influenced by parameters of the habitat: biotic factors, such as prey availability and predation risk, as well as abiotic factors, such as rain and wind, and sites for web or retreats. All these factors influence the costs and benefits of living in groups, which in turn provide selective pressure on the relative social complexity of a species. Diurnal retreats are critical for all three prolonged subsocial huntsman spiders (Sparassidae: Deleninae: *Delena cancerides*, *D. lapidicola*, *D. melanocheilus*), which live in interactive matrilineal family groups with a single adult female and multiple cohorts of siblings who remain together for many months prior to individual dispersal. The retreats provide the adults and developing offspring protection from predators, and moderate climatic factors. As relatively permanent structures in the environment, retreats are a resource “inherited” by lineages, but fought over if limited. All three social huntsman species live exclusively in retreats with specific features, under exfoliating bark of certain trees, flat rocks on granite headlands, or rolls of sloughed bark of *Eucalyptus regnans*, respectively. The three social species differ from each other in their age of dispersal, tolerance of immigrants, prey sharing, and number of sibling cohorts together. Ecological forces, particularly saturated habitats with limited retreat options for larger social groups and retreat size, have influenced the social ecology of these species. In *D. cancerides* habitats 85 to 100% of all possible retreats are occupied resulting in intense competition among maturing females. Offspring remain in the natal colony until sexual maturity to increase their resource holding power. Conflicts with potential reproductive competitors and immigrants are intense. In contrast, the other two species are less constrained by retreat limitation, so the payoffs for offspring

retention in the natal retreat are reduced and there is greater tolerance of immigrants.

Keywords: social evolution, intraspecific cooperation & competition, duration of association.

Oral presentation

Instilling Arachnophilia: Spiders in Children's Literature

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Herb Levi et al. opened up the world of spiders to the general public in North America with their informative *Spiders and Their Kin* (Golden Nature Guide, 1968). However, the time to generate a lifelong appreciation and tolerance, if not love, of spiders is in childhood. I surveyed a vast array of children's non-fiction books devoted to spiders and evaluated them using several criteria including accuracy, quality of the illustrations, age of readers/listeners, and how enjoyable and informative overall. There are also several fictional books with prominent spider characters. Although their spider characters are typically anthropomorphized, the reader is often given some biologically accurate information and left with a positive and/or sympathetic view of spiders. *Charlotte's Web* is a good example. A list of books that I recommend is provided.

Keywords: arachnophobia, children's literature

Oral presentation

Radiation of *Dysdera* spiders in the Canary archipelago probably included unique evolution of diet generalists from diet specialists

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Spiders of the genus *Dysdera* are the only predators outside the tropics that are woodlice specialists. They evolved different tactics and related cheliceral modifications for

capturing their armoured prey. In the Canary Islands this genus underwent species radiation resulting in almost fifty species. Our objective was to determine whether all Canarian *Dysdera* are woodlice specialists. In Tenerife and La Gomera we collected 17 species and potential prey cohabiting with them and tested whether the species accepted woodlice or alternative prey and how they captured woodlice. To predict the prey of the remaining Canarian species, we performed morphometric analysis of their mouthparts. The results indicate that only some of the Canary *Dysdera* are woodlice specialists, the phylogenetically basal clades appeared to be diet generalists. The woodlice specialists use three capturing tactics that are identical with the tactics present in the continental species, but two of them evolved independently in the Canaries. The common ancestor from North Africa was presumably a facultative woodlice specialist. Colonisation of newly evolved volcanic islands, where even the niches of polyphagous invertebrates were empty, was probably followed by dichotomous evolution—some species further specialised on capturing woodlice while the others became polyphagous. The dietary specialisation is usually considered to be an evolutionary trap. The Canary *Dysdera* are the first described case documenting that even dietary specialists can return to polyphagy when the competition for prey relaxes.

Keywords: diet specialisation, species radiation, morphological adaptations, prey

Oral presentation

Cladistic analysis of *Neostasina*, with comments on the phylogeny of Sparianthinae (Sparassidae)

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Sparianthinae currently includes fifteen genera, namely *Decaphora* Franganillo, *Defectrix* Petrunkevitch, *Pleorotus* Simon, *Pseudosparianthis* Simon, *Rhacocnemis* Simon, *Sagellula* Strand, *Sampaosia* Mello-Leitão, *Sparianthis* Simon, *Stasina* Simon, *Stipax* Simon, *Strandiellum*

Kolosváry, *Thelcticopis* Karsch, *Thomasettia* Hirst, *Uaiuara* Rheims and *Neostasina* Rheims and Alayón. The subfamily is widely distributed, with species occurring in all zoogeographical regions, except the Antarctic. *Neostasina* was recently proposed to include Neotropical Sparianthinae species with legs I and II with three pairs of ventral spines on tibiae and one pair on metatarsi. Currently the genus includes 27 species from the Antilles. In this study, a cladistic analysis using parsimony was carried out to test the monophyly of *Neostasina* and discuss the relationships between its species and between Sparianthinae genera. The data matrix comprised 72 morphological characters and 58 taxa. Of these, 18 belonged to *Neostasina*, 24 to other Sparianthinae genera, 15 to other Sparassidae subfamilies and one to Philodromidae. The analysis was carried out on TNT, under equal weights, and yielded two most parsimonious trees with 188 steps each. Results confirm the monophyly of *Neostasina*, which arises as sister to a clade including *Decaphora* and *Pseudosparianthis* (here considered a senior synonym of *Sampaosia*). The analysis did not fully resolve the relationships between the *Neostasina* species. Within the genus, the Jamaican species *N. liguanea*, *N. gunboat*, *N. guababoa* arise sister to *N. maroon*, nestled within a larger unresolved clade including the Jamaican *N. mammee* and the Cuban species *N. siempreverde*, *N. granpiedra*, *N. iberia* and *N. macleayi*. This large clade arises as a polytomy with *N. bryantae* and *N. amalie*, nestled within a larger polytomy including all the remaining species and a small clade including *N. ouali* and *N. lucasi*.

Keywords: morphology, phylogeny, neotropical, Sparassidae

Poster presentation

Revalidation and revision of the genus *Sadala* Simon (Araneae: Sparassidae)

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The genus *Sadala* was proposed by Simon to include four species previously described in *Sparassus* (*S. antiguensis* Keyserling, *S. rufus* Keyserling, *S. pellucidus* Keyserling, and *S. luteus* Keyserling), *Olios ventrosus* Nicolet, and six newly described species (*S. pictitarsis*, *S. nigristernis*, *S. keyserlingi*, *S. velox*, *S. mathani* and *S. punicea*). A few years later, Simon synonymized the genus with *Olios* Walckenaer claiming that he could not find significant differences to maintain the species in a separate genus. A comparison between the type specimens of the original *Sadala* species with the type species of the genus *Olios*, *Olios argelasius* Walckenaer, shows that the species described by Simon do not belong to this genus. *Olios argelasius* shows characters that are commonly associated to Sparassinae, such as two pairs of ventral spines on tibiae I–IV and chelicerae with two promarginal teeth and no intermarginal denticles. The *Sadala* species, on the other hand, show characters that suggest they are more closely related to Heteropodinae, such as three pairs of ventral spines on tibiae I–IV, three promarginal teeth and a cluster of denticles at the base of the cheliceral furrow. Male and female genitalia also show significant differences, such as the lack of typical apophyses and distal embolic coil in the male palp and lack of membranous parts in the internal duct system in the female vulva, all present in *Olios*. Based on the above mentioned facts, *Sadala* is revalidated to include *S. pictitarsis*, *S. nigristernis*, *S. keyserlingi*, *S. velox*, *S. mathani*, *S. punicea* and nineteen new species. In addition, *S. nigristernis* is considered a junior synonym of *S. velox* and *O. quinquelineatus* Taczanowski, *O. orchiticus* Mello-Leitão and *O. formosus* Banks are transferred to *Sadala*. The other species originally described in *Sadala* remain in *Olios* until a more thorough revision of the genus is conducted. Keywords: taxonomy, Araneae, neotropical region, new species

Student - Poster presentation

The goblin spider genus *Ischnothyreus* (Araneae, Oonopidae) in Java and Sumatra

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The genus *Ischnothyreus* Simon, 1893 from Java and Sumatra is revised with the description of seven new species from Java (*I. baltenspergerae* sp. nov., *I. bauri* sp. nov., *I. gigeri* sp. nov., *I. ligulatus* sp. nov., *I. nentwigorum* sp. nov., *I. sigridae* sp. nov., *I. ujungkulon* sp. nov.) and eight from Sumatra (*I. ascifer* sp. nov., *I. concavus* sp. nov., *I. habeggeri* sp. nov., *I. haymozi* sp. nov., *I. lucidus* sp. nov., *I. marggii* sp. nov., *I. microphthalmus* sp. nov., *I. obscurus* sp. nov.). Furthermore the male of *I. serpentinum* Saaristo, 2001 is described for the first time. Special morphological features of *Ischnothyreus* males and females are described and discussed, such as peculiar trochanter projections, partially fused pedipalp segments, processes on the cheliceral fang base in males and external and internal genitalic structures in females. All species are diagnosed, described and illustrated. This work is part of the planetary biodiversity inventory (PBI) project of goblin spiders (<http://research.amnh.org/oonopidae/>).

Keywords: genitalia, morphology, PBI, taxonomy

Student - oral presentation

Glacial refugia and riverine barriers: biogeography of *Acuclavella* (Opiliones, Ischyropsalidoidea) in Northern Idaho

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The utility of Opiliones to infer world-wide biogeographic patterns has long been realized, but the potential for these often poor dispersers to inform evolutionary processes at more shallow time scales is still underappreciated. Here we analyze a phylogenomic data set of over 5201 variable loci (5156 unlinked SNPs) generated via ddRAD sequencing to report on the biogeography of the Thorn Harvestmen *Acuclavella* (Dyspnoi, Ischyropsalidoidea) from the Western

Hemlock Zone of the Pacific Northwest, United States. The Western Hemlock Zone has a complex recent evolutionary past, with Cascade orogeny, Pleistocene refugia, and riverine barriers all interacting to shape its biogeographic history. Here we test several hypotheses on the effects of Pleistocene refugia and riverine barriers on diversification events between the *Acuclavella* species of northern Idaho. Namely, we predict that (1) diversification events within *Acuclavella* are associated with refugia and rivers, (2) inferred ancestral population sizes of *Acuclavella* species will show bottlenecks corresponding temporally with the Last Glacial Maximum, and (3) genetic diversity will be higher in refugia, with a phylogenetic “leading edge” model showing expansion out of refugia. This research provides important and novel insights into the role of Pleistocene glacial cycles and rivers in shaping the biodiversity of the Western Hemlock Zone of northern Idaho. More broadly, this research highlights the significant contributions that studying poorly dispersing denizens of forest litter can have for biogeographic inquiries.

Keywords: biogeography, Pleistocene refugia, riverine barriers, ddRAD, Opiliones, evolution

Poster presentation

First offering: spider identification field course, Southwestern Research Station of the American Museum of Natural at Portal AZ contributes to species records for the area

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A field course in spider collection and identification was offered at the Southwestern Research Station in the

Chiricahua Mountains of Arizona in July of 2015. Our nine participants included primarily graduate students and professionals from the United States and Canada. As a result of the collections made during the course, we completed a revision of the spider species of the Chiricahua Mountains area reported by Jung and Roth (1974). Familial representation in the local fauna is summarized herein.

Keywords: education, field course, species lists, southwest

Oral presentation

Spiderling interactions on the group web: social tyranny rules in *Agelenopsis aperta*!

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Investigation of between sib and non sib pairs of *Agelenopsis* spiderlings of same mass over 6 weekly feeding periods in which each individual is offered a termite prey at its funnel entrance indicates that this species does not cooperate in prey capture at this age. Further, 2/3 of the over 2000 pairs exhibited agonistic interactions over prey as opposed to feeding independently on the termite offered each one. The degree to which prey are contested differs among families indicating that there is a genetic basis to agonistic behavior. Once a distinct winner occurs in an interaction, this individual takes prey and/or keeps the other member of the pair from feeding. This is despite the fact that 1 termite is far more than an individual can consume. The result is that there will be a marked dichotomy in individual size that increases through time. This behavior may be adaptive in that it assures that some members of a family will be larger and more competitive over web-sites and resources following dispersal from the group web. Analyses completed thus far indicate that spiderlings do not discriminate between sibs and non sibs.

Keywords: spiderlings, feeding contests, behavior

Oral presentation

Next-generation systematics of Australasian idiopid trapdoor spiders: exploring a continental radiation

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Next-generation sequencing (NGS) approaches have revolutionized systematic arachnology, providing new markers, more characters and, once optimised, faster methods for data generation. Our understanding of the phylogeny and classification of mygalomorph spiders has benefitted from recent advances in molecular systematics, although many studies using Sanger sequencing methods remain limited by the number of loci available and the information content of those loci. Here we present a comprehensive phylogeny of the trapdoor spiders of the family Idiopidae in Australasia. Using massively parallel RNA-Seq methods for the development of new informative nuclear loci, and parallel tagged amplicon sequencing methods for the generation of a 12-gene dataset, we tested the phylogeny, generic classification and biogeography of Idiopidae across continental Australia. Resulting trees highlight the mesic Gondwanan heritage of Idiopidae in Australia, and provide evidence for three independent xeric radiations. In one of these arid-adapted genera, remarkable phragmotic abdominal modifications analogous to those seen in *Cyclocosmia* (Ctenizidae) and African *Galeosoma* (Idiopidae) have evolved twice in parallel in Western Australia. This phylogenetic framework provides the quantitative foundation for a new generic-level classification of the arbanitine Idiopidae, and for future species-level monography. Furthermore, new nuclear markers—developed and optimised for both Sanger and NGS sequencing platforms—offer great potential for the molecular analysis of Mygalomorphae

and other Arachnida.

Keywords: systematics; Mygalomorphae; next-generation sequencing; biogeography

Oral presentation

Influence of predators and senescence on male courtship investment in a wolf spider

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Active courtship is critical for mate attraction, but benefits of signal production depend on many influences. Sexual signaling can be energetically expensive, and has the potential to attract unwanted attention from predators. Male brush-legged wolf spiders, *Schizocosa ocreata* Hentz (Araneae: Lycosidae), actively signal females in the leaf litter habitat during their spring breeding season, but face distinct tradeoffs between current and future reproduction as the season progresses. Later in the breeding season, the number of available females, who typically mate only once, steadily declines, mated females become aggressive and cannibalistic, and leaf litter cover disappears, increasing male exposure to other predators. Further complicating reproduction, sexually selected male traits such as foreleg tufts are subject to wear with increasing age (senescence), potentially reducing male attractiveness to females. The terminal investment hypothesis predicts that with fewer available females, increasing predation risk, and physiological senescence as the season progresses, males should take greater risks to secure mating including courting in the presence of predators. We exposed males of increasing ages to female cues alone or female cues combined with predator cues, but found little evidence to support the terminal investment hypothesis in this species in that there was no age related increase in courtship investment in the presence of predator cues. However, we found evidence of male senescence based on

age-related changes in behavior, which has not previously been explored in this species. While males maintained similar levels of active courtship across all age classes, older males increased their relative investment in maintenance behaviors (grooming) and decreased non-courtship display behaviors. These findings suggest that studies of male behavior in this species should be carefully designed to control for age-related variation in behavioral response. Keywords: senescence, predation, age effects, chemical cues, context dependence

Student - oral presentation

What factors affect the relative abundance of dense, three dimensional webs?

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Using a precipitation-productivity gradient in western Ecuador, we considered the potential trade-off between costs of web repair and benefits of predator protection in influencing the relative abundance of dense, three-dimensional (3D) spider webs. 3D spider webs require large amounts of silk and activity to be maintained. Since heavy rainfall severely damages webs, we predicted that the relative abundance of 3D webs would decrease with increasing precipitation. Conversely, as 3D webs also confer greater protection against predators, and predators are predicted to be more abundant in wetter, more productive habitats, the relative abundance of 3D webs may increase with increasing precipitation. We found that 3D webs significantly increased in relative abundance with increasing precipitation, which suggests greater importance of their predator protection function. We also found, however, that 3D webs may avoid extensive damage from strong rains by choosing sites with greater immediate cover, which we found increased in abundance as precipitation, and thus vegetation lushness, increased.

Keywords: web architecture, ecological factors, observational, environmental gradient

Student - Oral presentation

Preliminary results of the cladistic analysis of the genera of Prodidomidae Simon 1884 (Araneae)

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Prodidomidae is currently composed of 309 species distributed in 31 genera occurring in all zoogeographical regions, except the Antarctic. The family is divided in three subfamilies: Prodidominae Simon, Theuminae Platnick & Baehr, and Molycriinae Simon, and characterized by the piriform gland spigots of the anterior lateral spinnerets extremely elongated and associated to highly plumose setae. Traditionally, Prodidomidae, along with six others families (Amoxenidae Simon, Cithaeronidae Simon, Gallienellidae Millot, Gnaphosidae Pocock, Lamponidae Simon and Trochantheriidae Karsch) composed the superfamily Gnaphosoidea. However, the latest hypothesis of relationship between the families of Araneomorphae, did not recover Gnaphosoidea and Prodidomidae was included in the CTC (Claw Tuft Clasper) clade. This group is characterized by the presence of a distinct mechanism for moving the claw tuft setae of the legs. Here, we present the preliminary results of a cladistic analysis of Prodidomidae genera to test the monophyly of the subfamilies and propose a relationship hypothesis between their genera. The data matrix comprised 45 species scored for 65 morphological characters. The ingroup comprised members of 20 prodidomid genera. The outgroup included members of 14 genera, all belonging to the family Gnaphosidae. The analysis was carried out using heuristic search algorithms under equal weights and resulted in 44 most parsimonious trees with 196 steps each. The strict consensus recovered the subfamily Theuminae, including the species *Anagrapbis palles*, a species originally allocated in Gnaphosidae. The analysis also recovered the subfamily Prodidominae, while the subfamily Molycriinae was not recovered.

Keywords: cladistic analysis, Prodidominae, Molycriinae, Theuminae

Student - poster presentation

A new genus of Neotropical spiders of the family Prodidomidae Simon (Araneae)

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Prodidomidae is distributed worldwide and currently includes 309 species in 31 genera. The family is divided in three subfamilies: Prodidominae Simon, Theuminae Platnick & Baehr, and Molycriinae Simon. Theuminae is the most diverse with 13 genera occurring in the Neotropical (nine), Afrotropical (three) and Oriental (one) regions. Four genera are described from Brazil: *Brasilomma* Brescovit, Ferreira & Rheims, *Lygromma* Simon, *Oltacloea* Mello-Leitão, and *Tricongius* Simon. The subfamily is characterized by the presence of a sternum with a large protrusion between the fourth coxae with numerous long, erect setae and by the female epigyne with strongly convoluted ducts. Here we propose a new genus belonging to the subfamily Theuminae from the Neotropical region including, at present, eight new species from Brazil (five from Pará, one from São Paulo, one from Pernambuco and one from Paraíba). Four species are known from both sexes, two only from males and two only from females. The genus is characterized by the male palps with a single retrolateral tibial apophysis, presence of basal cymbial process, long embolus with sinuous tip, thin and sinuous conductor and hyaline median apophysis and by the female epigyne with conspicuous anterior copulatory opening. Five species were collected exclusively in iron caves and have troglitic features such as vestigial eyes or absents.

Keywords: taxonomy, Brazil, Theuminae, new species

Student - oral presentation

Assessment of morphometric characters used to delimitate species in the genus *Apolpium* Chamberlin, 1930 (Olpidae: Pseudoscorpiones)

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Pseudoscorpiones is a mesodiverse order into the Class Arachnida. Species delimitation into several genus has been done in this group by means of taking diagnostic characters as linear measurements or proportions without any statistical criteria. Because of this, one specimen could be considered as a new species taking into account only its size or either how stouter or slender a structure can be if compared with itself in other species. Furthermore, it ignores the variability of this kind of characters, due to the fact that measurements may differ depending on the instruments or who conducts the research. On the other hand, the neotropical genus *Apolpium* Chamberlin, 1930 (Olpidae) has seven species described from Costa Rica to Ecuador with diagnostic characters such as length/width proportions of chela and length/width of pedipalpal tibia and patella and total length of the body. Therefore, the aim of this study was to explore and assess the potential and role of these morphometric characters in species delimitation for *Apolpium*. In order to achieve this, 170 specimens were studied from six collections, as well as the five types of the seven species. From the examined material, 36 measures were taken from 17 structures in all the body on 57 selected individuals. Then, a pool of statistics analyses including a Kolmogorov-Smirnoff test, cluster analyses, multiple correlations, principal components, discriminant function and multidimensional scaling were carried on. Those morphometric characters together showed first, that there was no significant difference of most of the proportions between males and females; second, a high correlation between structures of same appendages was evidenced; and finally the proportions lacked of explicative power to differentiate species. Given this, proportions themselves do not support enough the *Apolpium* species proposed currently and other kind of characters have to be explored in order to find trustworthy diagnostic ones.

Keywords: Pseudoscorpiones, morphometric characters, multivariate analyses, species delimitation

Student - oral presentation

Understanding how changes in the ground spider community can enhance restoration practices

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Fire-dependent jack pine forests of Michigan are the focus of conservation and restoration efforts as they are the breeding ground for the endangered Kirtland's Warbler (KW). Current forest management practices, focused on increasing KW habitat, however, simplify landscape structure. Without an understanding of how these ecosystems naturally respond to wildfire there are insufficient metrics to measure the success of restoration that emulates fire and post-fire succession. One such metric, or indicator of ecosystem function, is spider community structure and diversity. Specifically, the ground hunting spider guild (GHSg) is a good choice as they respond to environmental changes and are easily sampled. To quantify the GHSg community we established pitfall traps in 12 former wildfire sites in northern Lower Michigan. Sites were categorized as either young (2–7 years post-fire) or mature (23–41 years post-fire) and all were relatively unaltered by human activity. We observed significant differences in the GHSg community composition between the age classes (MRPP=0.001), and higher diversity (Shannon Diversity Index) in mature ($H' = 2.11$ versus young ($H' = 1.49$) stands ($p < 0.01$). Non-metric multidimensional scaling revealed that stand age, canopy cover, ground cover, and understory plant community composition and density (below 1 m) are important drivers of GHSg abundance. These data provide valuable insights into the role that natural disturbances, and their legacies, play in shaping jack pine forest ecosystems. Differences in the GHSg suggest that the heterogeneous stand structure associated with naturally regenerating stands may provide a variety of microclimates, habitat structures, and prey availability; making them suitable for maintaining a high diversity of spiders

across stand ages. Consequently, current forest management practices designed to enhance KW, by simplifying the landscape, may negatively affect other important ecosystem structures and functions.

Keywords: fire, ecological restoration, ground spider, community ecology

Student - oral presentation

Three dimensional analysis of the spider locomotory system—first answers and solutions

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Although an impressive body of knowledge exists, detailed comparative studies of structural and spatial aspects of the complex locomotory apparatus in Arachnida have produced contradictory results. In the course of a comparative survey recently started on this topic, we therefore studied three representative species of spiders (*Liphisitus malayanus*, *Cupiennius salei*, *Araneus diadematus*). One major aim of this study was to establish visualization methods and terminology to be easily and consistently applied to all arachnid taxa. Spiders comprise over 45,000 species and, in some features, show a fascinating disparity. Other features, such as the locomotory system, however, seem to be highly conserved. Generally, the locomotory system in spiders consists of the prosoma and its four pairs of walking legs, each comprising seven cuticular podomeres. The locomotory musculature can be subdivided into the extrinsic musculature situated in the prosoma and the intrinsic musculature located inside the walking legs. Here we present the first three-dimensional analysis of the locomotory system in spiders. Cuticular structures, muscles and tendons are visualized and described using state of the art morphological methods. To unify the nomenclature of the investigated structures, results are compared to published data and a position-based nomenclature of muscles is established which does not refer to homology in order to avoid a priori misconceptions. On the basis of these comparisons, homology hypotheses are formulated in order to

synthesize all current morphological knowledge. This in combination with interactive 3D representations confer our results a high degree of reproducibility.

Oral presentation

Experience with contaminated soil affects learning in a wolf spider

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The long industrial history of many urban communities ensures that heavy metals are pervasive contaminants in their soils. It is clear that childhood exposure to common metals, such as lead, can have profound effects on the intellectual development of humans but few studies have explored the impacts on invertebrates that spend their lives in close association with these contaminated soils. In initial experiments, we documented the ability of the wolf spider, *Pardosa milvina* (Araneae, Lycosidae) to learn to associate the odor of peppermint with food. Trained animals changed their activity when near peppermint and were more likely to move toward the peppermint odor in a two choice olfactometer. We repeated these experiments with animals that had spent one month on soil laden with heavy metals that was obtained from urban neighborhoods in Cleveland, Ohio, USA. While spiders living on the contaminated soil behaved differently from animals reared on uncontaminated soil, they did not learn to prefer the peppermint odor. We uncovered no evidence that our training protocols caused them to alter their activity in the presence of peppermint and they selected lanes at random in the two-choice olfactometer. These results suggest that *P. milvina* has some level of cognition and that their cognitive ability is affected by exposure to heavy metals. Thus, this spider may be an interesting model organism for the exploration of the neuropsychological impact of this kind of pollution. In addition, if learning is critical to the

success of these predators, populations living in impacted areas may play very different roles in the food web than those living in more pristine habitats.

Keywords: learning, behavior, contaminants, wolf spider, heavy metals, cognition, pollution

Oral presentation

Spider metacommunities on the edge: local and landscape scale processes on natural habitat islands in an agricultural landscape

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Natural grasslands have shrunk to habitat islands in most agricultural landscapes, still they play an important role in maintaining biodiversity. To preserve spider communities in grasslands patches it is important to study the drivers of community processes both at local and landscape scale. Metacommunity theory, in particular the elements of metacommunity structure (EMS) framework explores how regional processes, such as dispersal, combine with local dynamics, such as species' interactions and niche partitioning, to affect species' coexistence across scales. In the studied habitat island situation we wanted to know whether there are predictable, recurring spider communities in the similar grassland patches. The EMS framework is suitable to provide proximate answer by analyzing the coherence, turnover and boundary clumping in the species occurrence matrix. In the present study we sampled 28 localities, the interiors and edges of 14 grassland patches bordering arable fields. The EMS results indicated coherent species distributions, high species turnover (lower than expected nestedness) and clumped boundaries amounting to a Clementsian community organization. In a next stage of the analysis we used additional abundance data and environmental variables to assess by

ordination techniques the strength and scale of dispersion. By indicator species analysis we assessed the distinctness of the expected communities. These independent analyses reinforced the view of Clementsian communities by showing a strong local habitat filtering effects driven by plant species richness, strong dispersal up to 500 m landscape radius and a number of indicator species showing the coherent structure of species composition. Thus, if we intend to preserve diverse and characteristic spider communities, then local habitat quality and management has to have high priority, as well as there is an importance of natural landscape elements which can exert positive effects at considerable distances.

Keywords: community ecology, landscape ecology, community assembly, diversity, nestedness, ecosystem services, habitat island

Poster presentation

A new genus of the Subfamily Nopinae (Araneae, Caponiidae) from Neotropical region

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A new genus, *Medionops*, is proposed for a group of caponiid spiders found in the Neotropical region. *Nops simla* Chickering and *Nops cesari* Dupérré are transferred to *Medionops*. Additionally, five new species are described: *Medionops blades* n. sp. from Colombia, *Medionops claudiae* n. sp., *Medionops murici* n. sp. and *Medionops ramirezi* n. sp. from Brazil, and *Medionops venezuela* n. sp. from Venezuela. All these species are Nopinae and also have the translucent ventral extension of the membrane between the anterior metatarsi and tarsi, and a very short, almost unnoticeable, ventral translucent keel on the anterior metatarsi. Additionally, also have the unpaired claw on all tarsi elongate and dorsally reflexed and associated with a membranous pulvillus; a character present only in *Nops* and *Nopsides*. Members of this genus differ from other

Nopinae by the form of labium and endites; the conformation of male and female genitalia is also diagnostic.

Keywords: taxonomy, haplogynae, new species, Neotropics

Student - poster presentation

Spider population response to spatial-temporal variability in prey: Lake Mývatn, Iceland

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In places where resources are scarce, competition leads many organisms to engage in different types of behavior to protect and efficiently exploit these resources. Spider, although territorial, sometimes occur in aggregation and adjust web size according to foraging necessities. Lake Myvatn is known for its huge midge emergences. Spiders aggregate near the lake to exploit this prey resource, which varies in space and time. Our objective was to assess the spider population's behavioral response to this temporal resource in relation to habitat and distance in Lake Myvatn, Iceland. The orb weaver *Lairinioides patagiatus* occurs in high densities near its shores. Three surveys, considering midge emergence phenology, were conducted for *L. patagiatus* abundance and web size along a distance gradient. Prey abundance and habitat and habitat were accounted for as well. We found orb weaver abundance to increase with habitat complexity and temporal increases in prey availability, not distance. Web size was found to decrease with prey availability through time. We believe that *L. patagiatus* is responding behaviorally to the incoming temporal subsidies from Lake Myvatn. Due to the fact that food is generally limited, they aggregate near the lake shores when the midges emerge. As prey increases, food becomes a less limiting factor and spiders

become more abundant, which might suggest more tolerance of their conspecifics. Their change in behavior can also be appreciated in the reduction of web size. When food stops being a limiting factors, they invest less energy in foraging, probably to allocate more to reproduction. Spiders around Lake Myvatn have behaviorally adapted to exploit efficiently available resources in an otherwise resources lacking landscape.

Keywords: aggregation, foraging behavior, emergence, *Lairinioides patagiatus*, midges, subsidies, web size

Student - oral presentation

Phylogeny of *Selenocosmia crassipes* (Theraphosidae): combining morphology, DNA and venom

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Most of Australia's tarantulas were described around 1900's, except *Coremiocnemis tropix* Raven, 2005. Perhaps mostly because of their cryptic characters, a comprehensive taxonomic revision has been neglected. Although morphological work has been carried out, one species group is still unresolved using morphological data alone. *Selenocosmia crassipes*, possibly *Phlogius crassipes*, is a species complex that occurs from Rockhampton to the tip of Cape York in Queensland, Australia, a range of more than 1500 km. To test how many species there may be *S. crassipes*, molecular data has been extracted. Genes CO1 and 16S has been sequenced (forward and reverse) using traditional primers (CI-J-1751spid, C1-N-2776, N1-J-12261, LR-N-13398). Also, proteomic fingerprint of venom was done using LC/MS-MS, LC/MS, SDS-PAGE of 1 dimension. CO1 and 16S Bayesian tree separated *S. crassipes* into 3 clades, but one specimen are in different clade on each tree. 16S and CO1 combined tree showed 3 clades that correspond exactly with the CO1 tree. LC/MS venom data showed more similarity with 16S tree than

CO1 and combined trees. Cluster analysis on the intensity of 1D electrophoresis gel spots using Bray-Curtis similarity is possible to define 4 clusters that correspond with geographical distribution of the specimens, except one specimen from near Cooktown (Kings Plains) cluster with southern specimens. Similarity and permutation analysis of LC/MS-MS results indicate that some northern specimens have more similar venom to southern specimens than to other northern individuals. However, populations from an island in the middle of the range differ largely from northern and southern specimens. Combining the analyses, it is just possible to assume that a population of *S. crassipes* located along the Jardine River (northern Cape York) is different from all other *S. crassipes*, but the southern individuals are also different from specimens from the northern and middle part of the distribution range.

Keywords: CO1, 16S, venom proteomics, systematic, Australian tarantula

Oral presentation

Filling pieces in the scorpion venom puzzle

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Scorpion venom is a library of several compounds, traditionally divided into two fractions: toxic and non-toxic. Whereas the non-toxic fraction includes mixtures of mucopolysaccharides, lipids, free amino acids, enzymes, protease inhibitors and biogenic amines. The toxic fraction basically consists of peptides that are highly specific to ion channels of excitable cells. Over more than 400 million years, the venom arsenal has assembled into an effective weapon that works for defense and offense. Traditionally, venom studies consist of the isolation and biochemical characterization of specific peptides (e.g., toxins) from the venom mostly from buthid species. With the advent of the next generation sequencing, scorpion venom gland transcriptomes have improved our knowledge on target genes (e.g., those coding for toxins), and revealed different

components with no resemblance to known toxin types. It also showed us the presence of different genes coding for toxins or other venom components which may not be expressed in the venom or suffer from post-translational modifications. However, these transcriptome studies cover a narrow taxonomic sampling including several buthid species, plus fewer species from seven non buthid families. Here, firstly the status quo of venom biodiversity is summarized. Then, unpublished preliminary data of four venom gland transcriptomes of four non buthid scorpion families (two of them unexplored before) are presented. Finally, the phylogenetic affinities of some poorly known components, including scorpion calcines and La1-like peptides, reveal partially concordance with scorpion phylogenetics, suggesting the utility of these toxins and venom components as molecular markers in phylogenetic studies.

Keywords: venom, toxins, calcines, scorpions, La1-like peptides

Oral presentation

Influence of the biogeospatial environment on the distribution of spider communities

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The maintenance of local biodiversity is an important aspect of the long-term sustainability of agricultural production. Maintaining biodiversity, especially in regards to predator species, promotes natural pest control and many other ecosystem services. Spiders (Araneae) often prey upon common pest species, making them a beneficial component of agroecosystems. Spider species richness and diversity varies across landscapes and is often correlated with certain abiotic factors. This project investigates how four geospatial attributes—elevation, soil moisture, NDVI, and distance to edge habitat—influence spider species distributions across a farm-scape in South Georgia. Samples for the project were obtained from pitfall traps

placed along a grid pattern within a farm-scape in the Tift county area. Spiders were later removed, preserved in alcohol, and counted and identified to lowest taxon possible. Species data were compiled and correlated with the four selected attributes using multivariate methods and geospatial statistics. Preliminary analysis shows at least 12 different species of spiders present across the contrasting cotton farm-scapes, and one bioenergy feedstock, *Miscanthus giganteus*. The wolf spiders (Lycosidae) numerically dominated the communities. Further identification of spiders and more in-depth analysis of the data will allow for greater exploration of the relationship between spider abundance, diversity, and the farm-scape's geospatial attributes. Ultimately, the results should help growers identify potential spider hotspots within their farm-scapes, which could then be maintained to promote healthy populations of these beneficial predators.

Keywords: agroecosystems, bioenergy feedstocks, biophysical environment, natural enemies

Oral presentation

Who eats whom—life history strategies of the vinegaroon *Mastigoproctus giganteus*

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Little is known about the life history or biology of vinegaroons (Thelyponida). They are perhaps best-known for their vinegary smelling defensive spray that functions as a powerful defense against would-be predators. The chemistry of the spray of *Mastigoproctus giganteus* is well characterized and likely is similar throughout the order. Vinegaroon natural history is terra incognita and lacking even basic information including life spans, predators, prey, and whether individuals tend to be cannibalistic. Through an extensive series of field observations and experiments both in the field and the lab, I report on the acceptable prey, potential predators, and highlight the weaknesses or limitations of the different links of the life cycle *M. giganteus*. A teaser: they are not naturally cannibalistic. Keywords: predation, prey, life history, cannibalism, defense

Student - poster Presentation

Influence of web in prey detection: a comparison of four tarantula species

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Tarantulas are primarily sit-and-wait predators that do not rely on a web to capture prey. In many species, silk structures do not extend much past retreat entrances. There are species however that construct extensive sheets of web interconnected by silken tubes. Four species that build this type of retreat were chosen for this study: *Heterothele gabonensis*, *H. villosella*, *Holothele incei* and *Oligoxystre diamantensis*. Previous observations have shown that the *Heterothele* species react to prey more quickly and have a higher capture success rate in home containers with intact webs than in bare arenas. The goal of this study was to further examine how this network of web influences prey detection and capture behavior in other species of tarantula, and the impact of web removal. Feeding trials were conducted in situ, with each species divided into two treatment groups: one where the web was left intact, and the other had webbing removed 24 hours before the trial began. We hypothesized that spiders with intact webbing would capture prey faster and exhibit bolder behaviors. Each week, spiders were fed a single, live cricket weighing 80% of the spider's weight. Across six trials, latency to capture was recorded and analyzed using a three-way mixed ANOVA. Prey capture behaviors, particularly failed or aborted grabs, were recorded and ranked in terms of boldness. Web structure and percent coverage of the housing containers were also recorded and compared between species.

Keywords: Theraphosidae, tarantula, prey capture, web

Student - poster presentation

Male black widows decrease competition via web reduction

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Male adaptations that limit sperm competition include guarding females, applying mating plugs and chemically reducing the attractiveness or receptivity of females. Female web-building spiders often attract males with silk-borne volatile pheromones. In widow spiders (*Latrodectus*), the courting male often engages in web reduction behaviour, during which he excises and bundles sections of the female's web and wraps them with his own silk. This widespread behaviour may function in sexual communication (e.g., through dissemination of male sex pheromone) and/or decreasing the female's attractiveness. In a dense population of western black widows, *Latrodectus hesperus*, we ran mate attraction experiments to test the hypothesis that web reduction and/or male silk addition decrease web attractiveness. Male-reduced webs attracted one third as many males as intact webs; webs with a similar proportion of silk experimentally removed were as attractive as intact webs. However, the experimental addition of male silk did not affect web attractiveness. We conclude that web reduction in black widows limits male-male competition by reducing the attraction of rival males to females' webs. This effect is probably mediated through targeted excision of pheromone-laden silk by courting males, possibly in combination with the male's silk forming a physical barrier to pheromone emission. Keywords: chemical communication; courtship behaviour; pheromone, Theridiidae

Poster presentation

Effects of boldness on web-decoration behavior and foraging success

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Consistent inter-individual difference in behavior has been documented in many animals, including spiders. Many orb-web spiders decorate their webs to attract prey

and show considerable variations in the frequency of web decorations. Yet no study has explored whether and how personality could explain web-decoration behavior and thus foraging success in these spiders. Here, we tested for the presence of boldness in the St. Andrew cross spider, *Argiope catenulata*, and its effects on web-decoration behavior and foraging success. Boldness was present in *A. catenulata* juveniles and adults as well as females and males. In the wild, female boldness was correlated with how often females decorated their webs, and a good predictor of females' foraging success and growth. Bolder females decorated their webs more often, intercepted more prey and grew faster. This study highlights that spider personality should be considered in future studies of web-decoration behavior.

Keywords: personality, boldness, *Argiope*, web decoration, foraging success

Student - poster presentation

Expanding far from home: potential geographic occupancy of the invasive *Cyrtophora citricola* (Araneae: Araneidae) in America

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Invasive species often have negative effects on colonized ecosystems. Thus, assessing their environmental requirements is key to identify potential areas for their establishment and its consequent impacts. In this study we identify the climatic features that best describe the distribution of the invasive *Cyrtophora citricola* and evaluate its invasion risk in America. We used a Maximum Entropy algorithm to create predicted distributions based on: 1. native range, and 2. documented invasive range. Then we tested for niche conservatism by comparing the average results from Native and Invasive predictions using a Principal Component Analysis and a Discriminant Analysis. We found that the Native Model shares 29.7% of the climatic

conditions with the Invasive Model, while the later shares 20.3% of its climatic conditions with the Native range. We concluded that *C. citricola* has the potential for occupying and expanding into novel climatic conditions when compared with its native range. This is one of the first studies that analyzed the potential geographic expansion of an old world spider in the Neotropics, and set the bases for measuring the effect on the native spider fauna.

Keywords: niche expansion, invasive, biogeography, *Cyrtophora citricola*

Oral presentation

Burmese amber arachnids; biodiversity in a Cretaceous tropical forest

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Known for many years, but thought to be Cenozoic in age, there has been an upsurge in interest in amber from Myanmar in recent years, partly because of its increased availability (especially now on the Chinese market), and partly because we now know it is mid-Cretaceous (c. 99 Ma) in age. A great diversity of biotic inclusions have now been described. Most arachnid groups are known from Burmese amber: Araneae, Opiliones, Solifugae, Pseudoscorpiones, Anactinotrichida, Amblypygi, Thelyphonida, Ricinulei, Scorpiones, and Schizomida. In this talk, I shall briefly discuss the biodiversity of arachnids in Burmese amber, before describing some interesting new finds from the amber.

Keywords: paleontology, Opiliones, Tetrablemmidae, Ricinulei, Schizomida, Mesothelae, Pseudoscorpiones

Student - oral presentation

Are males really so insensitive? Palp morphology of a spider *Philodromus cespitum* reveals innervation

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Male spiders transfer their sperm via a secondary reproductive organ called palpal bulb. Based on several histological studies, this structure is considered to be unique among all animal genitalia due to possible lack of innervation. A recent study, however, reported first evidence of neurons in the male bulb in *Hickmania troglodytes* from a relict group of spiders. We performed a morphological study on male copulatory organ of a common entelegyne spider, *Philodromus cespitum*, whose males apply amorphous mating plugs into the female atrium after copulation. By means of microtomography, light and transmission electron microscopy we discovered a nerve-like structure in the bulb. The cymbium of the palp is richly innervated. One of the nerves departs into the bulb, runs through the whole structure and terminates at the base of the embolus. Interestingly, the nerve is in contact with two of three different glands situated in the bulb. These glands are connected to the spermatophore and may be involved in transfer of sperm as well as mating plug material. Our combined behavioral and morphological observations on the production of mating plugs in this species suggest that the male gains information about the intention of the female to interrupt the copulation and reacts by promptly extruding the plug material. This is the second case of bulb innervation in spiders and the first evidence for nerves in male copulatory organs of entelegyne spiders. Our results open the window into the research of genitalic sensory feedback in spiders.

Keywords: male genitalia, palp morphology, innervation, mating, histology, microtomography, mating plug

Student - poster presentation

Sexual dimorphism in venom gland anatomy in a sexually stinging scorpion

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Males of several scorpion species possess bigger telsons than females. In some of these species males repeatedly sting females during mating. This behavior (“sexual stinging”) is likely correlated with a sexual dimorphism in telson and venom gland size. As natural selection theory predicts bigger female venom glands (females need more nutrients for their offspring), we hypothesize that this sexual venom gland dimorphism evolved under sexual selection in relation to the male’s sexual stinging behaviour. We investigated morphometrics and morphology of male and female telsons and venom glands by means of light and transmission electron microscopy in the sexually stinging scorpion *Euscorpisus alpha* (Euscorpidae). Male telsons are significantly bigger and more voluminous than those of females. In the compound light microscope and transmission electron microscope, five different secretory cells can be distinguished with their representation varying considerably between sexes. While female secretory epithelium consists mainly of cells filled by granules, males carry mainly cells containing dissolvable vesicles. This cell type likely produces transparent venom that had been identified in other scorpions as so-called “prevenom”. The function of this secretion is discussed in relation to sexual stinging behaviour.

Keywords: sexual stinging, sexual dimorphism, venom gland, scorpion

Student - oral presentation

Developmental genetics of respiratory structures in Arachnoplumate and non-Arachnoplumate Orders

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Understanding of the developmental genetics of arthropod respiratory system is currently limited to the fruit fly *Drosophila melanogaster*. The tracheal tubule complex of *D. melanogaster* is initially formed by the invagination of segmentally iterated tracheal placodes in the pleural regions of abdominal segments. Arachnids represent a separate case of terrestrialization from insects, and the developmental origins of arachnid book lungs and tracheal tubules have not received comparable attention. We examined the development of respiratory primordia in embryos of a scorpion, a harvestman, and a spider. We used in situ hybridization and confocal microscopy to examine the relative placement of respiratory placodes and assay gene expression of candidate genes that are critical to tracheal fate specification in *D. melanogaster*. Here we show that the respiratory primordia of arachnids are not positionally homologous to those of insects, as they occur within the posterior region of the embryonic parasegment, demarcated by the expression boundary of the segment polarity gene *wingless*. Furthermore, we show that orthologs of tracheal inducer gene *tracheal-less* are not expressed in cells of arachnid respiratory organs. These data suggest that mechanisms of respiratory system development are not homologous in insects and arachnids.

Keywords: Scorpiones, book lung, tracheal tubule, Araneae, Opiliones, evo-devo, homology

Student - poster presentation

Variation in total mercury content among riparian and non-riparian wolf spiders

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Mercury is a persistent environmental contaminant that primarily originates from coal-fired power plants. Methylmercury biomagnifies as it moves through food chains, reaching toxic levels in apex predators. Wolf spiders can concentrate mercury at high levels, sometimes exceeding levels found in fish. Since these spiders occupy positions

within detrital, terrestrial, and aquatic food chains, the pathway for mercury biomagnification remains unknown. We collected two widespread wolf spiders, *Pardosa milvina* and *P. saxatilis*, at sites along the Susquehanna River near a coal-fired power plant and compared total mercury levels to spiders from an uncontrolled coal fire burn site (Centralia, PA) and reference sites away from the river or point sources of mercury pollution (agricultural fields). We collected 89 *Pardosa milvina* and *P. saxatilis* across the six sites and measured total mercury among individual spiders. We found significant differences in mercury level between these species despite being very similar in size, microhabitat, phenology, and phylogenetic proximity. We also found higher mercury levels among adult male rather than female spiders suggesting either trophic dimorphism or mercury depuration among females during egg production. Total mercury levels varied significantly by site. Spiders from Centralia had total mercury levels up to three times higher than those in riparian zones adjacent to the power plant and about nine times higher than spiders collected from agricultural fields. Significant differences in total mercury across different age classes were also found, indicating significant bioaccumulation. Our results suggest that these species may serve as important bioindicators for mercury bioaccumulation, biomagnification and transport across diverse habitat types. The high levels near Centralia, PA, suggest that, counter to conventional wisdom, aquatic environments are not necessary for significant terrestrial mercury bioaccumulation to occur.

Keywords: total mercury bioaccumulation, biomagnification, wolf spider, riparian

Oral presentation

Comparative analysis of euchelicerate genomes supports a single origin of the arachnid book lung

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The phylogenetic position of Scorpiones and the attendant evolutionary scenario of arachnid terrestrialization have a long and contentious history. The datasets of morphologists and paleontologists typically recover scorpions at or close to the base of the arachnid tree of life, whereas recent phylogenomic analyses have recovered support for a clade comprised of scorpions and tetrapulmonates (Arachnopulmonata). To adjudicate between these competing hypotheses with an independent data class, we examined the structure and composition of euchelicerate genomes, using mandibulate genomes as a point of reference. Here we show that a partial or whole genome duplication event is shared by arachnopulmonates, to the exclusion of apulmonate arachnids. Furthermore, we show that one or more whole genome duplication events independently occurred in Xiphosura. The signature of the duplication in Arachnopulmonata is retained by developmental patterning genes, with gene expression surveys revealing several cases of putative sub-functionalization of resulting paralogs in scorpion and spider exemplars. Taken together, these data imply a single origin of the arachnid book lung and transform previous scenarios of the evolution of terrestrialization in Arachnida.

Keywords: genomics, evo-devo, phylogenomics, terrestrialization, Hox genes

Poster presentation

High throughput analysis of shape evolution in the armored harvestman family Podoctidae

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The taxonomy and systematics of the armored harvestmen (suborder Laniatores) are based on various sets of morphological characters pertaining to shape, armature, pedipalpal setation, and the number of articles at the termini of the legs. More recently, male copulatory structures and appendicular secretory organs have been proffered as a potential source of phylogenetically informative characters. Few studies have tested the validity of these character systems in a comprehensive way, with reference to an independent data class, i.e., molecular sequence data. We examined as a test case the systematics of Podoctidae, a family distributed throughout the Indo-Pacific, using a five-locus molecular phylogeny as a point of reference. We mapped character data from various structures, including shape data, onto the molecular phylogeny, in order to quantify phylogenetic signal and to characterize evolutionary rate and trait correlation of discrete and morphometric characters. Here, we show that the subfamilies Ibaloniinae and Podoctinae are paraphyletic, with Erecananiinae nested within Podoctinae. Various genera were recovered as non-monophyletic. As a first step toward revision of the systematics of Podoctidae, we once again synonymize the genus *Paralomanius* Goodnight & Goodnight, 1948 with *Lomanius* Roewer, 1923 revalidated. Erecananiinae Roewer, 1912 is synonymized with Podoctinae Roewer, 1912 new synonymy. We pinpoint morphological data classes that are consistent with phylogenetic signal, and identify those highly prone to convergence. These results are anticipated to guide taxonomic practices in Laniatores systematics. Keywords: Opiliones; Grassatores; morphometrics; comparative methods; phylogenetic signal

Student - Oral presentation

Interspecific competition, group size and dispersal in a social spider

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The relative costs and benefits of group living change with group size. In the social spider *Anelosimus eximius*, as colonies grow, the number of insects captured per capita decreases, but the size of insects increases, causing biomass captured per capita to peak at intermediate colony sizes. We show that for small to medium-sized colonies spiders are larger in larger colonies. We found, however, that individual condition decreases as colony size increases, indicating that an individual's access to resources may become limited as colonies grow. Using artificial colonies in the lab we show that individual spiders are not able to monopolize large prey and that the variance in individual condition does not increase as colony size increases, and in fact may even decrease. It thus appears that scramble competition predominates in *A. eximius* colonies, especially at large colony sizes. We suggest that greater competition in larger colonies may drive adults to disperse. The fact that dispersing adults were found to be larger and in better condition compared to non-dispersers suggests that dispersal may be costly and that competition in large colonies may result in some individuals failing to secure sufficient resources to disperse. Keywords: sociality, competition, dispersal, *Anelosimus eximius*, group size, behaviour

Student - poster presentation

New Records of Harvestmen (Arachnida, Opiliones) from Minnesota, USA

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Although they are familiar and often abundant in many of the state's ecosystems, the Opiliones of Minnesota are significantly understudied in comparison to surrounding states and provinces. Minnesota's current species richness sits as five species that were last documented over half a century ago, while some neighboring states and provinces are known to harbor double or quadruple that number. We examined unidentified material from the University

of Minnesota Insect Collection, and also freshly collected specimens from the main campus of Macalester College (Ramsey County) and the college field station (Dakota County). We report eight previously undocumented species and two additional genera, identified using external and internal morphological characteristics. This work increases the known Opiliones species richness of Minnesota from five species to thirteen, and the known number of genera in the state from five to seven, including the first documentation of the widespread genus *Leiobunum*.
 Keywords: Opiliones, Minnesota, harvestmen, species richness

Student - poster presentation

Familiarity reduces aggression, but also mating success, for male *Leiobunum aldrichi*

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Animals often adjust behavior in response to interactions they have with conspecifics. For example, within a mating context, males may alter how they compete for mates depending on the level of familiarity they have with their competitors. We wanted to test if the mating dynamics of males change depending on whether they had prior experience with one another. We did this by using the harvestmen species *Leiobunum aldrichi* (Opiliones: Sclerosomatidae). We quantified mating dynamics (aggressiveness, likelihood of successful mating, and duration of copulation) in male-male-female mating trials where competing males were either familiar or unfamiliar with each other. We manipulated familiarity by pairing males overnight in cages in which they were separated by netting that allowed them to interact and exchange cues except through physical altercations. The following day we ran the male-male-female mating trials in which we paired males with either a familiar male (the male with which he was housed overnight) or an unfamiliar male (a male that was housed with a different male). We found that male-male aggression in familiar trials was considerably lower

than in unfamiliar trials. We also found males were half as likely to mate in familiar trials, potentially due to higher rates of rejection by females. These results demonstrate familiarity from previous social interactions may play an important role in mating dynamics.

Keywords: social experience, mating dynamics, behavior, familiarity, harvestmen

Oral presentation

Muscles, hydraulics and springs: perspectives on joint mechanics in arachnid locomotion

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This presentation reviews current understanding of the evolution and biomechanics of muscular, hydraulic and elastic mechanisms used in propulsive joint extension and explores new avenues of research. Emphasis is placed on three aspects, the significance of phylogenetic history, body size, and leg muscles other than extensors in shaping the taxonomic distribution of extension mechanisms. 1. Deep phylogenetic relationships among chelicerates indicates an evolutionary polarity in arachnids from primitive joints without dedicated extensor mechanisms (e.g., hydraulics, kinetic chains) to those with dedicated extension mechanisms (e.g., elastic sclerites, novel extensor muscles), but finer details will depend on a robust phylogeny of arachnids, which does not currently exist. 2. Specific mechanical predictions can be derived from an assumption of geometric similarity. The approach successfully predicts that hydraulic pressure used in propulsive leg extension is invariant with size, an observation that suggests that hydraulics is more effective for small arachnids than for large ones. A similar approach can be used to make testable predictions about muscular and elastic mechanisms. 3. Extension mechanisms do not operate in isolation, and most require antagonists to regulate the rate and range over which they operate. Antagonists can take the form of dedicated flexor muscles or muscles at adjacent joints that can affect extension through a kinetic chain consisting of the intervening podomere or bi-articular muscles. Further

progress in understanding the diversity of extension mechanisms in arachnids will depend on integrating studies of phylogeny, biomechanics and patterns of muscle activity.
Keywords: kinematics, locomotion, biomechanics, morphology

Student - oral presentation

Occupancy & locomotor behavior in *Schizocosa ocreata*: preliminary analysis & visualization in R

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In many experimental designs, researchers are interested in tracking and quantifying the movement and/or behavior of animal subjects. Several systems are available for purchase that are capable of such tracking (e.g., Ethovision[®] by Noldus), but those systems are often proprietary and expensive. We used BuriTrack, an open-source video capture application, as a base system for capturing spider movements and digitizing their location within an arena on a very fine scale relative to time. In our preliminary studies, 15-minute open field exploration trials each generated a robust data set including thousands of time-stamped x, y coordinates. Unfortunately, BuriTrack is not capable of converting positional information into distance or speed calculations, nor is it able to statistically examine the differences between experimental treatments. We used R, an open source software program, to build script that is able to automatically convert position and time data to more meaningful forms included travel distance, mean travel direction, “burst” speed, proportion of time engaged in thigmotaxis, and visualization of arena occupancy via spatial histograms. Many of these functions are not included in base R or found in any of its packages. The R scripts we developed will be made freely available to the scientific community for verification and further development.
Keywords: R programming, temporospatial analysis, video capture, open source

Student - oral presentation

Systematics of the “MPME clade” and the phylogeny of Linyphiidae (Araneae)

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Despite a considerable number of recent studies, the higher level phylogeny of Linyphiidae as well as its immediate sister group relationships are still contentious. While some relationships are well established, such as the monophyly of Mynoglenines and Erigonines, and the position of *Stemonyphantes* as the sister group of clade that includes all other linyphiids, much of the phylogenetic structure of this large family remains poorly understood. This study focuses on the relationships of linyphiids with emphasis on the Linyphiini (sensu Millidge). We will report the results of phylogenetic analyses of linyphiid relationships based both on molecular data from five genetic markers (16S, 18S, 28S, COI, and H3) and morphological characters.
Keywords: systematics, morphology, molecular, Linyphiidae, Araneoidea

Student - poster presentation

Revision and phylogenetic placement of the genera *Jalapyphantes* and *Selenyphantes* (Araneae, Linyphiidae)

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The monotypic genus *Selenyphantes* Gertsch & Davis, 1946 is known only from Guatemala and Mexico. *Jalapyphantes* Gertsch & Davis, 1946 comprises four species *J. cuernavaca*, *J. minorata* and *J. puebla* (from Mexico) and *J. obscurus* (from Colombia). With the exception of *J. cuernavaca* (the type species) all other *Jalapyphantes* species are described based only

on females. We revise and describe all species of both genera, including one new species of *Jalapyphantes* and five new species of *Selenyphantes*. Preliminary analyses of molecular data place *Jalapyphantes* and *Selenyphantes* as a monophyletic group sister to *Pocobletus*.

Keywords: taxonomy, Linyphiidae, neotropical, Araneoidae, systematics

Student - poster presentation

Mechanical work of walking on level and inclined surfaces in the tarantula *Eupalaestrus weijenberghi* (Araneae, Theraphosidae)

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The metabolic cost of locomotion in cursorial spiders is directly correlated with the mechanical work done during each movement cycle. The total mechanical work includes the energy variations of the body center of mass (bCOM) regarding the environment (external work) and energy variations of the body segments in relation to the bCOM (internal work). Males *Eupalaestrus weijenberghi* are characterized by having relatively long legs in relation to body size. During the sexual period males intensively walk searching for females, hence locomotion is crucial for reproductive success. We studied the mechanical work of locomotion in males, both at level and on gradient (12°). We registered free displacements of each individual using four video cameras synchronized and analyzed the bCOM and body segments movements, after 3-D reconstruction. At mean speed of $0.025 \pm 0.006 \text{ ms}^{-1}$, the internal work was lower than expected and did not show significant differences between level and gradient. It seems that the number and displacement of legs do not affect the total mechanical work of this species. The external work,

based on the positive variations of the total mechanical energy of bCOM, represented in fact the highest fraction of the total work during locomotion. Great differences were found in the amplitude of the two total energy components, kinetic and potential. These differences are responsible for a low value of pendular energy recovery. In fact, most of the variations in total energy, and therefore external work, are due to vertical displacement of bCOM. On gradient, the external work significantly increased, due to a larger component of positive gravitational work, and the energy recovery decreased. The role of the mechanical paradigms of locomotion in spiders can help to understand the evolution of locomotion in tarantulas, however, the pendulum mechanism seems not to be highly relevant. Keywords: Theraphosidae, locomotion, kinematic, mechanical work, energy recovery

Poster presentation

A new primitive trap door spider in Thailand

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The primitive trap door spiders of the genus *Liphistius* Schiødte, 1849 (Araneae, Mesothelae) constitute the most basal group of all extant spiders. These spiders retain many plesiomorphic characters, such as a segmented abdomen and spinnerets located on the median area of the opisthosoma. *Liphistius* comprises 50 described species endemic to Myanmar, Laos, Thailand, Malaysia, and Sumatra; 32 of these species have been described from Thailand. We found a large, previously unknown *Liphistius* population in Mae Wong National Park, Kamphaeng Phet province at elevations between 1000–1300 m above sea level. We collected specimens and recorded behavioral and ecological information, including length and width of the nest entrances, number of trip lines radiating from nest entrance, depth of the tunnels, number of openings of each nest (one or two), nearest neighbor distance among

nests, soil composition where the nests were found, and ambient temperature and humidity. Morphological studies of 35 *Liphistius* specimens (17 ♀, 18 ♂) revealed that the genital characteristics of both sexes are distinct from other previously described *Liphistius* species, prompting us to describe it as a new species. Unfortunately, this newly discovered species may already be in danger as a result of disturbance and deforestation that would be caused by a dam planned for Mae Wong National Park.

Keywords: *Liphistius*, Asia, new species, conservation

Poster presentation

Geographic structure and gene flow in a range-expanding communal spider, *Cyrtophora citricola* (Araneidae) in Israel

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The communal spider *Cyrtophora citricola* (Forsskål, 1775) is known historically from Europe, Africa, the Middle East and Asia, and from several recently colonized locations in the Americas. In Israel, *C. citricola* has been known from the Jordan Valley, the Negev desert and the Arava. Recently, the distribution of *C. citricola* in Israel has expanded. Anecdotally, new populations appear to be associated with increased agricultural activity. Here we address regional patterns of genetic variation within Israel. We collected *C. citricola* from the rift valley (Lake Kinneret, Northern Jordan Valley and the Arava Valley), and the western, northern, central and eastern Negev. We carried out multiplexed shotgun genotyping of 279 individuals to detect single nucleotide polymorphisms (SNPs) and used 3164 unlinked SNPs in Fst analyses. We found low Fst values (0.02 to 0.05) among western, northern and central Negev populations, indicating high gene flow among them and/or very recent common ancestry. Since *C. citricola* were not present there in the recent past, we favor the second hypothesis - recent colonization from the same source population. The source is likely to be the eastern

Negev and the Arava; Fst values between these two populations and the north, central and western Negev populations are higher (0.06 to 0.12), but still indicate substantial gene flow, especially between the Arava and eastern, central and northern Negev. Rift valley populations maintain substantial levels of gene flow (Fst values of 0.06 to 0.11), despite being widely separated. The Arava site seems to be an important hub connecting the rift valley populations to the Negev populations. In future work we will also use SNPs data in STRUCTURE analyses, and to investigate colony structure and sex-biased dispersal in this species.

Student - oral presentation

An unexpected journey: The evolution and biogeography of New Zealand Idiopidae

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Most of New Zealand was underwater in the late Oligocene (27–22 million years ago). When the waters began to subside and more emergent land became available, it was colonised by a variety of biota. The origins of most New Zealand lineages can be traced back to nearby continents, such as Australia. However, evidence suggests that a few have been associated with New Zealand and its supercontinent, Zealandia, since the breakup of Gondwana. New Zealand's endemic trapdoor spider genus, *Cantuaria* (Idiopidae), is one such candidate for a history of Gondwanan vicariance. *Cantuaria* appears dispersal limited and surprisingly speciose. We set out to use dated phylogenies, phylogeographic analysis, and ecological data to infer the history of *Cantuaria* in New Zealand. Were *Cantuaria* in New Zealand since Zealandia split from Australia 80 million years ago, or did they more recently undertake an unexpected journey? Keywords: phylogeography, dispersal, vicariance, Australasia, diversity, genetics, Bayesian analysis

Student - poster presentation

The many faces of *Cantuaria*: morphological plasticity in New Zealand's trapdoor spiders

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New Zealand's endemic trapdoor spider genus, *Cantuaria* (Idiopidae), is thought to contain 42 species in 10 distinct clades. While researching their biogeography, we found that genetic phylogenies from multiple loci were incongruent with morphological species delimitations. Male genitalia, while often useful in mygalomorph taxonomy, are highly polymorphic even within populations of *Cantuaria*. Our poster reveals the phylogenetic relationships within the genus *Cantuaria*, and discusses the plasticity of behavioural and morphological traits.

Keywords: phylogeography, palp, Australasia, localised distribution, speciation, characters

Student - poster presentation

A new record of the genus *Idris* (Scelionidae: Scelioninae: Idrini) from South Korea

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The family Scelionidae is distributed all around the world, which has approximately 3,000 species within 150 genera in the world. To date 39 species of 15 genera from three subfamilies in Scelionidae are recorded in South Korea. In this study, we report a new record of the genus

Idris with one species. There are many parasitoid and predatory insects specializing on spider eggs. Among scelionids, some species (*Baeus achaearneus*, *Comastichus zopheros*, *Idris* sp.) parasitize spider eggs. However, there was no Korean record for scelionid wasps parasitizing in egg sacs of spider. Based on morphology, ecology, and DNA identification, we recognized this species, *Idris* sp., being new to Korea. All examined specimens and DNA samples are deposited in Kunsan National University.

Keywords: Hymenoptera, Scelionidae, Scelionae, Idrini, *Idris*, parasitoid wasps, spider eggs

Student - oral presentation

Spider diversity response to garlic mustard invasion in a Wisconsin forest understory

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Little attention has been paid to non-herbivorous invertebrates, such as spiders, when assessing the impact of invasive plant species on animal biodiversity. In June 2015, we explored how spider community diversity is affected by the presence of the invasive forest understory herb garlic mustard (*Alliaria petiolata*) by sampling spiders using beat trays and handheld aspirators at a rate of 0.25 person-hours within thirty (5 X 5 m) plots at Bay Beach Wildlife Sanctuary in Green Bay, WI. We measured the percent cover of *A. petiolata* within each plot, calculated Shannon's Diversity for adult spiders, and assessed individual spider species for possible correlation with *A. petiolata* presence. A one-way ANOVA revealed that Shannon's Diversity and Berger-Parker index values of mature spiders responded differently among specific ranges of *A. petiolata* cover ($p=0.01$ and 0.03 respectively). Counts of the native Linyphiid *Ceraticelus fissiceps* correlated with *A. petiolata* percent cover under a quasipoisson regression ($p=0.02$). The results of this study suggest how spiders, unlike host-specific herbivores, may benefit from additional structural complexity resulting from a plant invasion.

Keywords: garlic mustard, community ecology, invasion ecology, spider conservation

Student - oral presentation

Net-casting neuroanatomy: Sensory structure modifications match central nervous system investment in the net-casting spider, *Deinopis spinosa*

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In attempt to better understand the link between brain and behavior, it's common practice to compare differences in brain size across animals differing in behavior. Here, we investigate the relative investment of visual processing centers and sensory integration centers in a species of spider that undergoes a dramatic behavioral and morphological shift upon maturity. *Deinopis spinosa* are nocturnal, net-casting spiders that possess massive secondary eyes used in their unique form of active foraging. Once mature, males cease foraging and their eye size decreases, inferring a decrease of reliance on vision, a sense extremely important within the juvenile stages of life. We tested the hypothesis that external sensory structure investment (i.e., eye diameter) predicts internal sensory processing investment (i.e., visual processing centers). Using micro-computed X-ray technology, we calculated the volume of various processing centers in penultimate and mature male and female spiders, inferring investment from relative volume of focal brain regions. As expected, mature males invested relatively less than penultimate males in visual only-processing centers (ON1 and ON2), while females do not show this trend. We also find a significant relative increase in arcuate body volume in mature males, another trend not seen in female *D. spinosa*. This brain region, previously described as a sensory integration center, may be responsible for processing information related to mate searching in mature male spiders, likely chemical in nature.

Keywords: neuroethology, neuroanatomy, visual processing, nocturnal predator, net-casting spider, Deinopidae

Student - poster presentation

Nocturnal no more: Body condition predicts diurnal foraging in the net-casting spider, *Deinopis subrufa*

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The time of day at which an animal is most active directly affects many aspects of its ecology and behavior. For example, nocturnal animals must forage under dim light conditions. Many nocturnal animals seem to have overcome this constraint by increasing the sensitivity of their eyes, commonly by increasing eye size. With the largest eyes of any spider, net-casting spiders from the genus *Deinopis* are well-suited for visually-guided, nocturnal behavior. Past *Deinopis* research has illustrated the importance of vision in nocturnal foraging, the day-time inactivity/diurnal cryptic behavior of multiple *Deinopis* species, and an intense retinal shedding every morning and re-synthesis every night. Taken together, these studies have led many to believe *Deinopis* spiders to be strictly nocturnal, while also being functionally blind during the daylight hours. Recent field and laboratory observations dispute the long held belief of *Deinopis* being strictly nocturnal. Here, we first document diurnal foraging behavior of *Deinopis subrufa* and empirically test the effects of light environment and body condition on the likelihood to forage during the day. We show that between 10–20% of *D. subrufa* remain foraging during daylight hours in their natural habitat. We also show that diurnal foraging activity is not dependent on light levels experienced in laboratory condition, but is predicted, in part, by body condition. Our study highlights the importance of careful field observations and empirical testing when labeling an animal's potential activity pattern.

Keywords: activity patterns, nocturnal, diurnal, net-casting spiders

Student - poster presentation

Female preference for male chemotactile cues in *Pardosa milvina* (Araneae, Lycosidae)

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Understanding the types of information organisms use to make mating decisions is a critical part of studying sexual selection. In the wolf spider *Pardosa milvina*, both air- and substrate-borne chemical cues from females attract males, and visual aspects of male courtship impact female mate choice. Few studies, however, have examined the impact of male chemical cues deposited on a substrate (chemotactile cues) on female preference. We first monitored the amount of time females spent on male chemotactile cues and the amount of movement females performed on these cues, when the cues were from males that differed in quality (well-fed or food limited) and were not physically present. We found that the time that females spent and the amount of movement females performed did not differ between male chemotactile cues. Next, we examined the time it took the female to approach and the time they spent in association with a male sequestered under a glass vial, where half the males were surrounded by their own chemotactile cues and half the males were not. We also monitored the number of male courtship attempts, as well as the number of female attempts to interact with the male. The presence of male chemical cues had no effect on the time it took a female to approach or the time the female spent in association with the sequestered male. However, the frequency of courtship bouts performed by the male was correlated with the time the female spent near him. In addition, the frequency with which the female appeared to have her attention directed toward the male was related to his courtship activity. Taken together, these experiments confirm that *P. milvina* females focus on the visual courtship display of males and suggest that they do not use chemical cues to recognize or assess male quality.

Keywords: sexual selection, mate choice, chemotactile cues, courtship

Poster Presentation

Low-input conventional farming supports biodiversity of spiders in eastern Poland

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Numerous studies show the negative influence of intensified agriculture practices on biodiversity of different groups of invertebrates, including spiders. To conserve biodiversity in European farmlands, different measures have been implemented for last years within EU Common Agricultural Policy, of which one of the most important is the agri-environmental scheme. There is still not much data concerning the effect of low-input conventional farming systems on spider communities. Our study aims to compare spider assemblages in winter cereals in low-input conventional and organic farming systems in high nature value farmlands of eastern Poland. The research was conducted in 2012 and 2013, on 28 and 24 study plots, respectively. The plots were divided in two categories: low-input conventional farming plots where only small doses of synthetic fertilizers and pesticides were used and organic farming plots (in agri-environmental scheme) where neither pesticides nor synthetic fertilizers were applied. Epigeic spiders were collected once a month from April till July in both years of study. They were caught by pitfall traps operating two weeks every month on each study plot. In organic fields the number of specimens was higher in comparison to conventional plots (14,797 and 14,599 specimens, respectively), while the species richness and diversity showed the reverse tendency (98 species, $H'=2,44$ in organic plots and 102 species, $H'=2,54$ in conventional fields). Differences in numbers of specimens and species richness were not statistically significant. For both types of study plots Linyphiidae and Lycosidae families were the most numerous in terms of specimen numbers. The linyphiids were more abundant in conventional plots and the lycosids were more numerous

in organic fields. However, the differences between these two farming systems were not statistically significant. Spider assemblages were also affected by vegetation and landscape structure.

Keywords: spider assemblages, farmland, biodiversity, agri-environmental scheme

Oral presentation

High phylogenetic utility of an ultraconserved element probe set designed for Arachnida

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Arachnida is an ancient, diverse, and ecologically important animal group that contains a number of species of interest for medical and engineering applications. Yet, many aspects of the arachnid tree of life remain unresolved, hindering comparative approaches to arachnid biology. Despite considerable effort, biologists' attempts to resolve the arachnid phylogeny have been confounded by limited and challenging morphological characters, as well as a dearth in genetic resources. Here, we present a genomic toolkit for arachnids featuring hundreds of conserved DNA regions (ultraconserved elements or UCEs) to allow targeted resequencing of any species in the arachnid tree of life. We used recently developed capture probes designed from conserved genomic regions of available arachnid genomes and enriched a sampling of 32 diverse

arachnids. Sequence capture returned an average of 487 UCE loci for all species, with a range from 170 to 722. Phylogenetic analysis of these UCEs produced a highly resolved arachnid tree with relationships largely consistent with recent transcriptome-based phylogenies. We also tested the phylogenetic informativeness of UCE probes within the spider, scorpion, and harvestman orders, demonstrating the utility of these markers at somewhat shallower taxonomic scale, even down to the level of species differences. This probe set will open the door to phylogenetic and population genetic studies across the arachnid tree of life, enabling systematics, species delimitation, species discovery, and conservation of these diverse arthropods.

Keywords: phylogenomics, target-enrichment, species delimitation, Araneae, Opiliones

Oral presentation

The effects of leg autotomy on the outcome of predator-prey interactions in *Pardosa valens*

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There are a variety of different factors that can influence the outcome of predator-prey interactions. One factor that has received little attention is how physical impairment can influence the ability of prey to survive predation events. In this study, we aimed to identify how a specific type of physical injury common to wolf spiders, autotomy, can influence how capable prey are at surviving predation. Female predatory *Rabidosia santrita* wolf spiders were captured and allowed to deposit chemical cues in half of the foraging arenas for three days prior to all predation trials. Females of the smaller prey species (*Pardosa valens*) were brought back to the laboratory. If eggs sacs were present they were removed, and half of the *P. valens* had a randomly chosen leg IV removed. *P. valens* were then allowed 24 hours to acclimate to laboratory and physical impairment conditions. Prey were then placed in Tupperware arenas (half of which contained chemical cues, and half of which did not) and allowed to acclimate

for an additional one hour before the introduction of the *R. santrita* predators. Containers were checked at predetermined intervals for prey mortality for a total of 24 hours. Preliminary data analysis indicates that regardless of whether predator cues were present or not, intact individuals always survived longer than autotomized individuals. When predator cues were present, both intact and autotomized *P. valens* survived longer than when cues were not present. Autotomy appeared to negatively affect a preys' ability to survive predation events, most likely as a result of decreased locomotory capability. When cues were present, spiders survive longer, possibly indicating that prey spiders may use chemosensory information from their environment to alter their anti-predator behavior.

Keywords: predator-prey interactions autotomy, *Pardosa valens*, *Rabidosia santrita*, chemical cues

Student - oral presentation

Neuroplasticity in a jumping spider

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Behavioral plasticity is usually associated with neuroplasticity, as changes in brain anatomy can be necessary for an organism to cope with changes in the environment. In some hymenopteran species, volume changes in specific brain areas have been found that are linked to learning, experience and formation of memory. Jumping spiders are known for a wide array of complex behaviors. Previous studies have shown that salticids possess extraordinary cognitive abilities including planning, learning and reversal learning. However, the underlying brain structures which enable them to exhibit such flexible behaviors are basically unknown. We explored the nervous system of

the jumping spider *Marpissa muscosa* and compared the volumes of higher integrating brain structures of individuals that grew up in four different environments: 1) wild-caught spiders, 2) spiders reared alone in a deprived setup, 3) spiders reared alone in an enriched setup, and 4) spiders reared in groups of several siblings. Our results demonstrate that neuroplasticity occurs in spiders and that brain structures in *Marpissa muscosa* plastically respond to the environment the individual is confronted with.

Keywords: neuroplasticity, volumetric measurements, microCT analysis, developmental plasticity

Student - poster presentation

Brain structure of the jumping spider *Marpissa muscosa* (Arachnida: Salticidae), an arthropod with extraordinary cognitive abilities

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Jumping spiders are known for their extraordinary cognitive abilities. Here, we explore and describe the anatomy of the brain in the jumping spider *Marpissa muscosa* by means of paraffin histology, microCT, immunohistochemistry and whole-mount immunolabeling. Specifically, we focus on different neuropils, as they are processing and integrating centers of the brain. The brain is the dominating structure within the prosoma. The brain is compartmentalized into a number of different neuropils that possess specific qualities. The most anterior part of the brain (protocerebrum) of *M. muscosa* comprises seven paired neuropils and one unpaired midline neuropil (arcuate body). Further ventral, the brain includes a pair of cheliceral- (deutocerebrum) and a pair of pedipalpal neuropils (tritocerebrum). All neuropils show a

strong synapsin-immunoreactivity as well as allatostatin-immunoreactivity. The mushroom bodies and the arcuate body are considered to be higher integrating neuropils of the brain. Both are connected to the visual neuropils in *M. muscosa* - the mushroom bodies to both, first and second order visual neuropils of the lateral eyes, and the AB to the second order visual neuropils of the anterior median eyes through an optic tract. The large size and apparent strong link to vision of mushroom bodies and arcuate body in *M. muscosa* adds further support to the hypothesis, that these neuropils play an important role in cognition and locomotion control of jumping spiders.

Keywords: neuroanatomy, jumping spider, cognition, neuropils

Student - oral presentation

A transcriptomic approach to exploring pseudoscorpion subterranean trait evolution

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Rapid advances in sequencing and computing technologies are having a transformative effect on the study of trait evolution in subterranean organisms. Although only vertebrate models have been developed to date, arthropods are by far the largest faunal component of subterranean systems. In this extreme environment pseudoscorpions can be very abundant and are species-rich relative to other arthropods. This makes them ideal models for exploring subterranean trait evolution. Most extant species are poorly vagile, and several genera have congeners that are exclusively surface or subterranean and express phenotypes along a continuum of cave- and surface-adaptation in their visual and integumentary systems. However, available molecular data is sparse: there is no nuclear genome, but two mitochondrial genomes and one transcriptome have been published. It is unknown whether the integument color is from pigmentation. To address these issues and develop pseudoscorpions as model taxa, first resources will be developed and then differential expression (DE) analyses will be run between cave- and surface-adapted

lineages. Congeners of *Kleptochthonius* (Chthoniidae) and *Hesperochnes* (Chernetidae) will be used. *Kleptochthonius* expresses the full continuum in visual and integumentary systems between cave- and surface-adapted species, while *Hesperochnes* are eyeless and have thickened cuticles with red coloration. Transcriptomes will be assembled from representative congeners, then DE analyses between cave- and surface-adapted pseudoscorpions will explore signals in the visual and integumentary systems between cave- and surface-adapted species. Known arthropod pigment pathways will be mined to see if pigments are responsible for red color in *Hesperochnes*. We present preliminary results from DE analyses of original transcriptomic resources that we have developed from cave- and surface-adapted pseudoscorpions and from our searching transcriptomes for components of pigment pathways.

Keywords: Pseudoscorpiones, pigment, trait evolution, subterranean

Oral presentation

The effects of octopamine and serotonin on a wolf spider's mating behaviors

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The underlying mechanisms of individual variation in mating behaviors often remain unknown. Biogenic amines are a potential source of such variation, as they can affect a wide range of behaviors by acting as neurotransmitters, neuromodulators, or neurohormones. Octopamine (OA) and serotonin (5-HT), for example, have been shown to regulate behaviors including aggression and mating behaviors in arthropods. The regulation of spider mating and aggressive behaviors, however, might be particularly important, as females might have to decide whether to mate with, or prey upon, courting males. The brush-legged wolf spider, *Schizocosa ocreata*, is a useful study organism to investigate the effects of OA and 5-HT on mating behaviors given the behavioral evidence for variation in male courtship, variation in female choosiness, male use

of coercive mating tactics, and female sexual cannibalism. We used topical application (via dimethyl sulfoxide) to manipulate OA and 5-HT levels at different concentrations (2mg/uL and 10mg/uL). In general, males provided with OA had significantly reduced levels of courtship in comparison to control groups in response to isolated female chemical cues. In live mating trials, males and/or females were each given 10mg/uL of OA or 5-HT in a 2x2 design in order to determine whether the male or female amine levels best predicted mating success. These live mating trials demonstrated that female biogenic amine levels are more likely to affect mating outcomes, likely due to increased aggression when given OA and reduced aggression when given 5-HT. Our findings demonstrate the importance of OA and 5-HT in the regulation of mating behaviors of a well-studied wolf spider, but might also lead to further evolutionary insight into the roles of OA and 5-HT in other arachnids and arthropods.

Keywords: male courtship, female mate choice, mating behaviors, neuromodulation, Lycosidae, *Schizocosa*

Poster presentation

The effects of dopamine on mating behaviors of a wolf spider

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An array of animal behaviors is modulated by biogenic amines (e.g., histamine, serotonin, octopamine, norepinephrine, and dopamine) that act as neurotransmitters, neuromodulators, or neurohormones. However, the role of these amines in the regulation of pre-copulatory and post-copulatory mating behaviors in arthropods, and especially arachnids, is poorly understood. Dopamine (DA), in particular, has been associated with motivation and reward across different contexts, and is increased during copulation in some vertebrates. In this study, we experimentally elevated DA levels in male and female brushed-legged wolf spiders, *Schizocosa ocreata*. Dopamine was given topically on the cephalothorax using dimethyl sulfoxide (DMSO) as a carrier solvent. Either the male, the female, or both sexes

was given DA and paired (1 male, 1 female) in live mating trials. Additional control groups were included to ensure that carbon dioxide or DMSO treatments did not affect mating behaviors. We found that DA did not have a significant effect on mating success or male courtship. However, dopamine shortened the copulation duration when the female was given dopamine. We speculate that dopamine stimulated the reward center, giving spiders no further motivation to mate and reducing the copulation duration. Keywords: mating behaviors, copulation, neuromodulation, biogenic amines, Lycosidae, *Schizocosa*

Oral presentation

Vision and visually guided behavior in the hunting spider *Cupiennius salei* (Araneae: Ctenidae)

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Cupiennius salei, a nocturnal Central American hunting spider, serves as important model in neurobiology, neurophysiology and neuroethology. Aside from its remarkable mechanosensory organs, it is equipped with eight well developed eyes. Behavioral observations confirm that vision is used by the spider in the context of orientation and hunting. This presentation aims to give an overview about experiments on visually guided behaviors in *Cupiennius*. These show that *C. salei* is capable of visual object detection and discrimination and likely also visual memory. *Cupiennius* is further likely to use vision for depth perception. Behavioral experiments suggest that the main depth cue is motion induced parallax, generated during their zigzag like approaches towards target objects. To overcome limitations of the previously used real-world arena setup, we recently started to use Virtual Reality (VR). Our setup consists of a large, actively driven sphere that compensates for the spiders' movement, and a circum surrounding seamless projection. The projection is updated in real time based on the spider's own movement, to create a closed-loop virtual reality environment in which the spider can move freely. The Spider VR allows

to uncouple potential depth cues (e.g., absolute and relative size differences, retinal expansion, motion parallax) and test their relevance independently. First experiments confirm the important role of motion parallax for the preference of close objects.

Keywords: vision, behavior, depth perception, Virtual Reality, learning

Poster presentation

SpiderVR: A virtual reality setup to investigate visually guided behavior in untethered hunting spiders

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Cupiennius salei serves as important model in neurobiology, neurophysiology and neuroethology. It is equipped with well developed eyes which are used in various biological contexts, such as orientation, object detection, object discrimination and visual learning. Traditionally, behavioral experiments were performed in large arena setups, where single or multiple target objects were presented and the spider's behavior was recorded. To overcome limitations of these real-world setups, minimize handling time between trials and to permit presentation of non-static objects, we designed a Virtual Reality (VR) setup that can be used to study visually guided behavior in freely moving large hunting spiders. The spider walks on top of an actively driven sphere that compensates for its movement. The spider's position is tracked using computer vision, which feeds into the motion compensation and the recording of the walking path. Virtual environments are presented on a circular screen using four video projectors that produce a seamless image of 360° horizontal and 50° vertical extent. The virtual scene is rendered for the current viewpoint of the spider and updated in real-time. Repetition of previously performed real world experiments in the virtual environment confirmed that SpiderVR can serve as alternative for the traditional approach.

Keywords: vision, virtual reality, behavior, computer vision, motion compensation

Oral presentation

Can genomic approaches resolve the phylogeny of Argyrodinae (Araneae: Theridiidae)?

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Spiders in the subfamily Argyrodinae (Araneae: Theridiidae) are known for their web invasion behaviors to the web of other spiders. These host-parasite associations include two forms: araneophagy and kleptoparasitism. Although the behaviors of argyrodine spiders have been the interest of behavioral ecologists for a long time, the lack of a robust phylogenetic treatment of this group has hindered the study of the evolution of these behavioral traits. Su and Smith (2014) reconstructed the first molecular phylogeny of the subfamily Argyrodinae and conducted several comparative analyses to test the evolutionary association of group-living behavior and host use. An updated molecular phylogeny showed the increase in species diversification rates in Argyrodinae is related to the origin of web invasion behavior and the origin of kleptoparasitism. However, these molecular phylogenies based on Sanger data could not resolve several deep nodes thus made the inferences of the behavioral evolution unsettled. Therefore, genomic approaches could be the solutions toward a robust phylogeny of Argyrodinae. I compared two genomic approaches, restriction enzyme associated DNA sequencing (RAD-seq) and targeted sequence capture methods (specifically, ultra-conserved element sequence capture, or UCEs) and discussed the feasibilities of using genomic approaches for Argyrodinae phylogeny. The preliminary results of the genomic approaches showed that RAD-seq approach is suitable for species group or genus level phylogenies. The number of homologous loci dramatically dropped when filtering the DNA fragments for constructing the phylogeny among genera. The UCEs approach is promising for a fully resolved phylogeny for Argyrodinae.

Keywords: phylogenomics, restriction site associated DNA sequencing, ultra-conserved elements, probe design, character evolution

Student - oral presentation

Behavioral responses to varying acoustic stimuli in the wolf spider *Gladicosa gulosa*

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

Keywords: wolf spider, behavior, communication, vibration, sound

Student - poster presentation

Behaviors associated with mating success in the wolf spider *Gladicosa gulosa*

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Behaviors associated with courtship and mating- both for courting males and choosy females- can be diverse. Consequently, investigating ecological variables associated with courtship and mating behaviors requires a baseline understanding of the behaviors themselves, and which behaviors are most closely associated with successful mating. Establishing a significant association between certain behaviors and mating success can elucidate which features may be indicative of male quality and which behaviors females might use to communicate acquiescence. Future studies can then use behavioral responses in controlled conditions as metrics for male quality and female choice. The “purring” wolf spider, *Gladicosa gulosa* (Walckenaer 1837) raises interesting evolutionary questions due to an airborne acoustic signal that males produce in conjunction with their vibratory display. However, with limited previous research on this species, there has been no quantitative evaluation of which behaviors in either sex are indicative of a higher probability of successful mating. We paired male and female *G. gulosa* under controlled laboratory conditions and recorded all visual and vibratory signals from both sexes. We then provided operational definitions of all observed male and female behaviors and quantified said behaviors in association with mating success and cannibalism events. We found behaviors in both male and female behaviors that indicated a high probability of mating success, as well as latency effects for male courtship. Females showed at least four visual behaviors that indicated receptivity (i.e., were followed by acquiescence to mate), several of which showed a significant positive correlation with male vibratory amplitude. These results provide a metric for future manipulations of ecological variables in association with sexual selection in this species.

Keywords: wolf spider, behavior, communication, courtship, sexual selection

Student - oral presentation

Urban Islands: a biodiversity survey of spiders on Portland, Oregon green roofs

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Urban development reduces green space and causes fragmentation of natural habitats, reducing the connectivity of populations of organisms. Green roofs (rooftops with vegetation and shallow soil) may help to augment green space in cities and provide connectivity for plant and animal populations. Spiders are good bioindicators of the health of an ecosystem; if spiders are abundant in green roof communities, there is a food source (typically arthropods) available to them, signaling a thriving ecosystem. We surveyed the spider community on 8 green roofs in Portland, Oregon, sampling every two weeks from April through September over two years. We examined whether plant composition on the green roofs influenced spider biodiversity and abundance by comparing herbaceous and *Sedum* planted roofs. We found that herbaceous roofs had only slightly higher abundance and diversity of spiders, but that both types of roofs harbored different compositions of spider species. The most abundant families found overall were Linyphiidae, Thomisidae, Salticidae and Gnaphosidae. Spiders in the family Linyphiidae are known to balloon as adults, which may explain why they are the most abundant family on every roof. Ballooning allows for greater dispersal and thus, greater access to high places like tall buildings. Interestingly, the green roof watering regime did not affect spider biodiversity, as the unwatered herbaceous roof had equivalent spider diversity to the watered roof. We suggest that cities incorporate a diversity of green roofs, including those with herbaceous and *Sedum* plantings, and low to no additional water, to best maintain arthropod biodiversity.

Keywords: ecoroof, urban ecology, spider ecology, pitfall trap

Student - poster presentation

Last male paternity bias in *Tetragnatha*—does intermating interval matter?

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Long jawed spiders of the genus *Tetragnatha* have been studied for their mating behavior, but few studies have determined the paternity patterns found in these species. Female reproductive morphology predicts that the last male to mate should be favored in species with cul-de-sac spermathecae, although other researchers have found either extreme variability or a last-male bias for the first egg sacs with an antichronological sequence of paternity for subsequent egg sacs. It has recently been demonstrated that males can remove amorphous mating plugs composed of rival male sperm. However, the influence of the age of the sperm plug on the ability of males to remove it has not been tested. Here, we used the classic sterile male technique to determine whether or not paternity was influenced by the age of the sperm plug in *Tetragnatha elongata*. Females were mated to two males sequentially and assigned randomly to one of two groups: presentation of the second male after either short (15 min) or long (6 hour) intermating intervals. Across both groups, we found a strong bias for last-male paternity in the first egg sacs laid. Here, we report the paternity patterns observed for subsequent egg sacs and the influence of the intermating interval. We discuss the implications of our findings for sperm competition in this species.

Keywords: sexual selection, sperm competition, sexual behavior, paternity analysis

Oral presentation

Prey color biases, learning, and colorful courtship in jumping spiders

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Understanding the design of prey defenses, such as aposematic colors, involves understanding the perceptual and cognitive abilities of predators that drive their evolution. Research in this area has focused on 'key' predators (e.g., birds), with less attention paid to invertebrate predators. To understand selection pressures that jumping spiders exert on prey color patterns, we first examined natural color biases in several species of both generalist and specialist predators across five jumping spider genera. Experiments using artificially-colored prey have revealed a few common themes. First, generalist predators typically avoided color patterns that are often associated with chemically-defended prey (e.g., red, yellow, and black-and-white stripes). Moreover, while these color biases generally appear to have innate components, they are also quite flexible in both the lab and field. In the lab, spiders can be 'trained' to develop either preferences or aversions by exposing them to different combinations of natural-occurring prey. In the field, we find additional evidence that prey color biases are flexible and shaped by experience: different populations (exposed to different types of colorful prey) exhibit different (and predictable) prey color biases. Finally, we examine the idea that species with the strongest aversions to aposematic color patterns also have the highest susceptibility to prey toxins. We discuss the implications of these findings for the evolution of prey coloration. Moreover, many of the colors that females avoid when foraging are the same colors that males incorporate into their colorful courtship displays suggesting that male color patterns may act as sensory traps to avoid cannibalism; we will discuss ongoing work examining potential spillover between a female's learned food color biases and her responses to the same colors in male courtship, and implications for the evolution of elaborate male coloration in salticids.

Keywords: Salticidae, color, foraging, mate choice, sexual selection, prey choice

Oral presentation

Leg injuries and wound repair among cosmetid harvestmen

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Previous studies of leg injuries in harvestmen have generally focused on the fitness consequences of leg loss for individuals that use autospasy as a secondary defense. In this study, we examined the rates of leg injuries among three species of cosmetid harvestmen, assessed the impact of leg damage upon locomotion in two species and investigated the process of wound healing over a 10 day period in one species. We observed considerable interspecific variation in leg injuries among male and female harvestmen. We also observed interspecific differences in the rate of damage in relation to leg position, with leg IV exhibiting the highest rate of injury. We hypothesize that interspecific variation in leg injuries may reflect encounters with different types of predators associated with specific habitats. With respect to the functional significance of leg damage, individuals with injuries (lab-induced) to leg IV (less than 48 hrs post-injury) walked at speeds significantly slower than uninjured adults or individuals collected from the field that had fully healed leg wounds. In the lab, we assessed wound healing by damaging femora IV of adults with a scalpel and observing the changes in the wounds over time. Using SEM, we classified wounds into four distinct stages: fresh (within 0–24 hrs, hemolymph coagulum forms), recent (from 48–144 hrs, hemolymph coagulum has smooth, featureless surface), older (at least 172 hrs post-injury, hemolymph coagulum is scale-like with observable cell fragments and fibers), and fully healed (scale replaced by new cuticle growth that may include setae and 1–2 auxillary claws on terminal stump). We also used SEM to examine leg injuries of an additional 41 individuals collected from the field. Although we did not observe any fresh wounds, we found multiple individuals that had healing wounds (recent or older) and several harvestmen with fully healed injuries.

Keywords: Opiliones, neotropical, natural history, Cosmetidae, morphology, SEM

Student - oral presentation

Taxonomy, phylogeny and biogeography of the *Cytaea* (Araneae: Salticidae) from the Australasian Region

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The main goals of the project are the following: 1) to revise the genus *Cytaea*, 2) to distinguish species groups, 3) recognize speciation centres, 4) to present a complete phylogeny and 5) distributional history of the genus, including bioclimatic and phylogeographical models. The genus *Cytaea* is distributed from SE Asia, through Australia, New Guinea to New Caledonia and other W Pacific archipelagos. It comprises 39 nominal species; however, the real numbers are far from being complete as during this project as many as 50 new species have been found in Australia alone. According to recent molecular and morphological data, the genus is a part of the tribe Euophryini and is estimated to be some eighteen million years old, with unclear origin area. The study, based on types and new material, includes hundreds of specimens and field records analysed using morphological (LM, SEM, X-ray microtomography) and molecular data (sequence data of COI, 28S rDNA, 16S-ND1 and Actin 5C gene fragments). The findings are promising, largely supporting results based on morphology and allowing us to distinguish eight species-groups and to initially suggest Australia-New Guinea as the genus' biodiversity (origin?) centre. So far, 12 nominal species have been re-studied (ET & BP). New morphological characters for the genus, such as "embolic teeth" and embolic accessory glands, have been discovered. The latter not only have diagnostic value, but are also potentially important in mating plug production. Mating plugs have also been found in females.

Keywords: jumping spiders, molecular phylogenetics, distribution, Australasia, mating plug, SEM

Oral presentation

Cascading increase of the chromosome number showing concentric rings in *Gagrellula ferruginea* (Arachnida: Opiliones) in two different mountains in Japan

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Gagrellula ferruginea (Loman 1902) (Opiliones: Eupnoi: Sclerosomatidae) is one of the most common species of harvestmen in main islands of Japan except Hokkaido. The species is diverse in coloration of body and at least 11 geographical forms have been recognized in the species. The number of chromosomes of the species also varies widely from $2n = 10$ to 24, geographically. Populations of the species with different chromosome numbers usually integrate one another through a hybrid zone where chromosome number is polymorphic including heterozygous karyotypes whose chromosome numbers are odd. However, sites where two forms with different colorations or different number of chromosomes are sympatrically found have been found at three different sites; two of them can be interpreted as cases of circular overlap. Thus taxonomy of the species is complicated and challenging. In the Tango Mountains, northwestern part of Kyoto Prefecture, Honshu, diploid number of chromosomes of the species abruptly increase from 14 to 20 toward the center of the mountains around Mt. Oye-yama from peripheral populations, making a series of chromosomal hybrid zones. Karyotypic analyses showed that a series of Robertsonian reciprocal translocations are responsible for the change and the change proceeded successively from $2n=14 \rightarrow 16 \rightarrow 18 \rightarrow 20$. On the other hand, a similar pattern of the increase in the chromosome number through Robertsonian translocations has recently been found in the Nunobiki Mountains, in the middle part of Mie Prefecture, Honshu. In the area, diploid number of chromosomes continuously varies from 12 to 18 depicting a concentric scheme again.

These cases seem to indicate occurrence of a chain process that generates rapid increase of the chromosome number.

Keywords: Opiliones, chromosomal evolution, geographic variation, speciation, hybrid zones

Poster presentation

Mass findings of an uncommon spider *Prodidomus rufus* from Komon-jo: Time capsule of indoor spider fauna from Edo Period

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A conspicuous amount of antique documents (= Komon-jo) that had been housed in a warehouse in Nakajima's residence in Iwami-cho, in Tottori Prefecture, Japan, were transferred to Tottori Prefectural Museum in 2008. The Nakajima family had served as a village headman of Tottori han (clan) in the Edo Period (1603–1868). During the process of the transfer, all the dried dead bodies and exuviae of insects and spiders that had attached to the documents were collected for the purpose of pest control. Identification of a total of 151 examples of spiders (33 bodies, 118 exuviae) revealed 18 spider species. Of these, most abundantly found was *Prodidomus rufus* Hentz 1847 (Prodidomidae) that comprises 2 males, 3 females, and 45 exuviae. This was followed by *Loxosceles rufescens* (Dufour 1820) (Sicariidae: 5 juveniles + 40 exuviae) and Gnaphosidae gen. & sp. (probably *Trachyzelotes jaxartensis* (Kroneberg 1875 or *Urozelotes rusticus* (L. Koch 1872 (1 juvenile + 16 exuviae). *Prodidomus rufus* is a very rare species, though distribution of the species is worldwide. Only 5 collecting records (latest is in 1991 are available in Japan after the first finding in Japan from inside house in Ozu City, Shikoku in 1913. The specimens also included *Dictis striatipes* L. Koch 1872 (Scytodidae) which lacks recent records in Japan and *Oecobius navus* Blackwall 1859 (Oecobiidae) which has never been recorded from the Sea of Japan side of Japan. The results suggests that indoor spider fauna in the Edo Period is quite

different from the one today. Beetles that feed dry provisions or wooden building materials such as deathwatch beetles (Anobiidae) were the most abundant in the samples collected. Prevalence of inexpensive bug repellents such as camphor balls might cause the change in the communities of house insect pests and house spiders as their predators.

Keywords: indoor spider fauna, historical faunal change, antique documents, *Prodidomus rufus*, rare species

Student - poster presentation

Spatio-temporal dynamics of generalist predators (*Tetragnatha* spider) and dipteras in environmentally friendly paddy fields

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Spiders have long been known as biological control agents in agricultural landscapes. This function is thought to be of particular importance for environmentally friendly farming (EFF) where agrochemical application is limited. For reducing pest damage in EFF, it is crucial to identify environmental conditions that increase spider abundance. In this study, we focused on spatio-temporal dynamics of *Tetragnatha* spiders that heavily rely on wetland habitats including paddy fields. As paddy fields are probably unsuitable habitats for spiders in non-crop (non-flooding) season, nearby ditches are likely to be alternative habitats for these spiders. Moreover, dipterans that emerge in large numbers from paddy fields are expected to be important bottom-up agents maintaining spider populations. Field surveys were conducted in 15 paddy fields under conventional fields and 18 paddy fields under EFF during three seasons in Tochigi Prefecture, central Japan. The results showed that *Tetragnatha* spiders were more abundant in paddy fields than in ditches during the growing season, but this tendency

was reversed during the non-crop season. Thus, complementary utilization of ditches and paddy fields during different seasons appeared to maintain *Tetragnatha* populations. Both *Tetragnatha* spiders and flying insects increased in paddy fields under only EFF, when the surrounding forest cover was high. There was a significant positive correlation between the abundance of flying insects and the population growth rate of *Tetragnatha* spiders, suggesting the bottom-up effect of flying insects emerging from paddy fields. We considered that the high potential productivity in paddy fields, coupled with the presence of nearby ditches, maintained high abundance of *Tetragnatha* spiders in paddy-dominated landscapes.

Keywords: agriculture, paddy landscape, natural enemy, farming practices

Poster presentation

Sternal apodemes in phalangodid harvestmen (Opiliones)

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The sternal apodeme (SA) is a rarely observed endoskeletal plate that has been documented only twice; first by Loman (1903 for the Asian species, *Mermerus beccarii* (Assamiidae)) and more recently by Thaler (1996 for three European species of *Scotolemon* (Palangodidae)). Here we record this apodeme in all examined genera of Nearctic Phalangodidae (*Banksula*, *Bishopella*, *Calicina*, *Crosbyella*, *Enigmina*, *Megacina*, *Sitalcina*, *Texella* and *Tularina*), although not the Malagasy phalangodid, *Bunofagea*. The SA was also not found in several other laniatorid families examined, including representatives of Insidiatores (Sclerobunidae and Triaenonychidae) and higher Grassatores (Assamiidae, Gonyleptidae, Podocidae, Pyramidopidae, Samoidae, and Zalmoxididae). The SA is a leaf-like plate that extends from the sternum into the abdominal cavity, where it serves to anchor the large muscles that insert into trochanter IV. The SA and associated musculature are found only in males, which

are richly endowed in additional sexually dimorphic structures. Of these, the most common are processes of the hind trochanter (TrIV), which range from small tubercles to short prongs to massive clubs. Similarly variable is the size of the SA (and consequently the associated musculature), from the largest observed in *Sitalcina californica* to the smallest in *Banksula grabami*. This variation of two associated structures suggests a correlation. Do larger TrIV structures require a larger muscle mass? Preliminary comparison of SA to TrIV size shows only partial correlation. Species with TrIV modifications do have larger SAs compared to those with unmodified TrIVs, but species with the largest SAs do not have the largest TrIV processes. The presence of moderate-sized SAs in species lacking male trochanteral modifications (such as species of *Calicina*) is puzzling and requires an alternate explanation.

Keywords: Opiliones, Phalangodidae, morphology, endoskeleton, sexual dimorphism

Oral presentation

Comparative mate assessment in wolf spiders: results from multimodal playback studies

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Although theory predicts that females should exhibit ordered preferences for size or expression of male quality-indicating traits, recent work suggests some species employ comparative rather than absolute evaluation of mates. We tested comparative assessment of differences in male quality by female *Schizocosa ocreata* (Hentz) wolf spiders with unimodal and multimodal video and vibratory playback choice tests. Females show ordered directional preferences for expression of male quality indicator traits (leg tuft size, vibration amplitude) in both individual sensory modes and multimodal signals, as quality of either signal mode affects mate choice outcome. Females exhibited transitivity of preference, consistently choosing males with higher quality relative to an alternate choice. Multimodal choice tests showed

that while females made predicted choices when male traits covaried positively, in negative covariance (cue-conflict) choice tests, females showed a bias for higher male quality in visual signals. Female wolf spiders therefore appear to exhibit comparative mate evaluation of individual signal modes in multimodal signals, and assess male quality among potential suitors.

Keywords: behavior, communication, vibratory signals, video playback, Lycosidae

Oral presentation

Securing paternity by mutilating female genitalia in spiders

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Competition between males and their sperm over access to females and their eggs has resulted in manifold ways by which males try to secure paternity, ranging from physically guarding the female after mating to reducing her receptivity or her attractiveness to subsequent males by transferring manipulative substances or by mechanically sealing the female reproductive tract with a copulatory plug. Copulations may also result in internal damage of the female genitalia; however, this is not considered as a direct adaptation against sperm competition but as a collateral effect. Here, we present a drastic and direct mechanism for securing paternity: the removal of coupling structures on female genitalia by males. In the orb-weaving spider *Larinia jeskovi* males remove the scapus, a crucial coupling device on the female external genital region. Reconstruction of the coupling mechanism using micro-CT-scanned mating pairs revealed that several sclerites of the male genitalia interact to break off the scapus. Once it is removed, remating cannot occur due to mechanical coupling difficulties. In the field, male-inflicted genital damage is very prevalent since all female *L. jeskovi* were found to be mutilated at the end of the mating season. External genital mutilation is an overlooked but widely spread phenomenon since 80 additional spider species were found for which male genital manipulation can be

suspected. Interlocking genitalia provide an evolutionary platform for the rapid evolution of this highly effective mechanism to secure paternity, and we suspect that other animal groups with interlocking genital structures might reveal similarly drastic male adaptations.

Keywords: sexual selection, conflict, securing paternity, functional morphology of genitalia

Oral presentation

A molecular phylogenetic approach to the New Zealand species of Enantiobuninae (Opiliones: Eupnoi : Neopilionidae)

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We report the first phylogeny based on molecular data for the New Zealand species in the genera *Forsteropsalis*, *Pantopsalis*, and *Mangatangi*, and comment on the taxonomic implications of our results, including the diagnostic viability of important morphological characters. Members of the New Zealand Enantiobuninae constitute some of the most charismatic soil arthropods of the archipelago, and a striking example of sexual dimorphism, with nondescript females but colourful males boasting exaggerated chelicerae many times longer than their bodies. The genera *Forsteropsalis* and *Pantopsalis* recently underwent revision, but many questions remained about the validity of many species designations, due to issues of characters of dubious taxonomic value, female specimens designated as holotypes despite the males holding all the diagnostic characters, and the suspected presence of more than one male form within some species. We present the first molecular phylogenetic study of the group, including extensive sampling of fresh material across New Zealand. Our results reject the controversial monophyly of Neopilionidae and comment on the taxonomic implications of the results, including the diagnostic validity of morphological characters traditionally used on the groups.

Keywords: Opiliones, Australia, biogeography, phylogeny

Oral presentation

Crowding leads to fitness benefits and reduced dispersal in a colonial spider

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Density-dependent dispersal is a mechanism of escaping decreased fitness associated with intra-specific competition. In group living species, however, high density is expected to be beneficial for the individual, at least up to a certain threshold. A possible mechanism for maintaining optimal density is negative density-dependent dispersal. To examine this hypothesis we studied the effect of colony density on fitness, dispersal and prey capture under different diets in *Cyrtophora citricola*, a colonial spider undergoing range expansion. Results support a negative density-dependent dispersal strategy: dispersal propensity of spiders decreased with colony density, especially when prey abundance was high, and spiderling site tenacity increased with colony density. Spider body mass increased with density, indicating positive density-dependent fitness (Allee effect). However, variance in body mass was higher in dense colonies than among solitary spiders, suggesting that spiders in the colony differed in their prey capture success. This interplay between Allee effect and dispersal strategy may have an important role in the life history and colonization success of colonial spiders.

Keywords: Allee effect, colonial spider, density-dependence, dispersal

Oral presentation

Effect of seasonal photoperiod on molting in *Loxosceles reclusa* and *Loxosceles laeta*

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In the winter of 2014–15, I attempted to push immature brown recluse spiders, *Loxosceles reclusa*, to maturity for a pest control experiment. Despite food offerings, they

stopped molting after October although their abdomens were well-nourished and were maintained at 25° C. It was surmised that decreased filtered daylight coming through a paper-covered window might be suppressing molting. Feeding was halted in January and 88 recluse spiderlings were checked weekly for molts. Molting resumed at the beginning of April and continued through May despite not being fed. To more thoroughly elucidate photoperiod effects on molting, during the week of the September 2015 equinox, immature brown and Chilean recluses were set up in three light regimes: 14:10 L:D, natural, 10:14 L:D. Through the winter, brown recluse molting was suppressed with no molting in the 10:14 regime from November to late March, minor molting in the natural exposure and moderate in the 14:10 regime. Chilean recluses showed no differences in molting across the three photoperiod regimes. This species difference may be explained in that brown recluses are temperate zone creatures where winter is typically accompanied by cold temperatures and reduced prey availability that would be detrimental to survival; Chilean recluses are tropical where winter light cycles may have little significance. The experiment was still underway when this abstract was submitted so additional information may develop.

Keywords: behavior, photoperiod, molting, *Loxosceles*

Student - oral presentation

Odor alters color preference in foraging jumping spiders

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In many prey taxa with aposematic coloration, prey defenses also involve signals in other modalities (odors, sounds, etc.). Yet the selective forces that have driven multimodality in warning displays are not well understood. One potential hypothesis that has recently received support in the avian literature, is that different signal components may interact synergistically, such that one component of the signal (odor) may trigger predator's

aversion to another component of the signal (color). Such synergistic effects on predator psychology have received little attention in invertebrate predators. We address this gap by asking how multimodality affects attack rates in a voracious jumping spider (*Habronattus trimaculatus*). Spiders were given the choice between red or black prey (artificially colored termites) in either the presence or absence of odor from a chemically defended coreid bug (*Acanthocephala femorata*). We found that when the scent was present, spiders were significantly more likely to avoid red termites compared with when absent. Interestingly, this pattern only held up when the scent was novel; subsequent exposure to the scent did not have the same effect on color preference. We discuss these findings in the broader context of predator psychology and argue that spiders may provide novel insights for the field.

Keywords: Salticidae, multimodality, aposematic, foraging

Student - poster presentation

Duplication and concerted evolution of MiSp-encoding genes underlie the material properties of minor ampullate silks of cobweb weaving spiders

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Orb-web weaving spiders and their relatives use multiple types of task-specific silks. The majority of spider silk studies have focused on the ultra-tough dragline silk synthesized in major ampullate glands, but all silk types have impressive material properties. For instance, minor ampullate silks of orb-web weaving spiders have lower strength but higher extensibility than draglines. Differences in material properties between silk types result from differences in their component proteins, which are members of the spidroin (spider fibroin) gene

family. However, the extent to which variation in material properties within a single silk type can be explained by variation in spidroin sequences is unknown. Orb-web weavers use minor ampullate silk to form the auxiliary spiral of the orb-web, while cobweb weavers use it to wrap prey, suggesting that selection pressures on minor ampullate spidroin (MiSp) sequences may differ between the two groups. Here, we characterize complete or nearly complete MiSp sequences from five cobweb weaving spider species in three genera and measure material properties of minor ampullate silks in a subset of these species. We also compare MiSp sequences and silk properties of our cob-web weavers to published data for orb-web weavers. We demonstrate that all our cobweb weavers possess multiple MiSp loci and that one locus is more highly expressed than the other in at least two species. We also find that the proportion of α -spiral-forming amino acid motifs in MiSp positively correlates with minor ampullate silk extensibility. Our sequences thus provide templates for recombinant silk proteins with tailored properties.

Keywords: concerted evolution, minor ampullate spidroin, cobweb weavers, physical properties

Oral presentation

Another bloody Australian in New Zealand: The invasive spider *Latrodectus hasseltii*

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Latrodectus hasseltii, the Australian redback, is an invasive spider that has been established in New Zealand since 1980. As well as its medical importance, *L. hasseltii* is a conservation threat to threatened endemic chafer beetles, skinks and New Zealand's endemic widow spider, *Latrodectus katipo*. This unwelcome Australian spider has the capability to spread further than its current range in New Zealand and can also spread to other parts of the world. However, there is hope for controlling it biologically using a volatile organic compound.

Keywords: invasive species, *Latrodectus*, New Zealand

Student - oral presentation

Male-male competition and chelicera morphology in New Zealand sheet-web spiders

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Animal weaponry has long captured the imagination of researchers, and can occur with varying degrees of exaggeration in different taxa. Exaggerated male weaponry are particularly common in species in which males defend females or their resources from potential rivals. While sexual selection is generally credited with their exaggeration, the particular processes and drivers are far from uniform. In particular, exaggerated jaws, horns and teeth may evolve through selection for males who can physically defend females or they may develop as badges of status to warn rivals off. New Zealand sheet-web spiders (*Cambridgea foliata*) are one such species in which male chelicerae (jaws) are substantially larger than those of female conspecifics. We used an integrative approach, combining behavioural and morphological analyses to pinpoint the selective pressures acting on male chelicera and to examine how chelicera morphology varies among males. We randomly paired males on female webs and recorded their behaviours. Then, we compared both internal and external chelicera morphology of males and females of varying sizes to see how internal and external traits covaried. In this species, male jaws are positively allometric while female jaws are not and larger males tend to win fights against smaller males while chelicera size does not seem to have an effect.

Keywords: sexual selection, male-male competition, chelicera morphology, allometry

Student - poster presentation

Fitness consequences of geographic variation in mate choice in a wolf spider

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Variation in mate choice within and among populations can have profound effects on sexually selected traits and ultimately on population divergence. However, our understanding of how changes in the costs or benefits of mate choice per se shape mate choice in and among natural populations remains limited. We use a population comparison approach in *Schizocosa* wolf spiders to determine the extent to which changes in benefits provided by males contribute to among-population variation in mate choice. Specifically, we test for population differences in the male signal variants that maximize copulation success and those that maximize female fitness, and we then determine whether signal variants associated with copulation and with female fitness are correlated among populations. In addition to contributing to the limited literature on adaptive mate choice variation, our work lays the foundation for further investigations of ecological causes of changing benefits as well as the potential role of variation in mate choice in driving signal divergence and premating reproductive isolation.

Keywords: mate choice, sexual selection, communication, divergence

Student - oral presentation

Genetic consequences of rapid range expansion in *Argiope bruennichi* populations

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Environmental changes, e.g., climate warming or increase in the area of wastelands, contribute to the expansion of many terrestrial invertebrates. In Europe, a strong northward expansion of *Argiope bruennichi* is observed. In Poland, by the end of the 1990s ca. 100 sites have been identified in many regions, except north-eastern parts of the country and mountains region in the south, where the climate is harsh. Currently, the wasp spider is distributed over the whole territory of Poland and it has become a

very common species. However, it is still unclear, whether the newly founded populations in mountain regions in the south or in harsh climatic conditions of north-eastern Poland are unstable and vulnerable to fluctuations, which hinders effective colonization. In expansive species, data about the genetic diversity and gene flow between local populations are important in predicting the longevity of the population, especially in newly colonized areas. The main goal of the research was to analyze genetic structure and to estimate a migration level of the wasp spider in Poland. Over 600 specimens we obtained from 24 sites. The genetic variability of the species and genetic differentiation among populations was estimated using 19 microsatellite loci. We found that in Poland *A. bruennichi* presents low level of genetic variability. Most of local populations were not in Hardy-Weinberg equilibrium. Genetic structure was weakly pronounced but some division of populations into geographical groups was supported by genetic data. We suggest that observed pattern of distribution of genetic diversity could be a consequence of rapid expansion and result of founder effect in the newly colonized areas.

Keywords: gene flow, dispersal, habitat fragmentation, population structure, isolation by distance.

Student - oral presentation

A first glance at the coupled genitalia of the harvestmen *Phalangium opilio* (Eupnoi)

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Harvestmen genital morphology has long been described mainly for taxonomic purposes, but genital coupling interactions remain largely unknown. Male genital functioning was generally inferred by artificial hydraulic expansion, since interactions between male genital parts (as well as their possible movements) were never seen. This is a huge information deficit for a better understanding of genital interactions in harvestmen, a group in

which complex genital morphology suggests functions beyond gamete transfer/oviposition. Previously, we studied a Laniatorean species's coupled genitalia in some detail (unpublished data). Here we present the first observations for the suborder Eupnoi. Three pairs of *Phalangium opilio* in copula were freeze-fixed with liquid nitrogen. One pair was submitted to microCT scan and the others photographed, since they were clearly in early stages of penetration: beginning of penetration, and mouth rubbing. The images show interesting new facts, e.g., pre-penetration interaction, depth of penis penetration, stylus location in relation to seminal receptacles, penis and ovipositor contact regions. These results, even though preliminary, contribute to fill the gap in harvestmen functional genital morphology, and also provide consistent data for sexual selection hypotheses formulation.

Keywords: Opiliones, genital coupling, genital morphology, mating

Student - poster presentation

Anti-predator submersion behavior: a coevolutionary arms race between two species of wolf spiders?

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Spiders exhibit a wide range of anti-predatory defenses that affect their overall behavior. The Red Queen hypothesis predicts situations in which interactions with predators can result in a coevolutionary arms race. We examined the predator-prey interactions between two species of semi-aquatic wolf spiders from Arizona. In these interactions, the smaller prey species will dive under the water to escape the larger species, however the larger species has also evolved a diving behavior. We compared the submersion tolerance and morphological characters that may influence such aquatic anti-predator behavior to determine if a coevolutionary arms race may be occurring. Results indicated that the prey species had a faster

submersion recovery time and a higher density of longer spines on their femurs when compared to the predator species. This may allow the prey species to remain submerged longer by way of a larger volume of trapped air, resulting in the ability to evade predation. Further investigation will determine whether the density of the hairs on the abdomen differs between predator and prey, as well as how the density of spines influences aquatic movement.

Keywords: anti-predator behavior, Red Queen hypothesis, Lycosidae, submersion, tolerance

Student - oral presentation

Macronutrient effects on juvenile jumping spider growth

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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. We measured the body size of 420 F1 jumping spiders, *Phidippus audax*, raised on 21 different diet treatments ranging from high protein to high lipid across several prey quantities. The ratio of lipid to protein in prey had the largest effect on spider growth in the high prey abundance treatments. Overall, spiders weighed more and had larger body size on diets that were more lipid-biased. Our results suggest that spiders require lipid rich prey for maximal growth. Previous work indicates most prey in nature are lipid poor. Spiders should then either select lipid rich prey over lipid poor prey or find alternative energy sources, like extra floral nectar.

Keywords: nutrition, macronutrients, jumping spider, growth, *Phidippus audax*

Oral presentation

Measuring the nutrient content of prey for spiders

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Diet quality has long been known to have large effects on the behavior, survival, growth and reproduction of spiders. The main attributes of prey thought to be responsible for these effects of diet quality are toxins and nutrients. For decades, analysis of prey nutrient content have measured nitrogen (N) and extrapolated to protein using an outdated conversion factor (6.25). Here, I test if N or protein is a better measure of the nutrient content of the prey of spiders. Overall, there was a poor correlation between the N and protein content of a wide range of arthropods and the estimated conversion factor was lower than the traditional 6.25. Analyses of N also overestimated the amount of protein left in prey remains after spiders finished feeding. The N content of prey remains is similar too, if not higher than, whole prey items. Yet, almost no protein is present in prey remains. Feeding experiments demonstrated that analysis of the protein content in whole prey items is a strong predictor of the amount of protein consumed from prey by spiders. Assays of protein content provide a more direct and cost effective method for measuring the nutrient content of prey and the nutrients that spiders consume from prey than the traditional method of measuring N and multiplying by 6.25.

Keywords: foraging, nutrition, prey, protein

Oral presentation

Female mating status affects male mating tactic expression in the wolf spider *Rabidosa punctulata*

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Males commonly alter the expression of alternative mating tactics based on their condition, the environment

they are in, and various characteristics of their potential mate. In the wolf spider, *Rabidosia punctulata*, males commonly adopt one of two mating tactics when encountering a female, multimodal courtship or the more aggressive direct mount that often incorporates grappling with females for copulation. While females of closely related species mate only once and become unreceptive and aggressive, a recent study showed that female *R. punctulata* mates multiply in a short time period. Here we explored how female mating status affects male mating behaviors. We exposed males to females that had or had not mated in previous trial and observed the mating tactics expressed. Previously mated females re-mated in 34% of second trials. The mating status of females affected the mating tactic that males used. Males paired with already mated females were significantly more likely to use grappling during the trial when compared to males that were paired with unmated females. Grappling was the most successful tactic at acquiring copulations with already mated females. This could be due to reduced receptivity by mated females not approaching males that simply adopt courtship.

Keywords: mating tactics, context dependent, multiple mating, Lycosidae

Oral presentation

Chemical and mechanical warfare: the defenses of armored harvestmen against spiders and flatworms

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Most spectacular adaptations exist in nature when it comes to predator-prey interactions but few studies report how the same prey react against different predators. Here we summarize studies we have been carrying out in the last five years on how Neotropical armored harvestmen defend themselves against sympatric and also nocturnal spiders and flatworms. We used two harvestmen species, one spitting spider, two large ctenids, one recluse spider and one

flatworm. We paired predator and prey, described their behaviors and tested hypotheses on the role of chemical defenses and the survival value of the thick harvestmen cuticle. Against spiders, the armor proved to be an excellent defense except against recluse spiders. These spiders have a remarkable strategy that involves searching for the soft parts like leg articulations and the distal parts of the legs and were able to kill harvestmen in most cases. The armor was also useless against flatworms, which hamper prey's movement with mucus, kill and ingest the internal organs of harvestmen. Against spiders, harvestmen seldom used their defensive secretions but these proved to efficiently repel flatworms. Against both predators, pinching with spines on legs IV repelled the predator, in some cases almost cutting the flatworm body in two pieces. While the classical literature emphasized the importance of chemical defense for harvestmen, we are showing that the relative importance of each defense is predator dependent.

Keywords: animal behavior, predator-prey interaction, defensive behavior

Student - oral presentation

Investigating the influence and regulation of catecholamines on circadian rhythmicity of anti-predator behavior in the orb-weaving spiders

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While it is widely assumed that circadian rhythms benefit organisms by allowing them to anticipate changing conditions, only a few studies have directly tested this. Being both predator and prey, orb-weaving spiders offer a novel, tractable model system to test whether circadian rhythms are adaptive due to their variety of temporal foraging strategies across species. Previous work suggests that spiders modulate their aggression/wariness over the 24-cycle and that aggression and wariness are modulated by biogenic amines (neurohormones). In this study, we analyzed temporal changes in catecholamine levels and transcriptional regulation in the orb-weaving

spider *Larinioides cornutus*. *L. cornutus* individuals were collected from sites in northeast TN. After a 7-day entrainment period, spider cephalothoraxes were dissected and haemolymph was collected at 4 different time points over a 24-hour cycle. We measured gene transcription levels and neurohormone levels in haemolymph and cephalothoraxes using RNA-sequencing and HPLC-ED, respectively. Levels of catecholamine neurohormones did change over the 24-hour period however, the patterns found were not uniform. Like brain-reward pathways in many other taxa, dopamine levels did rise during foraging periods (nighttime) of *L. cornutus*. In addition, patterns in gene expression further supported the fluctuating patterns of catecholamines.

Keywords: circadian rhythms, neurochemistry, transcriptomics

Oral presentation

Three dimensional analysis of the arachnid locomotory system - topics and problems

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The arachnid locomotory apparatus has formed the focus of zoological research for many decades. However, the 3D revolution opens up fascinating new possibilities for visualizing highly complex animal features and therefore makes a re-investigation of the locomotory system and all its substructures necessary. Here we present the concepts behind a recently started project in which the cuticular, muscular and nervous elements of all four pairs of walking legs will be described three dimensionally for representatives of all major arachnid lineages. In addition, the complete prosomata, i.e., the extrinsic locomotory musculature and all other skeletal musculature will be studied in order to account for the structural basis of leg movement and the generation of the hydraulic pressure responsible for leg extension in a number of arachnid taxa. As well as presenting major components of the locomotory system, we discuss

theoretical problems which occurred during the initial investigations.

Poster presentation

Role of elongated chelicerae in male-male contest and female mate-choice in the spider genus *Myrmarachne* (Araneae: Salticidae)

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Exaggerated male structures, which are sexually dimorphic, have evolved in many animals, and often serve a role in sexual selection, that is, either male-male competition or female mate-choice or both. Such exaggerated structures also exist in ant-mimicking jumping spiders from the genus *Myrmarachne* in the form of elongated chelicerae. This study focused on the species *Myrmarachne maxillosa* as the model for investigating the role of elongated chelicerae in sexual selection, effect of which is suggested by the variance of chelicera size within males and between the sexes of the species. Males are randomly pitted against each other to examine the effect of chelicera length in male-male competition; males and females are randomly paired in simultaneous-choice trials to examine the effect of chelicera length in female mate-choice. Our results showed that males with longer chelicerae won the majority of the fights, and females preferred males with longer chelicerae that courted longer. We concluded that chelicera length can be used as a reference for success in male-male competition as well as preference in female mate-choice.

Keywords: ant-like jumping spider, *Myrmarachne*, male-male contest, female mate-choice, ornament, armament, sexual behavior

Oral presentation

Repeated evolution of power-amplified predatory strikes in trap-jaw spiders (Araneae, Mecysmaucheniidae)

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Small animals possess intriguing morphological and behavioral traits that allow them to capture prey, including innovative structural mechanisms that produce ballistic movements by amplifying power. Power-amplification occurs when an organism produces a relatively high power output by releasing slowly stored energy almost instantaneously, resulting in movements that surpass the maximal power output of muscles. For example, trap-jaw power-amplified mechanisms have been described for several ant genera, which have evolved some of the fastest known movements in the animal kingdom. However, power-amplified predatory strikes were not previously known in one of the largest animal classes, the arachnids. Mecysmaucheniidae spiders, which occur only in New Zealand and southern South America, are tiny, cryptic, ground-dwelling spiders that rely on hunting rather than web-building to capture prey. Analysis of high-speed video revealed that power-amplified mechanisms occur in some mecysmaucheniid species, with the fastest species being two orders of magnitude faster than the slowest species. Molecular phylogenetic analysis revealed that power-amplified cheliceral strikes have evolved four times independently within the family. Furthermore, we identified morphological innovations that directly relate to cheliceral function: a highly modified carapace where the cheliceral muscles are oriented horizontally; modification of a cheliceral sclerite to have muscle attachments; and in the power-amplified species, a thicker clypeus and clypeal apodemes. These structural innovations may have set the stage for the parallel evolution of ballistic predatory strikes.

Keywords: ballistic movement, functional morphology, phylogenetic, evolution

Student - oral presentation

Exploring the relationship between collective personality and behavioral plasticity in warring arthropod societies

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Collective personalities of animal societies can sometimes predict whether they flourish or whether they fail. These collective personalities often arise from the behavioral composition of the individuals that comprise the society. Different behavioral compositions generally perform differently in orchestrating and shaping complex tasks such as foraging, prey capture, and colony defense. In instances where predators and prey share a long evolutionary history, prey species sometimes exhibit a specialized, species-specific, anti-predator response to their presence. Here we show how different behavioral compositions of desert social spider (*Stegodyphus dumicola*) societies survive and modulate their collective foraging and defensive behavior in the presence or perceived presence of a common voracious predator, the pugnacious ant (*Anoplolepis custodiens*). Our results reveal a subtle interaction between group composition and group experience in determining the collective behavior of spider societies, which, in turn, can impact their survival under siege in situ.

Keywords: sociality, plasticity, personality, predation

Poster presentation

Competition and autotomy affect survival and development in cellar spiders

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Cellar spiders, *Pholcus phalangioides*, are well-known for their cosmopolitan distribution, facilitated by their ability to live indoors in colder areas. Indoor living combined

with a two year life span and high reproductive capacity can set the stage for large, dense populations where intra-specific competition for prey and territory may be intense. Cellar spiders are able to autotomize limbs (to escape a predator or a bad molt), but are unable to regenerate lost limbs. Thus, losing a leg as a juvenile is likely to incur lifelong costs. We tested the effects of competition and autotomy on survival and development in juvenile *P. phalangoides*, housed singly or with a partner (either a sibling or non-sibling) between the third and fourth molts. Treatments for this experiment were: 1) autotomized-Intact paired siblings, 2) autotomized-Intact paired non-siblings, 3) intact-intact paired siblings, 4) intact-intact paired non-siblings, 5) single intact individuals, and 6) single autotomized individuals. In each treatment with only one spider, 11 of 16 survived to complete the fourth molt, but of the survivors, three had to autotomize one or more legs to escape a bad molt. In treatments with a lone spider, mortality was confined to times when molting was occurring. Pairing with another spider, introduces the risk of cannibalism on top of an already challenging transition. Cannibalism rates were high in all paired treatments and in the paired Autotomized-Intact treatments; spiderlings missing a leg were more likely to be cannibalized by their intact partners. These results indicate that whereas autotomy is likely helpful to juvenile spiders in escaping a bad molt, it also reduces their ability to compete with conspecifics.

Keywords: cellar spiders, autotomy, competition, survival

Oral presentation

Pre-Pleistocene geological events shaping diversification and distribution of primitively segmented spiders on East Asian margins

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Phylogeographical research in the East Asian continent and islands (East Asian Margins, or EAM) suggests predominant Pleistocene over-water dispersal events from continent to islands, but more ancient biogeographical patterns in EAM remain obscure. We explored biogeographical histories and population genetic structures of the primitively segmented spiders, *Heptathela* and *Ryuthela* (Liphistiidae), broadly codistributed across EAM islands. Time-calibrated phylogenetic, biogeographic and population genetic analyses were performed. Dating analyses suggest that i) phylogenetic origin of *Heptathela* + *Ryuthela* is estimated at 26.6–18.4 Ma (95% HPD) when EAM islands became separated from the continent, ii) the crown ages of *Heptathela* (18.0–10.7 Ma) and *Ryuthela* (17.8–8.7 Ma) coincide with the formation of Japan Sea and Okinawa Trough respectively, iii) a split within *Ryuthela* (13.9–6.0 Ma) coincides with the opening of the Kerama Gap, but a split within *Heptathela* (18.0–10.7 Ma) pre-dates the formation of the Tokara Gap, iv) speciation within *Heptathela* and *Ryuthela* is relatively recent (6.0–0.3 Ma). Population genetic and demographic results suggest interrupted gene flow within and among islands, with most species exhibiting stable past populations. Our results corroborate predominantly vicariant origins of genera and species, and suggest total lack of overwater dispersal in these sedentary spiders.

Keywords: biogeography, continental islands, dispersal, Kyushu, phylogeography, Ryukyus, vicariance

Poster presentation

Extant primitively segmented spiders have recently diversified from an ancient lineage

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Living fossils are lineages that have retained plesiomorphic traits through long time periods. It is expected that such lineages have both originated and diversified long ago. Such expectations have recently been challenged in some textbook examples of living fossils, notably in extant cycads and coelacanths. Using a phylogenetic approach, we tested the patterns of the origin and diversification of liphistiid spiders, a clade of spiders considered to be living fossils due to their retention of arachnid plesiomorphies and their exclusive grouping in Mesothelae, an ancient clade sister to all modern spiders. Facilitated by original sampling

throughout their Asian range, here we provide the phylogenetic framework necessary for reconstructing liphistiid biogeographic history. All phylogenetic analyses support the monophyly of Liphistiidae and of eight genera. As the fossil evidence supports a Carboniferous Euramerican origin of Mesothelae, our dating analyses postulate a long eastward over-land dispersal towards the Asian origin of Liphistiidae during the Palaeogene (39–58 Ma). Contrary to expectations, diversification within extant liphistiid genera is relatively recent, in the Neogene and Late Palaeogene (4–24 Ma). While no over-water dispersal events are needed to explain their evolutionary history, the history of liphistiid spiders has the potential to play prominently in vicariant biogeographic studies.

Keywords: biogeography, systematics, vicariance, dispersal, ancestral areas

Oral presentation

Evolutional pattern of the mimic-model relationship in the genus *Myrmarachne* (Araneae: Salticidae)

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The genus *Myrmarachne* MacLeay, 1839 comprises the species that show ant-like appearance and behavior, and they are considered to be Batesian mimics. In fact, the ant-like appearance works effectively to get a protection against predators that dislike ants (Huang et al 2011; Nelson & Jackson 2006). However, the model ant of each *Myrmarachne* species has not been

specified sufficiently, and the evolutionary pattern of the mimic-model relationship is unclear. To reveal probable evolutionary pattern of the mimic-model relationship in the genus *Myrmarachne*, we established the mimicry relationship between *Myrmarachne* species and ants on the basis of the size, shape, coloration, geographical distribution and natural history information. The phylogeny of *Myrmarachne* species was also inferred by molecular analysis of mitochondrial CO1 region. Based on available data obtained until now, we will discuss the evolution of the mimic-model relationship.

Keywords: myrmecomorphy, Batesian mimicry, taxonomy, Southeast Asia

Poster presentation

Assembly and annotation of the mitochondrial genome of the striped scorpion, *Centruroides vittatus*

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We have assembled a complete mitochondrial genome for the striped scorpion, *Centruroides vittatus*, from Illumina miSeq data. The *C. vittatus* mtDNA genome matches the published *C. limpitus* mtDNA genome (81.6%) with a similar genome size (14.6 kb) and the same order of the 13 protein coding genes. The A + T content of the *C. vittatus* mtDNA assembly is also similar to *C. limpitus* (68.1% to 64.46%, respectively). Most of the nucleotide variation between the *C. vittatus* and *C. limpitus* mtDNA genome occurs in the putative noncoding regions. Availability of multiple complete mitochondrial genomes will advance molecular phylogenetic and biogeographical investigations.

Keywords: scorpion, mitochondrial genome, genomics, mitochondrion

Oral presentation

Maternal feeding and webs influence dispersal in the colonial orb-weaver, *Cyrtophora citricola*

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Although colonial spiders are thought to have parasocial, rather than subsocial, origins, colonies may grow through the retention of juveniles, and the genetic structure of colonies remains unknown for most species. We examined the role of natal philopatry in the formation, growth, and decline of *Cyrtophora citricola* colonies in a semi-natural setting. I placed gravid females on high and low diets onto potted trees in a net house and examined their webs daily for hatching, juvenile web building, and migration among trees. About half of spiderlings from the first clutch built their webs within the support silk of their mother's web, and they were less likely to disperse if the mother had been on the high feeding regime and if her web was larger. These effects held only for the first cohort of hatchlings. Later cohorts dispersed at greater rates, and neither maternal feeding nor web size affected the probability of dispersal. However, the total number of offspring staying in the colony remained correlated with web size, suggesting that spiderlings prefer to build webs within the silken framework of their mother's web, but that her web can become saturated with juvenile webs and thereby force later hatchlings to disperse.

Keywords: colonial, dispersal, foraging, migration, silk, social, web

Poster presentation

Cuticular compounds in a subsocial spider with kin recognition

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In the prolonged subsocial spider, *Delena cancerides*, juveniles remain with their mother under a piece of bark until they reach maturity. Unlike most other group-living spiders, *D. cancerides* is a central place forager: individuals leave the bark retreat at dusk to feed and return at dawn. Spiders can travel many meters in a single night and may encounter foreign colonies. Molecular data show that some individuals in a colony are immigrants unrelated to the adult female and her offspring, and behavioral assays show that spiders differentiate kin from nonkin by preferentially cannibalizing nonkin and spending more time investigating unfamiliar conspecifics. To understand the mechanism behind this recognition, I extracted the cuticular molecules of male and female spiders and the juveniles of two families. I present the preliminary analysis of the compound blend and their differences among individuals.

Keywords: chemical communication, hydrocarbon, kin recognition, subsocial

Oral presentation

Salticidae (Arachnida: Araneae) of islands off Australia revisited

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Island salticids have been studied on several occasions, including our first approach made in 1999. The current project included 64 islands, most of them in tropical part of Queensland. The islands have been divided according to their climate (tropical, temperate), origin (coral, volcanic), distance from the continent (within or outside the continental shelf), size, topography, biotic diversity and intensity of human penetration. Due to the fact that some islands were connected with the continent during Pleistocene ice age and others had no such connections, we expected their faunas to be more balanced (continental) or disharmonic, respectively. The material included about 700 field records and

has been analyzed in terms of genus/species diversity, endemism, biotic preferences and dispersal. At least 41 genera have been identified and the number of species appeared several times higher. In comparison to over 70 genera and 400 species known from the whole Australia, the numbers seem quite substantial. Several genera predominated the data: *Lycidas/Jotus* (101 records), *Cosmophasis* (37), *Holoplatys/Ocrisiona* (29), *Simaetha* (22), *Clynotis* (19), *Neon* (19). The majority of records came from different types of forests and the list of microhabitats included leaf litter, tree trunks/bark, and vegetation of different strata, each known to require unique living strategies and to offer different dispersal potential. Not surprisingly, the Lord Howe Island has proved to possess highly endemic fauna, but also other islands, such as Barrow Island (close to Western Australian coast) appeared an important biodiversity centre (genus *Cytaea*). Our research confirmed the islands to be an important model for the research of salticid dispersal and colonization, but for the results to be fully comprehensive the sampling methods should be unified and the investigated biota and microhabitats should be more representative.

Keywords: Salticidae, taxonomy, islands, biogeography

Student - oral presentation

Ornamental coloration associated assessment strategy in male-male contests of *Siler semiglaucus* jumping spiders

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Animals engaging in potential time and energy cost contests are expected to estimate either the resource-holding potential (RHP) of their own ('self-assessment strategy'), or difference between their rivals and their own ('mutual assessment strategy'). Body size is commonly used as a proxy for RHP in animal contests. Male ornamental coloration exhibits on the body of male

individuals is also commonly used as a visual signal in intraspecific communications in many species, but evidence of whether it could be an appropriate proxy of RHP is scarce. Here, we staged contests between age- and size-matched male *Siler semiglaucus*, a widely distributed Southeast Asian jumping spider, to tackle this question in terms of its effect on both contest outcome and strategy. Meanwhile, we investigated if contest intensity (escalation) could also serve as a measure of contest cost, compare with contest duration in male-male contest.

Keywords: male-male contest, assessment strategy, coloration, jumping spider, *Siler semiglaucus*

Oral presentation

Spider silk does not support the growth of bacteria

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Spider silks are fascinating biopolymers, the strength of which can be comparable to that of the synthetic super fiber Kevlar. Their mechanical properties have been intensively investigated, however, their chemical properties have received less attention. Though spider silks are made from proteins, in nature they were seldom observed to be decomposed by bacteria or fungi. To reveal why microbes can not grow well on spider silk, we tested silks of three spider species building three web types: orb web builder *Nephila pilipes* (Nephilidae), the funnel web builder *Hippasa holmerae* (Lycosidae), and the tent web builder *Cyrtophora moluccensis* (Araneidae). We used *Bacillus subtilis*, *Escherichia coli*, and two strains of bacteria isolated from silk decoration of *Cyclosa mulmeinensis* (Araneidae). We examined the antimicrobial effect of spider silks by cross-streaking assays and the results showed that there was no inhibition zone in the vicinity of spider silks. In addition, we also used spider web silks to culture the bacteria using three different media: LB (containing all nutrients), NFG (nitrogen-free glucose) and PBS (no nutrient

buffer). Results showed that the number of bacteria in LB medium was significantly higher than those in NFG and PBS media. However, the number of bacteria cultured in NFG and PBS media did not differ significantly. These results suggest that the reason bacteria can not easily consume spider silk is that the nutrients in spider silk can not support the growth of bacteria, rather than the silk containing antimicrobial chemicals to inhibit the growth of bacteria.

Keywords: spider silk, bacterial growth, *Nephila pilipes*, *Hippasa holmerae*, *Cyrtophora moluccensis*

Oral presentation

If they could only bite you: venom composition and potency of daddy long-leg spider venom

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Pholcid or “daddy long-legs” spiders are notorious for their toxic venom, even though its potency has never formally been studied. Urban myths surrounding the venom of these common spiders have survived years of curiosity and rumor with no supporting scientific evidence. We have identified the venome - transcriptomic and proteomic venom components - of the North American species *Physocyclus mexicanus* and analyzed its potency on natural prey. The result is a comprehensive collection of data from Sanger sequencing, Illumina 3000 sequencing, and mass spectrometry (LC-MS/MS). We found that the majority of the venom proteome are toxic elements including digestive enzymes (astacin metalloproteases, serine proteases and metalloendopeptidases) and venom peptide neurotoxins. We have identified several new groups of venom peptides, all of which are homologous with toxins from other haplogynes ($e < 10^{-5}$), except one. Finally, bioassays on crickets

caused flaccid paralysis with an effective paralytic dose of 3.9µg/g. Altogether, these data provide an important contribution to comparative venom analyses, fill in another piece of the phylogenetic puzzle among haplogyne spider venoms, and address the myth of daddy long-leg spider venom potency.

Keywords: venom, astacin metalloprotease, neurotoxin, cDNA library, mass spectrometry, bioassay

Oral presentation

Retinal specializations and the architecture of visual signals

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One widespread feature of visual systems is regionalization of visual competency across the visual field, including regions of heightened motion sensitivity, spatial acuity and/or color vision. Animals compensate for this regionalization with gaze movements that aim specialized retinal regions at areas of interest within the visual scene. These movements determine what animals see when they interact with visual stimuli. However, we know almost nothing about how animals use their gaze to evaluate communicatory displays. We know even less about how visual displays have evolved to effectively capture, retain or manipulate the gaze of signal receivers. We have begun to explore this critical aspect of visual signaling in the jumping spider genus *Habronattus*. The extreme regionalization within their modular visual systems, and their diverse courtship displays combined with a well-characterized phylogeny enable us to investigate how female gaze interacts with male displays, both during courtship signaling and over evolutionary time. By employing gaze-tracking, video playback, and signal manipulations, we are approaching three questions: 1) Where do jumping spiders focus attention when viewing complex displays, and how do visual systems influence the evolution of visual signals? 2) Conversely, how do visual signal traits

act on the evolution of the receiver's visual system? 3) How are multiple visual functions (e.g., color vision, motion detection) integrated during active display evaluation? Our data from *H. pyrrithrix* reveal discrete distance-dependent dance motifs that match regional competencies of the female visual system, and show that females pay specific attention to subsections of the male display. Analysis of other *Habronattus* species with distinct visual environments, coloration, and courtship dances offers a tantalizing opportunity to deepen our understanding of visual signaling, and reveal principles that may be applicable across taxa.

Keywords: Salticidae, color vision, communication, sensory drive, courtship

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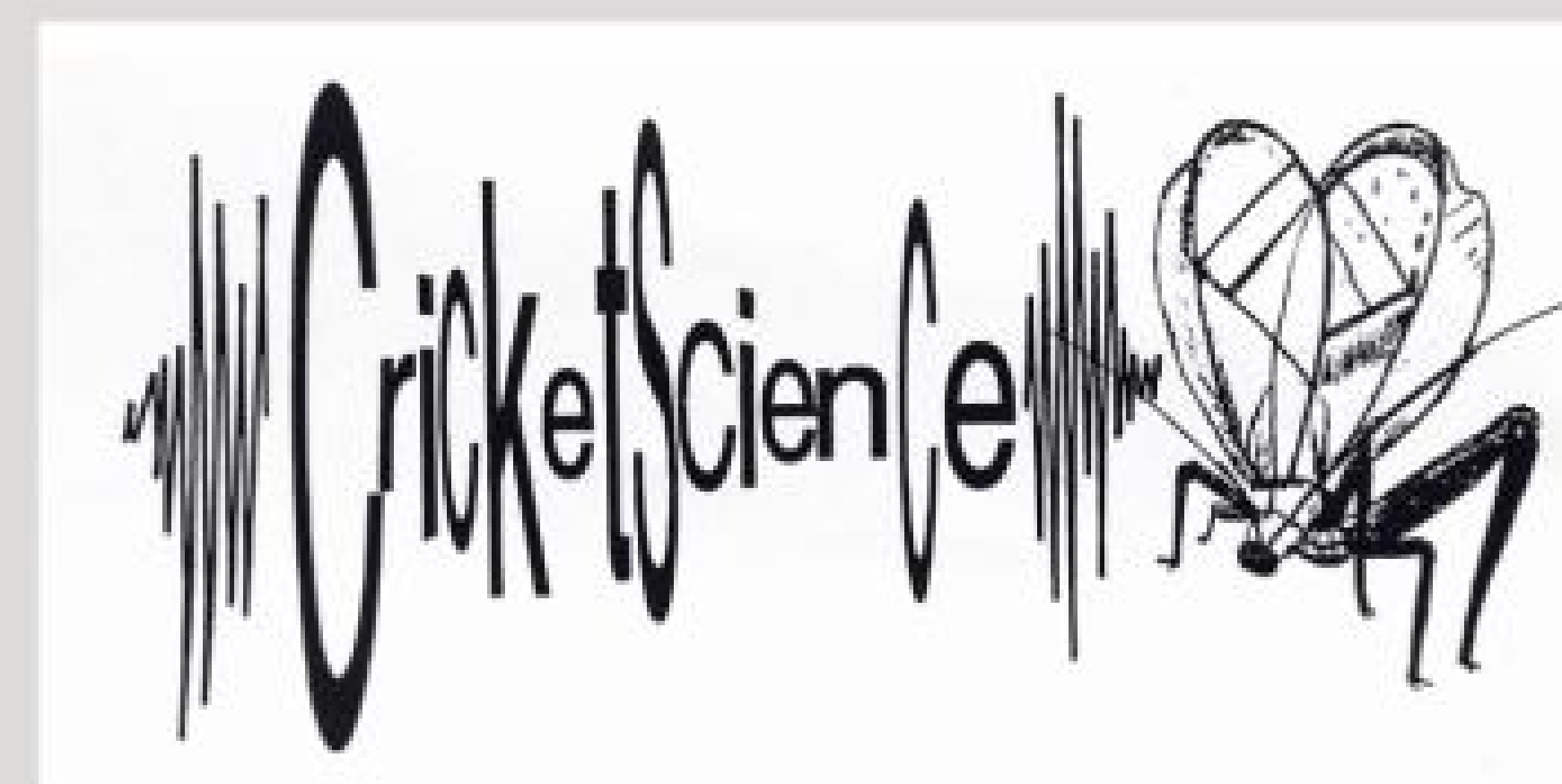
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