20th ANNUAL ANIMAL BEHAVIOR CONFERENCE

March 28-30, 2013
Bloomington, Indiana

Keynote Speaker: Frances Champagne

Satellite Symposium: "Mechanisms Matter"
Keynote Speaker: John Godwin
The 20th Annual Indiana University

Animal Behavior Conference Schedule

Thursday, March 28th

4:00 – 5:30 PM  Exemplar Awardee Seminar: Emília Martins, Indiana University  
(IMU Frangipani Room)  
TAKING THE LONG VIEW: CAUSES AND CONSEQUENCES OF SIGNAL EVOLUTION

6:00 – 8:00 PM  Poster Session (IMU Maple, Walnut, Oak Rooms)  
Posters will remain on display until 12 PM Friday

8:30 – 10:00 PM  Film Showing: Ordinary Extraordinary Junco (Radio-TV Building* 251)  
Written and Produced by Jonathan Atwell and Ellen Ketterson

*The Radio-TV building is located at 1229 E 7th St, near the arboretum.

Friday, March 29th IMU Frangipani Room

8:30 – 9:00 AM  Breakfast (a few breakfast items, coffee, tea)

8:55 – 9:00 AM  Welcoming Remarks  
G. Troy Smith, CISAB Director

ORAL PRESENTATIONS (IMU Frangipani Room)

Session I  

Moderator: Karen Bohorquez

9:00 – 9:15 AM  Oliver Beckers, Indiana University  
RESOURCE COMPETITION AND THE RAPID DIVERSIFICATION OF LIFE HISTORY TRAITS: LESSONS FROM EXOTIC DUNG BEETLE POPULATIONS
9:15 – 9:30 AM Diana Hews, Indiana State University
STAGED TERRITORIAL INTRUSIONS AND AGGRESSIVE VISUAL SIGNALING IN MALES OF SCELORPORUS LIZARD SPECIES THAT DIFFER IN ABDOMINAL PATCHES IN AN OLD LINEAGE

9:30 – 9:45 AM Edgar Mantes, Northeastern Illinois University
CIRCADIAN RHYTHMS MODULATE BEHAVIORS OF THE PRAYING MANTIS, HIERODULA MULTISPINA, AT VARIOUS LEVELS OF ANALYSIS: RETINAL PHYSIOLOGY, LOCOMOTION, AND PREY CATCHING BEHAVIOR

9:45 – 10:00 AM Kelly Ronald, Purdue University
INTRASEXUAL SELECTION IN A BROOD PARASITE: THE ROLE OF HORMONES, HUNGER, AND HEARING

10:00 – 10:15 AM Delia Shelton, Indiana University
GEOMETRY OF COLLECTIVE DETECTION IN ZEBRAFISH (DANIO RERIO)

10:15 – 10:30 AM Morning Refreshment Break

Session II
Moderator: Mark Peterson

10:30 – 10:45 AM Robert Bowers, Indiana University
MECHANISMS FOR COMBINING MATE-CHOICE INFORMATION FROM MULTIPLE MODELS

10:45 – 11:00 AM Sarah Keesom, Indiana University
SEROTONIN INCREASES IN THE AUDITORY MIDBRAIN OF MALE MICE DURING ENCOUNTERS WITH FEMALES

11:00 – 11:15 AM Katherine McCann, Georgia State University
SOCIAL DEFEAT IN SYRIAN HAMSTERS: CONTROLLABILITY, DURATION AND SOCIAL RECOGNITION

11:15 – 11:30 AM John Shorter, North Carolina State University
THE GENETIC ARCHITECTURE OF AGGRESSION IN DROSOPHILA MELANOGASTER

11:30 – 11:45 AM Sarah Wofford, Bowling Green State University
SEX AND FIGHTING: MALE AND FEMALE CRAYFISH USE DIFFERENT ASSESSMENT STRATEGIES DURING AGONISTIC BEHAVIOR

11:45 – 12:00 PM Allison Brager, Morehouse School of Medicine
GENETIC AND TISSUE-SPECIFIC REGULATION OF SKELETAL MUSCLE STRUCTURE AND FUNCTION

12:00 – 1:30 PM LUNCH BREAK (Restaurant guide available at registration table)
### Session III

*Moderator: Leah Wilson*

<table>
<thead>
<tr>
<th>Time</th>
<th>Speaker</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>1:30 – 1:45 PM</td>
<td>Aubrey Kelly, Indiana University</td>
<td>FUNCTIONAL SIGNIFICANCE OF A PHYLOGENETICALLY WIDESPREAD SEXUAL DIMORPHISM</td>
</tr>
<tr>
<td>1:45 – 2:00 PM</td>
<td>Paul Meyer, Indiana University</td>
<td>NON-NUTRITIVE THERMOTACTILE STIMULATION INDUCES ODOR PREFERENCE IN C57BL/6 MICE</td>
</tr>
<tr>
<td>2:00 – 2:15 PM</td>
<td>Victoria Templer, Emory University</td>
<td>COGNITIVE MECHANISMS UNDERLYING MEMORY FOR SEQUENCES IN MONKEYS</td>
</tr>
<tr>
<td>2:15 – 2:30 PM</td>
<td>Piyumika Suriyampola, University of Louisville</td>
<td>MANIPULATING TERRITORY SHAPE VIA LANDMARKS</td>
</tr>
<tr>
<td>2:30 – 2:45 PM</td>
<td>Brian Gall, Hanover College</td>
<td>LOCATION, LOCATION, LOCATION: MINUTE ADJUSTMENTS BY AN EGG LAYING AMPHIBIAN HAVE A LARGE EFFECT ON OFFSPRING SURVIVAL</td>
</tr>
</tbody>
</table>

### Session IV

*Moderator: Mikus Abolins-Abols*

<table>
<thead>
<tr>
<th>Time</th>
<th>Speaker</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>2:45 – 3:00 PM</td>
<td>Gregory Kohn, Indiana University</td>
<td>COURTSHIP AS A TWO WAY STREET: FEMALE VOCAL BEHAVIOR AND REPRODUCTIVE PERFORMANCE</td>
</tr>
<tr>
<td>3:00 – 3:15 PM</td>
<td>Alison Ossip-Klein, Indiana University</td>
<td>SEX DIFFERENCES IN COLOR INCREASE OVER EVOLUTIONARY TIME IN SCELOPORUS LIZARDS</td>
</tr>
<tr>
<td>3:15 – 3:30 PM</td>
<td>Ryan Wong, North Carolina State University</td>
<td>CHARACTERIZING THE NEUROGENOMIC PROFILES OF ALTERNATIVE STRESS COPING STYLES IN WILD-DERIVED ZEBRAFISH</td>
</tr>
<tr>
<td>3:30 – 3:45 PM</td>
<td>Susan Gershman, The Ohio State University</td>
<td>TIME FLIES: CIRCADIAN RHYTHMS AFFECT MALE ATTRACTIVENESS</td>
</tr>
<tr>
<td>3:45 – 4:00 PM</td>
<td>Awards Ceremony (G. Troy Smith)</td>
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</tr>
<tr>
<td>4:00 – 5:00 PM</td>
<td>PLENARY SPEAKER: Frances Champagne, Columbia University</td>
<td>DEVELOPMENTAL PROGRAMING OF BEHAVIOR VIA EPIGENETIC PATHWAYS</td>
</tr>
<tr>
<td>7:30 – 9:30 PM</td>
<td>Evening Reception</td>
<td>Laura Hurley and G. Troy Smith’s House (map on page 7 of the program)</td>
</tr>
</tbody>
</table>
**Saturday, March 30th**  
Myers Hall* Room 130

### Saturday Satellite Symposium

*Mechanisms Matter: Hormonal and Neural Regulation in Animal Behavior*

<table>
<thead>
<tr>
<th>Time</th>
<th>Session</th>
</tr>
</thead>
<tbody>
<tr>
<td>9:00 – 9:05 AM</td>
<td>Opening remarks</td>
</tr>
</tbody>
</table>
| 9:05 – 9:20 AM| **Alan Barker, Indiana University**  
EFFECTS OF CHRONIC COCAINE ON REWARD OMISSION EFFECT IN SPRAGUE-DAWLEY RATS |
| 9:20 – 9:35 AM| **Jessica Hanson, Indiana University**  
CONTEXT-DEPENDENT FLUCTUATION OF SEROTONIN IN THE AUDITORY MIDBRAIN: THE INFLUENCE OF SEX, REPRODUCTIVE STATE, AND EXPERIENCE |
| 9:35 – 9:50 AM| **Jeffrey Lucas, Purdue University**  
SIGNS AND INDIVIDUAL VARIATION IN SENSORY SYSTEMS |
| 9:50 – 10:20 AM| **INVITED SPEAKER: Dale Sengelaub, Indiana University**  
NADS, NEURONS, AND THE NASTY: THE CELLULAR BASIS OF MALE COPULATORY BEHAVIOR |
| 10:20 – 10:35 AM| Morning Refreshment Break                                               |
| 10:35 – 10:50 AM| **Mark Peterson, Indiana University**  
NATURAL VARIATION IN GENE EXPRESSION AND TESTOSTERONE PRODUCTION: IMPLICATIONS FOR THE EVOLUTION OF HORMONE-MEDIATED PHENOTYPES |
| 10:50 – 11:05 AM| **Ian Hall, Columbia University**  
THE *XENOPUS* AMYGDALA GENERATES SOCIALLY APPROPRIATE VOCAL RESPONSES TO COMMUNICATION CUES |
| 11:05 – 11:20 AM| **Lauren Rudolph, Indiana University**  
MECHANISMS OF A CRITICAL PERIOD: MAINTENANCE OF MUSCLE ERα PERMITS ESTRADIOL-DEPENDENT DENDRITE GROWTH IN A SEXUALLY DIMORPHIC NEUROMUSCULAR SYSTEM |
| 11:20 – 11:50 AM| **INVITED SPEAKER: Kimberly Rosvall, Indiana University**  
MECHANISMS OF BEHAVIORAL ADAPTATION AND ACCLIMATION: IDENTIFYING PRESSURE POINTS OF SELECTION BY COMPARING ACROSS LEVELS OF BIOLOGICAL ORGANIZATION |
| 11:50 AM – 1:30 PM| **LUNCH BREAK**                                                          |
Ryan Paitz, University of Illinois
CHARACTERIZING THE CONVERSION OF YOLK ESTRADIOL TO ESTROGEN SULFATES DURING EMBRYONIC DEVELOPMENT IN THE RED-EARED SLIDER

Alejandro Velez, Purdue University
SEASONAL VARIATION IN AUDITORY PERFORMANCE IN THREE SONGBIRDS

KEYNOTE SPEAKER: John Godwin, North Carolina State University
NEUROENDOCRINE REGULATION OF SEXUAL PLASTICITY IN FISHES

*Myers Hall is located on East 3rd St., near Woodlawn Ave.*
ACKNOWLEDGEMENTS

A big “Thank You” to the conference organizers!


CISAB Staff: Linda Summers, Tamara Marnell, and Charli Taylor

Thanks also to our sponsors, who made this conference possible!

- Department of Biology, Indiana University
- Department of Psychological and Brain Sciences, Indiana University
- W.M. Keck Center for Behavior Biology, North Carolina State University
- Center for Behavioral Neuroscience, Atlanta, GA
- Drs. Laura Hurley and G. Troy Smith, Department of Biology
Map and Directions to Smith/Hurley House

1. Take your favorite route south (unless you live even further south) to Tapp/Country Club/Winslow/Rogers.
2. Go east on Tapp/Country Club/Winslow/Rogers (unless you're coming down Smith Rd., in which case, go west).
3. Turn south onto Snoddy Rd.
4. Turn left onto Robin Rd. (at the bottom of the hill).
5. Robin Rd. will turn to the right. Our driveway will be right in front of you (where Robin Rd. turns left again). Our house is white with red brick.

Address: 3660 Robin Rd.
Phone: (812) 332-1691
ORAL PRESENTATION ABSTRACTS
(in order of presentation)

Session I
1. Oliver Beckers (obeckers@indiana.edu)

RESOURCE COMPETITION AND THE RAPID DIVERSIFICATION OF LIFE HISTORY
TRAITS: LESSONS FROM EXOTIC DUNG BEETLE POPULATIONS

O.M. Beckers, A.P. Moczek
Department of Biology, Indiana University, Bloomington, IN

Geographic variation in resource competition can generate substantial differences in selection pressures, potentially leading to divergences between populations. The dung beetle *Onthophagus taurus* is native to the Mediterranean and was introduced less than 50 years ago to Australia (AUS) and North America (NA). Female *O. taurus* care for their offspring by providing dung in form of a brood ball, which constitutes the sole food available for larvae to complete their development. The density of conspecific and heterospecific competitors for dung is several orders of magnitude higher in AUS populations than in NA populations. We investigated the effects of differential resource competition between AUS and NA populations on juvenile and adult life history traits (e.g., brood provisioning, fecundity, fertility, developmental time) across three generations. Our results indicate that AUS females have evolved greater efficiency in terms of resource allocation and reproduction, affecting both larval and adult life history traits, as predicted by the increased levels of competition for dung present in AUS. Interestingly, some of the differences observed between populations disappeared in later generations, suggesting that maternal effects and phenotypic plasticity may affect life history traits and their short-term evolution.

2. Diana Hews (diana.hews@indstate.edu)

STAGED TERRITORIAL INTRUSIONS AND AGGRESSIVE VISUAL SIGNALING IN MALES
OF *SCELORPUS* LIZARD SPECIES THAT DIFFER IN ABDOMINAL PATCHES IN AN OLD
LINEAGE

D. Hews¹, C. Vital², J.J. Zuniga-Vega³, E. Martins⁴
¹Department of Biology, Indiana State University, Terre Haute, IN, ²Universidad Autonoma de Ciudad Juarez, Juarez, Chihuahua, ³Universidad Nacional Autonoma de Mexico, Mexico City, Federal District, ⁴Department of Biology, Indiana University, Bloomington, IN

As in many animals with social signals, *Sceloporus* lizards use multicomponent visual signals involving color and motion. Most *Sceloporus* species are sexually dichromatic, and males have paired blue abdominal patches used in postural displays during male aggression. Several independent evolutionary losses or reductions of the blue belly patches occur in *Sceloporus*. Previous work on a pair of *Sceloporus* species in a relatively young lineage found species differences in traits associated with color and visual signals, and found that some differences may be mediated by the endocrine system. As part of a larger study looking at the evolution of signaling in this genus, we report on a behavioral study on two species in a relatively older lineage within the genus. Behavioral responses of males to staged territorial intrusions (STIs) differed between a white-bellied species, *S. siniferus* and a closely-related species with blue abdominal patches, *S. merriami*. Males in *siniferus* (white) were more likely to use broadcast displays (push-ups) and the highly aggressive modifiers (full show) compared to *merriami* (blue). The blue species also was more likely to escalate directly to physical contact. Hence, there is evidence of decoupling of the correlations among color and signaling behavior that were documented in the younger lineage. We discuss these species differences in the context of considering differences in habitat complexity and in the risk of predation.
3. Edgar Mantes (E-Mantes@neiu.edu)

CIRCADIAN RHYTHMS MODULATE BEHAVIORS OF THE PRAYING MANTIS, HIERODULA MULTISPINA, AT VARIOUS LEVELS OF ANALYSIS: RETINAL PHYSIOLOGY, LOCOMOTION, AND PREY CATCHING BEHAVIOR

E.S. Mantes, W. Bogue, B.W. Popkiewicz, A.F. Urdiales, F.R. Prete, A.E. Schirmer
Department of Biology, Northeastern Illinois University, Chicago, IL

Circadian rhythms are ubiquitous among vertebrates and invertebrates, and recent data indicate that the underlying mechanisms are similar across taxonomic groups. With the exception of two papers published in 1979 and 1981, nothing is known about the effects of biological rhythms on praying mantis behavior. Hence, we studied the mantises, *Hierodula multispina* and *Sphodromantis lineola* to determine the possible effects of circadian rhythms on (i) retinal (compound eye) sensitivity, (ii) compound eye pigment migration (i.e., light/dark adaptation), (iii) spontaneous locomotor behavior, (iv) and prey catching behavior. Chronic electrophysiological recordings of retinal activity under constant light conditions for 72 continuous hours revealed rhythmic patterns in photoreceptor sensitivity with an average period of 21.6 hours. Photographic monitoring of compound eye color over the same period indicated a proximal/distal migration of eye pigments during light/dark periods, respectively. Pigment migration did not occur in the absence of light/dark cues. When tested with computer generated prey-like stimuli, prey catching behavior was significantly elevated during the subjective night when eye sensitivity was greatest compared to the subjective day. Finally, spontaneous locomotor activity was recorded continuously on a modified treadmill for fourteen days. Activity levels peaked at the transitions between the light and dark cycles. Together, these data reveal circadian modulation of behaviors at both the cellular and organismal levels of analysis, and represent novel findings about this charismatic taxon. Continued studies are underway to elucidate the full impact of circadian rhythms on praying mantis behavior and physiology.

4. Kelly Ronald (kspratte@purdue.edu)

INTRASEXUAL SELECTION IN A BROOD PARASITE: THE ROLE OF HORMONES, HUNGER, AND HEARING

K. Ronald, E. Fernandez-Juricic, J. Lucas
Department of Biology, Purdue University, West Lafayette, IN

There is substantial evidence for seasonal variation in the vocal signals of many songbird species; interestingly, recent studies have also shown that there is seasonal variation in the auditory processing of acoustic signals. Male brown-headed cowbirds (*Molothrus ater*) have been used in multiple studies of mate-choice and endocrinology and, as a result, we now know much about the seasonal variation in the behavior and hormones in this species. Nevertheless, we are still unaware of how the auditory processing of male cowbirds may vary due to changes in physiological condition. Here we discuss the behavioral and physiological changes during two critical periods in the male cowbird's annual cycle: breeding and molting, and demonstrate how testosterone and food availability within these periods affects the processing of auditory stimuli, respectively. Results will be discussed in the context of sexual selection theory and the implications of seasonal changes in auditory processing will be reviewed.
GEOMETRY OF COLLECTIVE DETECTION IN ZEBRAFISH (DANIO RERIO)

D.S. Shelton, B.C. Price, E.P. Martins
Department of Biology, Indiana University, Bloomington, IN

By living in groups, animals can benefit from enhanced detection of food patches and suitable habitat. Certain spatial arrangements can create super-sensory systems that detect disturbances faster than could any solitary individual. The spatial orientation of a group can also reduce individual vigilance time thereby reducing the total time any one individual is vigilant. Here, we investigated individual and collective geometry of zebrafish (Danio rerio) in response to weak water flows. By varying the flow rate, we asked 1) whether groups vary their spatial orientation in ways likely to enhance lateral line function and 2) if individuals exhibit behavioral variation consistent with relying on group dynamics to reduce individual vigilance. We found that groups of zebrafish responded to increasing water flow by elongating and orienting perpendicular to the direct of flow, thereby potentially enhancing the ability of the group as a whole to detect disturbances. In contrast, individual fish oriented randomly in the water column, showing no evidence of placing themselves to maximize detection using the lateral-line system. Taken together, the results suggest that zebrafish use group behavior to enhance detection and allow for greater individual behavioral flexibility for members.

Session II
6. Robert Bowers (ribowers@indiana.edu)

MECHANISMS FOR COMBINING MATE-CHOICE INFORMATION FROM MULTIPLE MODELS

R. I. Bowers, P. M. Todd
Department of Psychological and Brain Sciences, Cognitive Science Program, Indiana University, Bloomington, IN

Information about the mate choices of others is apparent and abundant in many social settings. Humans, like several other species, use such information when making their own mate choices, preferring mates that are apparently preferred by others (mate-choice copying). How this occurs is not well understood. Past mate-choice copying work has focused on changes in preference following presentation of only a single source of mate choice information. However, in many real mating circumstances, observers have access to a great deal of social information from multiple models choosing and rejecting mates. How do mate seekers integrate multiple sources of social information? Discerning the form of such integration is important not only for a complete functional description of the operation of mate-choice copying, but furthermore such analyses begin to address questions about mechanism, helping to differentiate among models of cognitive processing. Specifically, we compare a summing hypothesis, by which each interested or disinterested model independently impacts ratings, with a copy-the-majority hypothesis, by which the observer aggregates available information and changes ratings based on whether more models show interest or disinterest. We present female subjects with four independent sources of mate choice information about each of several men: real speed-dating videos featuring the focal male with a female model. We found that change of ratings of a focal individual rise monotonically with the number of models showing interest, and to levels well beyond those observed in previous studies using comparable methods with only one model each.
7. Sarah Keesom (skeesom@indiana.edu)

**SEROTONIN INCREASES IN THE AUDITORY MIDBRAIN OF MALE MICE DURING ENCOUNTERS WITH FEMALES**

S.M. Keesom, L.M. Hurley
Department of Biology, Indiana University, Bloomington, IN

For animals that cope with changing situations, context-appropriate behavior is essential for survival. Sensory plasticity can facilitate appropriate behavior by emphasizing relevant stimuli. One candidate mechanism for the context-dependent regulation of sensory filtering is through neuromodulation by serotonin, because release of serotonin is sensitive to contextual cues, and serotonin alters the stimulus-evoked activity of sensory neurons. Here, we investigated rapid fluctuations of serotonin in the inferior colliculus, an auditory midbrain nucleus, of male mice while they interact with females. In this context, mice produce both audible and ultrasonic vocalizations. While males primarily emit complex ultrasonic vocalizations, females emit audible squeaks that indicate rejection of the male, implicating audition as an important modality for male mice during courtship. We used the electrochemical technique of carbon fiber voltammetry to measure changes in serotonin during behavior. We also investigated how specific components of context correspond to serotonin, by examining relationships between the male serotoninergic response and physical traits and behaviors (e.g., vocalizations) of both sexes. Here, we demonstrate that serotonin increases when male mice encounter females. This corroborates with other findings from our lab; serotonin increases in males interacting with males and in females interacting with males. Taken together, these studies support the hypothesis that serotonin acts as a general social signal across multiple contexts.

8. Katharine McCann (kmccann3@gsu.edu)

**SOCIAL DEFEAT IN SYRIAN HAMSTERS: CONTROLLABILITY, DURATION AND SOCIAL RECOGNITION**

K.E. McCann, K.L. Huhman
Center for Behavioral Neuroscience, Georgia State University, Atlanta, GA

Syrian hamsters, *Mesocricetus auratus*, are highly territorial and will quickly and reliably attack an intruding conspecific. Losing a fight, however, has long-term behavioral consequences. After one social defeat, hamsters abandon all territorial aggression and become highly submissive, even towards a non-threatening social stimulus such as a caged conspecific or a smaller, non-aggressive opponent. This drastic change in behavior has been termed conditioned defeat (CD). Although hamsters generalize this submission to all conspecifics after an inescapable defeat, we have shown that hamsters are able to recognize a previous attacker and avoid that individual more than an unfamiliar aggressor. While our laboratory primarily uses inescapable social defeat to model the clinical psychopathologies (e.g., anxiety, posttraumatic stress disorder) that can result from bullying or abuse, we have shown that escapable social defeat also results in CD, albeit to a reduced degree. The purpose of the present study was to determine whether the different intensities of CD observed between groups was due to the difference in controllability or duration of the initial social defeat. Using a yoked design, we were able to demonstrate that when the duration of social defeat was held constant, there was no effect of controllability on CD behavior exhibited during testing as evidenced by the finding that the two groups exhibited similar levels of CD. These data suggest that for hamsters the ability to "control" (i.e., escape from) a socially stressful situation does not reduce the effect of social defeat on subsequent agonistic behavior.
9. John Shorter (john_shorter@ncsu.edu)

**THE GENETIC ARCHITECTURE OF AGGRESSION IN DROSOPHILA MELANOGASTER**

J.R. Shorter¹, C. Couch¹,², R. Anholt², T.F.C. Mackay¹
¹Department of Genetics, ²Department of Biology, North Carolina State University, Raleigh, NC,

Most animals display aggressive behavior to secure food resources, protect against predators and facilitate access to mating partners. Among social animals, appropriately balanced aggressive behavior gives rise to a stable social organization by creating and maintaining dominance hierarchies. Inappropriate or excessive aggression has detrimental consequences for the individual and a society. Aggressive behavior is genetically complex, influenced by many genes as well as interactions with the environment. However, the genetic pathways affecting variation in aggressive behavior are evolutionarily conserved, enabling general inferences to be drawn from genetic analysis using a model system. We investigated the natural genetic variation of aggression using the *Drosophila* Genetic Reference Panel (DGRP), a collection of 205 inbred lines with fully sequenced genomes. We performed a genome wide association study (GWAS) and identified 338 loci associated with variation in aggression. Additionally, we performed an independent experiment to replicate causal candidate loci by creating an outbred population from lines representing the extremes of the DGRP. We measured aggressive behavior of 3,000 individuals across 7 generations from this outbred population and will perform QTL mapping to identify loci associated with aggression. We will then compare results between the outbred population and the DGRP to identify overlap between genes and gene networks that influence aggression. We will confirm candidates by using RNAi knockdown to reduce gene expression and quantify its effect on aggression. These experiments will provide insight into the genetic architecture of aggression and identify novel genetic variants responsible for naturally occurring variation in this complex trait.

10. Sarah Wofford (sjwofford1@gmail.com)

**SEX AND FIGHTING: MALE AND FEMALE CRAYFISH USE DIFFERENT ASSESSMENT STRATEGIES DURING AGONISTIC BEHAVIOR**

S. Wofford, P. Moore
Department of Biology, Bowling Green State University, Bowling Green, OH

Agonistic behavior is an important social aspect of animal behavior, and the outcome of agonistic interactions is critical to the acquisition of resources such as food, shelter, and mating opportunities. During agonistic interactions, individual participants make behavioral decisions based on energy and time investment such as escalating the intensity of the interaction and whether to end the interaction by retreating. Each of these decisions can be informed through self-assessment (i.e., energy reserves, fight capability, size) cumulative assessment (i.e., components of self-assessment in addition to the effects of opponent-inflicted injury) or through some form of mutual assessment (i.e., comparative energy reserve, size differential). Crayfish are ideal model organisms for the study of such behavior due to ritualized fighting and a well-established ethogram. In this study, we are examining the assessment strategies that crayfish employ during same and mixed sex fights. After a brief acclimation, two individuals (male-male, female-female, or male-female) were allowed to interact for 15 minutes. Video analysis was used to calculate fight duration and times spent at various intensity levels. Analysis indicates that males and females appear to be using two different assessment strategies. In male-male fights, agonistic decisions are based on a self-assessment strategy whereas in female-female fights, decisions are based on a cumulative assessment strategy. In mixed sex bouts, a mixed strategy appears to underlie a crayfish’s decision to retreat.
Bmal1 is a rhythmically-expressed gene found in many central and peripheral tissues. Recent studies have shown that knockdown of Bmal1 is associated with skeletomuscular and metabolic pathologies. To provide further resolution that Bmal1 regulates skeletal muscle structure and function, we examined the architecture, insulin sensitivity, and large-scale changes in gene expression of skeletal muscle and locomotor activity in mice with overexpression of Bmal1 specific to the skeletal muscle (Bmal1++). Muscle architecture was examined with electron microscopy. The cross-sectional area of each muscle fiber was significantly larger in Bmal1++ vs. WT mice (3000±200 µm² vs. 2000±250 µm²; p<0.05), despite no genotype difference in total number of muscle fibers. Insulin sensitivity was measured by i.p. administration of insulin (0.75 unit/kg) 12 h after fasting and ex vivo (0.66 µunits/µl) by radioassay. There were no genotype differences for either measure. DNA microarrays found 291 genes with increased rates of expression ranging from 25%-900% and 202 genes with decreased rates of expression ranging from 25%-60% in Bmal1++ vs. WT mice. Bioinformatic analyses identified that most of the genes regulated circadian rhythmicity, muscle architecture, motor output, and glucose homeostasis. Infrared sensor technology revealed genotype- and time-specific differences in locomotor activity intensity. These results provide further resolution that Bmal1 regulates skeletal muscle structure and function.

Session III

12. Aubrey Kelly (aubkelly@indiana.edu)

FUNCTIONAL SIGNIFICANCE OF A PHYLOGENETICALLY WIDESPREAD SEXUAL DIMORPHISM

A. Kelly
Department of Biology, Indiana University, Bloomington, IN

Male-biased production of vasotocin/vasopressin (VT/VP) in the medial bed nucleus of the stria terminalis (BSTm) represents one of the largest and most phylogenetically widespread sexual dimorphisms in the vertebrate brain. Although this sex difference was identified nearly 30 years ago, the function of the dimorphism has yet to be determined. Because 1) BSTm VT/VP neurons respond selectively to affiliation-related stimuli, 2) VT/VP is often associated with lower aggression, and 3) BSTm VT/VP is typically produced only during periods of reproduction, we hypothesized that the sexual dimorphism serves to dampen male aggression during interactions with mates and offspring, effectively compensating for greater aggression in males. Using antisense oligonucleotides to bilaterally knock down production of VT in the BSTm, we here quantified effects on a wide range of male and female behaviors in a colony setting. Consistent with our hypothesis, antisense knockdown of BSTm VT production significantly increased aggression in males, but not females, and also decreased courtship singing. Numerous other behaviors were not affected, including pair bonding and maintenance behaviors. These data suggest that the male biased dimorphism of the BSTm VT/VP cell group serves to promote affiliative interactions in males, while concomitantly suppressing aggression.
13. Paul Meyer (pammeyer@indiana.edu)

**NON-NUTRITIVE THERMOTACTILE STIMULATION INDUCES ODOR PREFERENCE IN C57BL/6 AND MICE**

P. Meyer, J. Alberts
Department of Psychological and Brain Sciences, Indiana University, Bloomington, IN

Mouse pups (*Mus musculus*) placed on the midline of a mesh floor suspended over two odor fields, one containing homecage bedding and the other clean bedding, preferentially selected the homecage area when tested on Postnatal Day (PD) 5, 10, or 12. PD5 pups exhibited no preference for their homecage bedding when given the alternate choice of bedding from another age-matched litter whereas PD10 and 12 pups significantly preferred their homecage odors. To test whether the developmental trajectory of such home orientation can be shaped by experience, on PD8 and PD9 pups were exposed for two hours to one of two novel odors applied to either a lactating or non-lactating foster dam or a warm tube. To identify whether mere exposure to an odor could induce a preference a fourth group of pups were exposed to scented gauze during otherwise identical conditioning sessions. A final set of pups was exposed to an unscented foster dam to serve as a control group. Both gauze- exposed and control groups showed no preference for either odor when tested on PD10 whereas pups placed with a lactating dam spent significantly more time over the conditioned odor. Moreover, pups placed with the non-lactating dams or the warm tube also preferred the conditioned odor, indicating that the preference can be attributed to non-nutritive, thermotactile maternal cues.

14. Victoria Templer (victoria.templer@emory.edu)

**COGNITIVE MECHANISMS UNDERLYING MEMORY FOR SEQUENCES IN MONKEYS**

V.L. Templer, R.R. Hampton
Department of Psychology, Emory University, Atlanta, GA

One important aspect of episodic memory is the ability to remember the order in which sequences of events occurred. However, the cognitive mechanisms underlying memory for sequences have not been determined. We presented monkeys with lists of five images drawn randomly from a pool of 6,000 images. At test, two images were presented and monkeys were rewarded for selecting the image that had appeared earlier in the studied list. Monkeys learned to discriminate the order of the images, even those that were consecutive in the studied list. In subsequent experiments we found that discrimination of order was not controlled by list position or relative memory strength. Instead, monkeys used temporal order, a mechanism that appears to encode order of occurrence relative to other events, rather than in absolute time. We found that number of intervening images, rather than passage of time per se, most strongly determined the discriminability of order of occurrence.
MANIPULATING TERRITORY SHAPE VIA LANDMARKS

P.S. Suriyampola, P.K Eason
Department of Biology, University of Louisville, Louisville, KY

Theoretical work suggests that the optimal shape of a territory is round, based on the assumptions that defense costs are minimized in a round territory. However, landmarks could affect territory shape by altering defensibility. In this field study, we investigated the effects of landmarks on the shape of convict cichlid (Amatitlania siquia) territories. We provided cans as breeding sites and used aquatic plastic plants as landmarks. We determined territory shape and location relative to the nest, comparing trials without landmarks to trials with one plant or four adjacent plants as landmarks. During ten-minute trials, we observed pairs' behavior, recording the location of each intruder chase. We then used these locations to outline and measure the territory. We observed each pair with either one or four plants and also without landmarks, alternating which treatment occurred first and performing the second trial 24 hours after the first. We used the ratio between length and width as a measure of territory shape. Territories without landmarks were nearly circular, with the nest at the center. With one plant, the territory shape did not change, but fish moved their territory boundary closer to the landmark and thus the nest. This shift of territory boundary also occurred in the treatment with four plants. In addition, when four plants were present the territories were significantly more elongated. These results suggest that the advantages of having a landmark at a boundary outweigh any disadvantages of defending a non-circular territory and having the boundary nearer the nest.

LOCATION, LOCATION, LOCATION: MINUTE ADJUSTMENTS BY AN EGG LAYING AMPHIBIAN HAVE A LARGE EFFECT ON OFFSPRING SURVIVAL

B.G. Gall¹, E.D. Brodie III², E.D. Brodie, Jr.³
¹Department of Biology, Hanover College, Hanover, IN, ²Department of Biology, University of Virginia, Charlottesville, VA, ³Department of Biology, Utah State University, Logan, UT

One of the most important defenses for the eggs of ovipositing female organisms is to avoid being laid in the same habitat as their predators. However, for most organisms, completely avoiding an offspring's predators is not possible. One mechanism that has been largely overlooked is for females to partition an oviposition site into microhabitats that differ in quality for offspring survival. We conducted a series of experiments to examine whether female newts avoid microhabitats utilized by their offspring's primary predator, caddisfly larvae. Female newts avoided laying eggs near predatory caddisflies and shifted egg laying upward in the water column when provided with a vertical dimension. This adjustment corresponded with behavioral limitations in caddisflies. Results from a field experiment indicate that the behavioral strategy employed by female newts increases offspring survival. This subset of non-genetic maternal effects, which we deem micro-oviposition avoidance, is likely an important yet underexplored mechanism by which females increase offspring survival.
COURTSHIP AS A TWO WAY STREET: FEMALE VOCAL BEHAVIOR AND REPRODUCTIVE PERFORMANCE

G. Kohn
Department of Psychological and Brain Sciences, Indiana University, Bloomington, IN

Little is known about the role of female vocalizations in avian courtship. Across many species females respond to male courtship displays with a contingent song or call. If such vocal responses are a sexually selected trait, then variation in female vocal behavior may correspond with their reproductive performance. During the breeding season female brown-headed cowbirds often respond to male song with a vocalization known as the chatter. Here we investigated if variation in female vocalizations remained repeatable across years, and predicted reproductive performance. A flock of cowbirds housed in a large aviary complex was observed during the spring of 2011 and 2012. We recorded courtship interactions, including singing behavior for males and chatters, consortships, and eggs laid for females. We discovered that female chatter rates were repeatable across years. Females who were more likely to respond to male song displays were also more likely to be in a consortship, more likely to lay eggs and laid more eggs than other females. To our knowledge, this study presents the first demonstration that a repeatable female vocal trait can predict a female’s reproductive output, and suggests female vocal signals may have an important role in determining a pair’s reproductive success.

SEX DIFFERENCES IN COLOR INCREASE OVER EVOLUTIONARY TIME IN SCELOPORUS LIZARDS

A.G. Ossip-Klein¹, J.R. Oyola Morales², C. Vital³, J.J. Zuniga-Vega⁴ D.K. Hews⁵, E.P. Martins¹
¹Department of Biology, Indiana University, Bloomington, IN, ²Cornell University, Ithaca, NY, ³Universidad Autonoma de Ciudad Juarez, Mexico, ⁴Universidad Nacional Autonoma de Mexico, ⁵Indiana State University, Terre Haute, IN

Sex differences in color are often due to different selective pressures acting on males and females, and often increase over evolutionary time. In the lizard genus, Sceloporus, there appear to be several, independent losses of sex differences in color, due to male shifts from blue to white ventral coloration. However, there are several limitations to the human eye (including the inability to detect ultraviolet light), and we thus often underestimate the spectral variation present in animal color patterns. Here, we test for cryptic (i.e., not visible to the human eye) sex differences in color across white-bellied lizards, and ask how sex differences in color change over evolutionary time across 4 morphologically diverse Sceloporus species. We find that white-bellied lizards that appear to be the same color, actually exhibit cryptic sex differences in color, with the older lineage exhibiting a greater degree of sexual dimorphism. We also find that sex differences in color increase over an evolutionary timescale in the ultraviolet and middle-wavelengths of light, for both white-bellied species and blue-bellied species. This is potentially due to selection for increased signal efficiency in one sex.
19. Ryan Wong (ryan_wong@ncsu.edu)

CHARACTERIZING THE NEUROGENOMIC PROFILES OF ALTERNATIVE STRESS COPING STYLES IN WILD-DERIVED ZEBRAFISH

R.Y. Wong, J.R. Godwin
Department of Biology, North Carolina State University, Raleigh, NC

Animals encounter stressful situations on a regular basis. How an animal successfully copes with these stressors has important individual and evolutionary consequences. There are two qualitatively different response patterns to stressors that are marked by differing behavioral and physiological responses: proactive and reactive coping styles. Those exhibiting a proactive coping style to stressful situations (i.e., bold personality type) rely on a feed-forward response, and have lower behavioral flexibility and endocrine stress response whereas those displaying a reactive coping style (i.e., shy personality type) display generally an opposing response. We have generated zebrafish strains that exhibit proactive- and reactive-like behavioral stress coping styles (LSB and HSB, respectively) that are consistent across contexts and age. However, we do not know what the molecular bases are for these alternative behavioral phenotypes. To identify genes that may underlie the differences in coping styles, we analyze the neurotranscriptomic profiles of our proactive- and reactive-like strains of zebrafish. RNA-sequencing identified approximately 1800 differentially expressed genes between HSB and LSB strains. Gene ontology analyses revealed several overrepresented processes (e.g., nucleotide metabolic activity, oxidation-reduction processes, MHC protein complex, antigen activity). We conducted an additional systems level analysis via weighted gene coexpression network analysis (WGCNA). WGCNA showed that five modules are significantly associated with strain. To identify genes that potentially have an important role in stress coping styles, we identify overlapping genes using modules identified in WGCNA and data from our previous pharmacological study.

20. Susan Gershman (gershman.6@osu.edu)

TIME FLIES: CIRCADIAN RHYTHMS AFFECT MALE ATTRACTIONNESS

S. Gershman¹, E. Tounishe², H. Rundle²
¹Evolution, Ecology, and Organismal Biology, Ohio State University, Marion, OH
²University of Ottawa, Ottawa, ON, Canada

If the expression of a sexually selected male trait is a reliable indicator of male quality, it should be costly for males to produce. Consequently, if males can modulate the expression of this costly trait, they should express the trait only when it will improve their reproductive success. In Drosophila serrata, females prefer males that have a specific chemical profile of nine cuticular hydrocarbons (CHC). Female preference shows significant linear selection on male CHCs, and this linear selection gradient can be used to compute a measure of multivariate male attractiveness for each male. In this study, we examined the effect of time of day and social environment on male attractiveness. We found that there is a cyclical pattern to male attractiveness that corresponds to both the circadian cycle and female activity. Further, males are more attractive in the presence of females, and in the absence of competitor males. Prior to this study, it was previously unknown that male Drosophila could be adaptively plastic in their expression of CHCs.
Though genetic variation can have a significant impact on neurobiological and behavioral outcomes, it is evident that environmental experiences can similarly affect biological processes leading to altered neurobehavioral characteristics. Variation in gene regulation has emerged as a mechanism through which the environment can interact with genes to allow for the emergence of divergent phenotypes. Moreover, there is increasing evidence that environmentally-induced changes in gene expression may be achieved through epigenetic pathways. Epigenetic modifications – molecular pathways through which transcription is altered without altering the underlying DNA sequence - play a critical role in the normal process of development and are potentially heritable. A broad range of “experiences” has been demonstrated to alter epigenetic pathways, including prenatal exposure to stress and toxins, postnatal variation in maternal care, and the experience of enhanced social/physical environments. Here, I will describe evidence implicating epigenetic factors, such as DNA methylation, histone modifications, and microRNA in the link between experiences occurring during development and altered neuroendocrine and behavioral outcomes. I will also discuss how these molecular events are hypothesized to contribute to the transgenerational inheritance of traits.

Invited Plenary Speaker: Dr. Frances Champagne, Assistant Professor, Columbia University

Dr. Champagne completed her undergraduate degree in the Department of Psychology at Queen's University in Kingston, Canada, in 1995. After completing a M.Sc. in Psychiatry in 1999, she obtained her PhD in the Department of Neurology and Neurosurgery at McGill University in Montreal under the supervision of Michael Meaney. From 2004-2006, she conducted postdoctoral research at the Sub-Department of Animal Behaviour at the University of Cambridge, UK. In July 2006 she was appointed the position of assistant professor in the Department of Psychology at Columbia University in New York City.
POSTER ABSTRACTS
(in alphabetical order of presenter’s last name)

1. Artem Abakumov (artem.abakumov@yahoo.com) and Ernesto Melchor (emelchor@neiu.edu)

THE EFFECTS OF 1-METHYL-4-PHENYL-1,2,3,6-TETRAHYDROPYRIDINE ON BEHAVIOR IN ADULT ZEBRAFISH, DANIO RERIO

A. Abakumov¹, E. Melchor¹, N. Glaser¹, S. Saszik¹, T. Puryear²
¹Department of Psychology, ²Department of Biology, Northeastern Illinois University, Chicago, IL

In zebrafish, Danio rerio, anxiety related behaviors have been suggested to alter social interaction exhibited through a paradigm known as shoaling, which is defined as behavior in which zebrafish swim within a close proximity to one another. Our research focused on the effect of MPTP (1-methyl-4-phenyl-1,2,3,6-tetrahydropyridine) on the anxiety related behaviors in zebrafish, specifically, changes in thigmotaxis. Thigmotaxis is defined as wall hugging and is considered as a reliable measure for anxiety in rodents. Groups of 10 zebrafish were designated as either control or experimental subjects. Experimental fish were exposed to 220 µM of MPTP for 5 minutes and immediately placed into a 350 ml tank. Behavior was recorded individually for 3 minutes and the swim pattern analyzed for thigmotaxis (a swim path within 2 cm of the wall) using ImageJ software. Preliminary data shows that MPTP altered anxiety related behaviors. Experiment zebrafish traveled a greater distance (M = 19.82cm, SD = 30.14) compared to control (M = 9.62cm, SD = 12.38), however, there was a reduction in the amount of thigmotaxis (30% for control and 5% for MPTP). Together this suggests a change in behavior that is due to alterations in the function of anxiety-related circuits. It is possible that abnormalities in the typical swim pattern by MPTP could alter shoaling behavior. If true, this would provide evidence of the underlying role of dopaminergic circuits related to reward pathway circuits involved in normal social interactions in zebrafish.

2. Brad Abplanalp (babplan@purdue.edu)

VISUAL ECOLOGY OF RED-WINGED BLACKBIRDS AND COMMON GRACKLES

B. Abplanalp, L. Tyrrell, B. Moore, J. Hanchar, E. Fernandez-Juricic
Department of Biological Sciences, Purdue University, West Lafayette, IN

Most songbirds use their visual systems to gather information about their environment to modulate their behavioral responses under different ecological scenarios (e.g., predator approach, foraging, mating). The area of visual coverage around the head and regions on the retina with high visual acuity (e.g., foveae) play an important role in the quantity and quality of information gathered. We measured visual fields and the position of the fovea in two species of blackbirds (Red-winged Blackbird and Common Grackle). Despite being closely related and sharing many habitat characteristics, these species use different foraging techniques. Common Grackles are opportunists that mostly pick up plant material, whereas Red-winged Blackbirds use a gaping strategy where the bill is inserted into the ground and the mandibles are opened to expose arthropods. Our results show that Red-winged Blackbirds have a wider binocular field and a wider blind area than Common Grackles. Additionally, Common Grackles have a fovea that projects laterally and slightly down. Red-winged Blackbirds’ fovea also projects laterally, but slightly further forward and along the horizontal plane. The wide binocular field and fovea position in Red-winged Blackbirds brings higher acuity portions of the retina into the frontal visual field, which could allow for visual inspection of the bill when gaping. Since Common Grackles do not frequently use the gaping strategy, the cost of having a narrower binocular field is balanced by the benefit of a narrower blind area behind the head and greater overall visual coverage to detect predators.
EXPRESSION OF ESTROGEN RECEPTOR \( \alpha \) IN THE BRAIN OF FEMALE RATS WITH DIFFERENT HORMONE STATUS

J. Bailey, S. Pugh, X. Liu, H. Shi
Department of Zoology, Miami University, Oxford, OH

Sex hormone estrogen plays pivotal roles in the regulation of sexual behavior and energy homeostasis by interacting with ER\( \alpha \). How estrogen regulates ER\( \alpha \) remains controversial. Sham-operated gonadally intact rats at estrus (the phase when female rats display sexual receptivity following estrogen secretion peak) or diestrous, and ovariectomised (OVX) rats with cyclic estradiol (OVX+E2; 2 \( \mu \)g 17\( \beta \) E2, one injection every 4 days) or vehicle (OVX+Oil) replacement were investigated. Immunohistochemistry was used to visualize ER\( \alpha \) in the medial preoptic area (MPA) and periventricular nucleus (Pe) related to sexual behavior and HPG axis, the arcuate (ARC) and VMH nuclei related to food intake, and paraventricular nucleus (PVN) related to energy expenditure. Estrous rats expressed greater numbers of ER\( \alpha \) at the MPA, Pe, and VMH than diestrous rats, indicating that ER\( \alpha \) may regulate difference in sexual and reproductive activity between estrus and diestrous. Additionally, estrous and diestrous rats had similar numbers of ER\( \alpha \) at PVN and ARC. Two OVX groups had similar numbers of ER\( \alpha \) at the PVN, ARC, and VMH, but OVX+Oil rats expressed more ER\( \alpha \) at the MPA and Pe than OVX+E2 rats. These data suggested that E2 replacement suppressed ER\( \alpha \) expression in the neurons involved in sexual activity, but not in the neurons involved energy balance. ER\( \alpha \) quantity varied during the estrous cycle and was regulated by E2 replacement at physiological dose, which was region specific in the hypothalamus, suggesting that factors other than estrogen level modulate ER\( \alpha \) expression in various neuronal groups.

EFFECTS OF SOY GLYCCEOLLINS ON BEHAVIOR AND GENE EXPRESSION IN MICE

S. Bamji\(^1\), R.B. Page\(^1\), A. Sanders\(^1\), D. Patel\(^1\), A. Alvarez\(^1\), C. Gambrell\(^1\), K. Naik\(^1\), A. Raghavan\(^1\), K. Stocke\(^1\), E. Gordon\(^1\), M.E. Burow\(^2\), S.M. Boue\(^3\), C.M. Klinge\(^4\), M. Ivanova\(^4\), C. Corbitt\(^1\)

\(^1\)Department of Biology, University of Louisville; \(^2\)Department of Hematology & Oncology, Tulane University; \(^3\)USDA, New Orleans; \(^4\)Department of Biochemistry & Molecular Biology, University of Louisville, Louisville, KY

Glyceollins are produced by soy grown under stressful conditions. These compounds have known anti-estrogenic effects, e.g. inhibiting estrogen-responsive tumor growth, but also mechanisms of action not involving estrogen receptor (ER) signaling. However, no published studies have investigated the effects of glyceollin on gene expression in the brain or on behavior. We implanted 17\(^{\beta}\) estradiol or placebo slow-release pellets into ovariectomized CFW mice followed by 11 days of exposure to 20mg/kg glyceollin, or DMSO:PBS vehicle, delivered in 50\( \mu \)l i.p. Open field trials for anxiety-like behavior were run on day 11. Although we anecdotally noted increased defensive behavior in glyceollin mice, we found no differences in open field measures among groups. Mice were euthanized on day 12; total RNA extracted from whole brain and other estrogen-responsive tissues. Transcript profiling performed via the Affymetrix Mouse Gene 1.0 ST Array. Using a combination of p-value and effect size thresholding, we identified over 200 differentially expressed genes (DEGs) between one or more treatment pairs. Surprisingly, we detected only 11 DEGs between the estradiol and control treatments. However, 78 genes were differentially expressed between the glyceollin and control treatments. Clustering across all DEGs revealed that transcript abundances were similar between the estradiol plus glyceollin and estrogen only treatments. However, gene expression in glyceollin animals was distinct from both of these treatments and was generally characterized by higher transcript abundance among DEGs. Thus, glyceollin may act in the brain through ER-dependent/ER-independent mechanisms.
5. Philip Blankenship (p_blanken@yahoo.com)

SEARCHING BLINDLY: EVALUATING AGING EFFECTS ON SELF-MOVEMENT CUE PROCESSING IN HUMANS USING AN ANALOGUE OF THE FOOD-HOARDING PARADIGM

P. Blankenship, T. Musson, J. Torrence, J.R. Koppen, D.G. Wallace
Department of Psychology, Northern Illinois University, DeKalb, IL

Spatial orientation, or the ability to navigate through space, is dependent on multiple specialized neural processes. The ability to orient through space changes with age. The mechanism for this age-related change in spatial orientation ability continues to be debated. The food-hoarding paradigm is a behavioral task that has been developed to dissociate environmental and self-movement cue processing. Previous work has adapted components of the food-hoarding paradigm to the human ambulatory and manipulatory scales to investigate self-movement cue processing. Similar kinematic and topographic movement characteristics were observed in humans and rats across analogous tasks. The current study investigates the influence of age on self-movement cue processing in human participants (n=8) ranging in age from 21 to 86. Participants were blindfolded and instructed to search, with their fingertip, for a piece of Velcro placed at random positions on a table (searching segment). Upon finding the Velcro participants were instructed to return to the starting location (homeward segment). Both topographic and kinematic characteristics of the homeward segment were used to assess direction and distance estimation. Age of the participant was observed to significantly influence the homeward segment direction and distance estimation. This suggests that the ability to process self-movement cues varies across the lifespan; however, further work is needed to establish the nature of the processing deficit observed in the current study.

6. Daniel Brennan (d-brennan@neiu.edu)

ANALYSIS OF ZEBRAFISH (DANIO RERIO) DEVELOPMENT AND BEHAVIOR

D. Brennan¹, S. Saszik¹, T. Puryear²,
¹Department of Psychology, ²Department of Biology Northeastern Illinois University, Chicago, IL

Modern medicine has created a culture of medications and supplements. During pregnancy many women take supplements in an attempt to ensure a healthy child, free from birth defects. Biological mechanisms are complex and studies of model organisms help determine the effects of prenatal medications in the mechanisms of embryonic development. Danio rerio (zebrafish) is an ideal model organism to study the effects of medications and supplements taken during embryonic development. Researchers can easily manipulate the eggs with chorion allowing easy observation of systems development. To contrast the effects of medications and supplements it is important to understand normal zebrafish development. In this experiment, adult zebrafish were bred under standard conditions (Westerfield, 1982) and embryos were harvested. The embryos were incubated in 50mL of aquarium water at 27.8°C. During 4 and 7 days post-fertilization (4DPF and 7DPF) the larvae were recorded to observe behavior. Morphology and reaction to a tail-touch stimulus were measured. At 4DPF, 45% of larvae reacted to stimulus. The mean reaction time was 473.3±90.1ms. The mean length at 4DPF was 3.61±0.05mm. At 7DPF, 57.1% reacted to stimulus and 42.9% avoided the stimulus. The mean reaction time was 270.7±95.7ms. The mean length of 7DPF embryos was 3.66±0.94mm. Determining the behavior of control zebrafish will allow comparisons of zebrafish treated with medications and supplements.
7. Benjamin Brier (bebrier@indiana.edu)

**SEASONAL REGULATION OF VASOACTIVE INTESTINAL POLYPEPTIDE RECEPTOR AND ITS RELATIONSHIP TO FLOCKING AND AGGRESSION IN SPARROWS**

B. Brier, L.C. Wilson, J.L. Goodson  
Department of Biology, Indiana University, Bloomington, IN

At the termination of the breeding season, many bird species abandon exclusive territories and join flocks that range from small parties to thousands of individuals. This dramatic seasonal shift in behavior has profound fitness implications, but the neural and endocrine mechanisms that promote seasonal flocking are not well understood. Vasoactive intestinal polypeptide (VIP) is known to influence a variety of affiliative and aggressive behaviors. Previous work in our lab indicates that winter upregulation of VIP might mediate the seasonal switch to the winter flocking phenotype. In order to determine whether seasonal expression of flocking is associated with seasonal upregulation of VIP binding sites, we collected brains from the following species: field sparrows, dark-eyed juncos, song sparrows, and eastern towhees. All four sparrows are territorial in the breeding season. Field sparrows and dark-eyed juncos join flocks in the winter while song sparrows and eastern towhees do not. We collected brains in both spring and winter, and collections were preceded by field-based assessments of aggression. We quantified binding of [125]-labeled VIP in numerous forebrain areas. A general winter increase in VIP receptor density is seen across species in many of the examined brain areas. A Species*Season interaction is observed for binding site density in the medial amygdala, a node in the vertebrate social behavior network, with winter flocking species showing a greater winter increase in binding sites. We found that receptor densities correlated with aggressive behaviors. The direction of these correlations differed with both species and brain area.

8. Jacob Brown (jdbppb@mail.missouri.edu)

**DOSE RESPONSE FOR COCAINE-INDUCED LOCOMOTOR ACTIVITY IN RATS SELECTIVELY-BRED FOR HIGH/LOW MOTIVATION TO VOLUNTARILY RUN**

J.D. Brown¹, C.L. Green⁵, I. Arthur⁵, F.W. Booth¹,²,³,⁴, D.K. Miller⁵  
¹Department of Medical Pharmacology and Physiology, ²Department of Biomedical Science, ³Dalton Cardiovascular Research Center, ⁴Department of Nutrition and Exercise Physiology, ⁵Department of Psychological Sciences, University of Missouri, Columbia, MO

This study aimed to further characterize a novel colony of Wistar rats selectively-bred for high (HVR) and low (LVR) voluntary running behavior. We aimed to examine sex differences and line (LVR vs. HVR) differences in locomotor activity (LA) levels in young, sedentary rats. METHODS: Eighty minutes of LA were measured on 3 successive days to determine novelty-induced (Day 1), baseline (Day 2), and cocaine-induced (Day 3) LA in young (30-38d), male and female HVR/LVR rats. On Day 3, rats received an injection of saline (Control), 10, 20, or 30mg/kg cocaine. RESULTS: HVR rats demonstrated greater novelty-induced (Day 1) and baseline (Day 2) LA than LVR rats. At 10mg/kg cocaine, while HVR females showed greater LA than LVR females, both lines of females exhibited greater LA than HVR and LVR males. At 20mg/kg cocaine, HVR and LVR males demonstrated similar LA as HVR females but not LVR females, which still maintained a higher LA. At 30mg/kg, HVR female, LVR male, and LVR female all demonstrated similar LA values that were higher than HVR males. CONCLUSION: Our results suggest that cocaine-induced LA is dependent on cocaine, dose, sex and voluntary running genetic potential. Lower doses (10mg/kg) of cocaine promote LA differences between female lines, while higher doses (30mg/kg) of cocaine are needed to promote LA differences in male lines. Sex hormone and/or dopaminergic signaling systems are logical targets for future research to elucidate the mechanisms underlying these observations.
9. Christopher Burdett (burdettcl@nku.edu)

RELATIONSHIPS BETWEEN MOTHER-PUP INTERACTIONS AND JUVENILE PLAY-FIGHTING BEHAVIOR IN LABORATORY RATS

C. Burdett, M.E. Bardgett
Department of Psychology, Northern Kentucky University, Ludlow, KY

Early-life social behaviors appear to be important for appropriate brain development and adult behavior. Two distinct forms of early-life social behavior have been well documented in rats: mother-pup interactions and juvenile play-fighting behavior. The purpose of this study was to investigate if there were associations between these two forms of behavior. Long-Evans rats were videotaped weekly beginning at postnatal day 14 through postnatal day 41. During the first week, interactions between pup, mother, and a littermate were recorded over a 20-minute period. During the last three weeks, interactions between three cagemates were recorded over a 20-minute period weekly. The measures taken during the mother-pup session were then correlated with measures of total expressive and receptive play-fighting interactions generated during the last three weeks of testing. Notably, there were few scores from the mother-pup observations that significantly correlated with later play-fighting scores. This may reflect the small number of animals involved in the study or the lack of sensitivity in some measures. However, the number of contacts directed by a mother towards a pup and the pup's own activity were significantly correlated with total receptive play-fighting interactions during later development. Overall, mother-pup interactions and later play-fighting behavior may represent autonomous aspects of social development in normal laboratory rats. Nonetheless, it remains possible that large-scale alterations of maternal behavior or pup reactivity to such behavior can significantly modify later play-fighting behavior.

10. Melissa Burns-Cusato (m.cusato@centre.edu)

FREE-RANGING VERVET MONKEYS REACT TO ANCESTRAL PREDATORS AFTER THREE CENTURIES OF ISOLATION

M. Burns-Cusato1, A.Glueck2, B. Cusato3
1Behavioral Neuroscience Program, Centre College, Danville, KY, 2Psychology Department, Texas Christian University Forth Worth, TX

When isolated from predators for long periods of time, some species have been shown to lose antipredator behaviors whereas other species retain antipredator behaviors for several generations. Blumstein's Multipredator Hypothesis proposes that the presence or absence of other types of predation risks in the new home range determines whether antipredator behaviors will be retained or lost, respectively, by an isolated population (Blumstein, 2006). Free-ranging vervet monkeys (Chlorocebus sabaeus) that inhabit the Caribbean island of Barbados are an ideal population to test this hypothesis. Vervets were brought from Africa to Barbados in the late 1600s. The ancestral African vervet population lived amidst several types of predators (leopards, snakes, and eagles). In contrast, there are no vervet predators on the island of Barbados. Thus, the multipredator hypothesis predicts that Barbadian vervets will not show the predator-specific antipredator behaviors observed in African vervets. The present experiments were designed to determine if Barbadian vervets recognize as threatening two ancestral predators of the African vervets, snakes and leopards. In experiment 1, free-ranging vervets were presented with a black rubber snake and a black rope on separate trials. Approach to the snake-like stimuli and vocalizations were recorded. In experiment 2, peanuts were presented in front of both a photograph of a leopard and a photograph of an herbivore from the ancestral home range. Number of peanuts retrieved, duration in front of, and vocalizations in response to each photo were recorded. Implications for the Multipredator Hypothesis will be discussed.
CONSISTENT INDIVIDUAL BEHAVIORS IMPORTANT FOR EARLY SURVIVAL IN JUVENILE RED-EARED SLIDERS (TRACHEMYS SCRIPTA)
A.W. Carter, R.T. Paitz, R.M. Bowden
School of Biological Sciences, Illinois State University, Normal, IL

Reptiles display a wide array of behaviors including sociality, territoriality, sexual displays, basking, predatory, antipredatory, and reproductive behaviors. Individual variation in these behaviors can result in differential life-history strategies and fitness. The majority of these behaviors have been well characterized in adults; however, individual variation of behaviors in juveniles is less understood. We characterized several ecologically relevant behaviors in juvenile red-eared sliders (Trachemys scripta) that are important indicators of early survival as hatchlings emerge from the nest and seek cover and resources. We measured righting response latency to activity, initial habitat choice, overall activity, and propensity to bury. Turtles were placed in an arena on the intersection of four microhabitats: sand with cover, open sand, water with cover, and open water and were able to move freely throughout the enclosure for 30 minutes. Each individual was sampled twice. We found repeatable individual differences in behavior in turtle hatchlings. Hatchlings showed consistent righting response time, latency to activity, and bury behavior. Moreover, we found that righting time significantly correlates with latency to activity in an arena. Our data suggest two behavioral strategies upon release among hatchlings, "bold" and "shy," which may result in differential survival. "Bold" hatchlings had quicker righting times as well as a shorter latency to activity period in the arena, whereas "shy" turtles exhibited opposite behaviors. Future research will seek to understand if these behavioral syndromes result in differential fitness in the wild, and how maternal effects and other environmental factors may influence these phenotypes.

FLIGHT INITIATION DYNAMICS OF TWO TRUE FROGS, LITHOBATES CATESBEIANA AND L. CLAMITANS
C.S. Cloyed and P.K. Eason
Department of Biology, University of Louisville, Louisville, KY

The decision of when to flee a predator depends on the costs and benefits of flight. Many studies have investigated the dynamics of flight in prey species and used flight-initiation distance (FID) to measure flightiness. Here, we used two species of closely related frogs, Lithobates catesbeiana and L. clamitans, to test FID predictions. We tested broad scale visibility by taking data at night and during the day. We altered the costs of flight by approaching the frogs from inside and outside the pond. In our analysis we included frog size, distance to pond, and percent of vegetative cover at the frog's initial location and at a spot equidistant to the pond but in the opposite direction. We used an information theoretic approach to construct models. For L. catesbeiana the model of best fit included approach in or out of the pond, time of day, body size, distance to refuge, percent cover away from the pond. The first four parameters had slopes significantly different from zero. For L. clamitans the model of best fit included time of day, body size, and percent cover at the original location and away from the pond. Body size and time of day had slopes significantly different from zero. L. catesbeiana and L. clamitans both respond to potential predators economically, fleeing when the risks associated with remaining are too great. However, they differ in their sensitivity to predators, with L. catesbeiana having longer FIDs than L. clamitans and being significantly affected by more parameters.
SOCIAL ISOLATION, STRESS, AND DEPRESSION: INSIGHTS FROM AN ANIMAL MODEL

Psychology Department, Northern Illinois University, DeKalb, IL

Depression is common in humans, and is among the leading causes of quality-of-life problems worldwide. The development of depression may be influenced by exposure to and inability to cope with stressors. Long-term social stressors, such as isolation or feelings of loneliness, may lead to depression in humans and depressive behaviors in animal models, as well as physiological health problems. Prairie voles are a useful animal model for investigating interactions between social and environmental stressors, because their social bonds are similar to those of humans. We hypothesized that isolation would induce depressive signs, and exposure to additional environmental stressors would exacerbate these depressive behaviors. Adult female prairie voles were either paired with a female sibling or isolated from the sibling for 4 weeks. Following this period, half of the paired and isolated animals were exposed to 7 days of chronic unpredictable mild stressors while the other half remained undisturbed. Following the 7 days of stressors, both paired and isolated animals were exposed to the forced swim test (FST), which measures depressive behaviors in rodents. Isolated animals showed significantly more depressive behaviors during the FST and when exposed to chronic mild stressors than those that were paired with a female sibling. These findings suggest that social isolation produces depressive behaviors, and additional stress from the environment can exacerbate these behaviors in socially isolated animals. Future analyses will investigate more specifically the neurobiological mechanisms through which social experiences and environmental stress interact to influence health.

THE SENSORY BASIS OF RHEOTAXIS IN NONUNIFORM FLOW

J.P. Elder, S. Coombs
Department of Biological Sciences, Bowling Green State University, Bowling Green, OH

When placed into a current, many fish exhibit an unconditioned upstream orienting response (positive rheotaxis). This behavior occurs in the light or in the dark, and with or without a functional lateral line system. Much of the previous study of this behavior has been undertaken in rectilinear flow. However, turbulence is a widespread condition of aquatic systems; several fish species show conditional preferences for turbulence levels, indicating that fish can both detect and respond to turbulence. The goals of the present study were to examine the effects of a turbulence-generating structure (TGS, an array of equally-spaced 0.6 cm-diameter cylinders) on the rheotactic response of Mexican tetras (Astyanax mexicanus). The rheotactic response of individual fish was tested in an ascending sequence of flow speeds (0, 1, 2, 4, 7, & 12 cm/s) under different sensory conditions (in light and dark and with intact and pharmacologically-disabled lateral line systems). The degree to which fish faced upstream increased with flow speed in all tested conditions. This rate of increase was similar in all visually-enabled fish, regardless of turbulence level and whether the lateral line was enabled or disabled. However, the rate of increase was higher in TGS+ than TGS- conditions in visually-disabled fish with intact lateral line systems. This effect was not present in fish with disabled lateral line systems. These results suggest that the lateral line plays an important role in rheotaxis when currents are turbulent and visibility is poor.
MATE SEARCHING AND RECOGNITION CUES DURING PUPAL MATING IN HELICONIUS BUTTERFLIES

C. Estrada
Smithsonian Tropical Research Institute, Chicago, IL

In variety of animal species males establish permanent associations with sexually immature females and guard them until mating. This male strategy to compete for mates presumably occurs in about half of the species in the genus of tropical butterflies, Heliconius. The origin and maintenance of precopulatory mate guarding or ‘pupal mating’ in Heliconius is puzzling. First, searching for cryptic hidden female pupae required the adaptation of novel behaviors and signaling systems, as male butterflies use primarily female wing coloration for mate searching and recognition. Second, although pupal mating has clear benefits to males, forcing copulation might impose fitness cost to females leading to sexual conflict. I investigate the cues involved in mate searching and recognition in pupal mating to understand how this behavior evolved and is maintained in Heliconius. Previous work with H. charithonia has shown that males use chemical cues released by host plants and visual cues from caterpillars to find potential partners, and that they are able to estimate the maturity and sex of pupae using primarily short range, sex-specific chemical cues. New data from H. erato and other Heliconiinae species show little variation in chemical mixtures released by pupa. Overall these results suggest a poor role of pupal chemical cues in species recognition and variation in the degree of cooperation of females in this mating strategy. I will discuss the degree to which these results agree with postulations that pupal mating was key for the assemblage of butterflies in these and related genera in tropical ecosystems.

THE EFFECTS OF SOCIAL EXPERIENCE ON ULTRASONIC VOCALIZATIONS AND BEHAVIOR IN MALE-MALE MOUSE INTERACTIONS

C.J. Finton, G.L. Sell, S.M. Keesom
Department of Biology, Indiana University, Bloomington, IN

Social experience is important for development of social behaviors. For example, social isolation can drastically impact behaviors like vocal communication, an important kind of social behavior. Mice emit ultrasonic vocalizations (USVs) in many social contexts, notably during courtship and same-sex interactions. In female-female and male-female interactions, USVs have been shown to be experience-dependent. However, few studies have investigated how social experience affects USVs produced during male-male interactions. The purpose of this study was to see if there were changes in USVs and other behaviors based on prior experience (group housed or raised in isolation) in male-male interactions. Three to four week old male mice were housed for 4-6 weeks in either group housing or isolation. During testing, two mice interacted in a neutral arena for 15 minutes. USVs were measured and analyzed through spectrographic analysis, and behaviors such as facial and anogenital sniffing, jumping, rearing, and mounting were also analyzed. During interactions with isolated mice, males displayed increased social investigation time and emitted more and longer syllables. A positive correlation between duration of USV syllables and social investigation time was also observed. In particular, there was a positive correlation between the proportion of harmonic USV syllables and frequency of mounting. These results demonstrate that past experience is extremely important in interactions between mice and add to the increasing knowledge of how and why mice communicate with each other.
IMPACT OF FATHER ABSENCE ON SEXUAL LIFE-HISTORY STRATEGY IN EMERGING ADULT MEN AND WOMEN

J.R. Garcia¹, N.M. Cameron²
¹The Kinsey Institute for Research in Sex, Gender, and Reproduction, Indiana University, Bloomington, IN, ²Center for Development and Behavioral Neuroscience, Departments of Psychology and Biology, Binghamton University, Binghamton, NY

Psychosocial acceleration theory (Belsky, Steinberg, & Draper, 1991) is an evolutionary model that has been applied to understanding the regulation of reproductive strategies in humans. Based on life-history theory, this model contends that stressful family environments, especially non-intact families, result in an adaptive accelerated regulation of children's development. This model of parent-offspring interaction predicting reproductive strategy has been well supported, particularly with respect to age at puberty and sexual debut among females. However, relatively little work has been done to assess the extent to which these reproductive strategies remain intact throughout later development and into adulthood. Similarly, few studies have explored the contextual factors of romantic/sexual outcomes with respect to contemporary norms. The current study explores the impact of parent absence during childhood, on the sexual behaviors of emerging adult men and women attending a U.S. university (N=617; 62% female, 38% male). We find that ethnicity and father absence impact romantic/sexual outcomes, in a context-specific fashion. Findings are somewhat consistent with psychosocial acceleration theory.

A PHYLOGENETIC TEST OF THE RED QUEEN HYPOTHESIS: EVOLUTION OF SEX AND PARASITISM IN THE NEMATODA

A.K. Gibson
Biology Department, Indiana University, Bloomington, IN

Sexual reproduction poses a paradox for evolutionary biology. It is substantially more costly than asexual reproduction. Yet in many taxa, notably animals and plants, sexual reproduction is far more frequent than is asexual reproduction. How can the prevalence of sexual reproduction be reconciled with its inherent costliness? The Red Queen Hypothesis argues that antagonistic coevolution selects for the maintenance of genetic diversity and sexual reproduction in interacting species, in particular in hosts and their parasites. While the maintenance of sex in hosts is a major area of study, the maintenance of sex in parasites is not. I evaluate the prediction that sexual outcrossing is more common in parasites than in their free-living relatives. I apply phylogenetic comparative methods to test for the predicted association between parasitism and outcrossing in the diverse Nematode phylum. I find that the frequency of outcrossing in parasites significantly exceeds that in free-living species, and I demonstrate that this association is robust to a phylogenetic correction for shared ancestry. Finally, I show support for correlated evolution of outcrossing and parasitism in the Nematode phylogeny. This work demonstrates the value of applying phylogenetic comparative methods to the diverse Nematode phylum to address the paradox of sex and the evolution of mating systems.
19. Ashley Goudjo-Ako (goudjoaj@miamioh.edu)

**BROWN FAT TRANSPLANTATION REGULATES ENERGY EXPENDITURE IN MICE**

A.J. Goudjo-Ako, E.G. Spicer, H. Shi
Department of Zoology, Miami University, Oxford, OH

BAT burns energy and counteracts obesity. Increasing amount of active BAT beneficially regulates energy homeostasis. We developed a BAT transplantation model by adding interscapular BAT of donors into subcutaneous regions of recipients. Transplanted BAT had normal appearance with blood vessels and nerve fibers ten weeks after surgery. Transplanted BAT and endogenous BAT had similar mRNA levels of UCP1 and PGC-1α, suggesting sympathetically regulated thermogenic function of transplanted BAT. Transplanted mice also responded to sympathetically activated conditions. Sham-operated control (Sham) and recipient (BAT Trans) mice responded similarly to cold exposure at 4°C, with similar BAT temperature through the 4-hour cold exposure. In addition, Sham and BAT Trans mice increased their heat productions to the same level during the norepinephrine challenge test; however, BAT Trans mice had greater oxygen consumption, suggesting that their energy expenditure was elevated to a greater extent. To test whether BAT transplantation regulates energy balance during obesity development, Sham and BAT Trans mice were fed a high-fat diet (HFD-sham, HFD-BAT). Both groups consumed more calories and gained more adiposity than the chow groups. Caloric intake was not different between transplanted and sham groups within the same diet. HFD-BAT mice had lower body fat with increased oxygen consumption and lowered respiratory quotient than HFD-sham mice, suggesting greater energy expenditure and usage of fat as fuel. In summary, mice with BAT transplantation had normal response to sympathetically challenged conditions but exhibited resistance to HFD-induced obesity due to increased energy expenditure.

20. Jacob Graving (jgravin@falcon.bgsu.edu)

**NAVIGATING IN THE DARK: THE SENSORY BIOLOGY AND BEHAVIOR OF WHIP SPIDERS (ORDER AMBLYPYGI)**

J. M. Graving¹, D.D. Wiegmann¹, V. P. Bingman²
¹Department of Biological Sciences, ²Department of Psychology, Bowling Green State University, Bowling Green, OH

The size of olfactory brain structures is hypothesized to reflect evolutionary navigation demands. Field observations of whip spiders, a nocturnal arachnid (Order Amblypygi), suggest that they are skilled navigators and exhibit a high degree of site fidelity. Amblypygid mushroom bodies, brain structures that process olfactory information, are the largest of all terrestrial arthropods. Preliminary data suggest that the mechanism by which they navigate involves the use of olfactory cues, a rare sensory mode in arachnids. We developed a means to evaluate the unique navigational abilities of Amblypygids under laboratory conditions, where they exhibit a high level of fidelity to an artificial shelter. Utilization of space and exploratory behaviors are also discussed.
21. Achikam Haim (haim.1@osu.edu)

**EFFECTS OF GESTATIONAL STRESS ON POSTPARTUM MOOD, MOTIVATION AND NUCLEUS ACCUMBENS PLASTICITY**

A. Haim¹, M. Sherer², B. Leuner¹,²  
¹Department of Neuroscience, ²Department of Psychology, Ohio State University, Columbus, OH

Postpartum depression (PPD) is experienced by 10-15% of all new mothers who often show impaired maternal care. Maternal care is a motivated behavior regulated by reward value of pups. Impaired maternal care seen in PPD may thus result from reduced maternal motivation. Gestational stress (GS) is a major risk factor for PPD but the effects of GS on maternal motivation and structural changes in reward circuits remain unspecified. As such, we assessed the impact of GS on postpartum depressive-like behavior, maternal care, maternal motivation, and structural changes in the nucleus accumbens (NA). Pregnant rats were exposed to stress or served as controls. During the postpartum period, rats were evaluated for depressive-like symptoms (food intake, weight gain, forced swim test), maternal care (pup retrieval, self-grooming, time spent over pups), and maternal motivation (conditioned place preference, CPP). Following behavioral testing, brains were processed using Golgi impregnation for analysis of dendritic length, branching, and spine density of NA medium spiny neurons. Our results show that GS decreased pregnancy weight gain and maternal food intake indicative of anhedonia. In addition, GS increased immobility time in the forced swim test suggesting increased depressive-like behavior. GS also impaired maternal care by increasing pup retrieval latency and self-grooming time while decreasing time spent over pups. In the CPP paradigm, GS reduced pup preference. Finally, GS decreased total dendritic length and branching in the NA. Our results suggest that impaired maternal motivation and reward may underlie poor maternal care associated with PPD.

22. Rachel Hanauer (rhanauer@indiana.edu)

**FEATHER CORTICOSTERONE DOES NOT RELIABLY PREDICT MAGNITUDE OF THE ACUTE CORTICOSTERONE RESPONSE TO STRESS IN A WILD PASSERINE**

R. Hanauer, E. Ketterson  
Department of Biology, Indiana University, Bloomington, IN

The adrenal steroid hormone corticosterone (CORT) regulates energy balance and behavior and responds to stress. Individuals vary in how much they elevate CORT in response to acute stressors such as handling. Known as the stress response, elevated CORT is a stable trait that relates to survival. Interest has grown in measuring CORT extracted from feathers or hair because they are easier to collect and might reveal how acute and chronic stress are related. Individual variation in feather CORT is correlated with the stress response in captive red-legged partridges; whether this is true for free-living birds is not known. I tested whether feather CORT reliably predicts circulating CORT in wild male dark-eyed juncos (n=80) captured during the breeding season at two populations in southern California. I collected blood samples at 0 and 30 minutes after capture along with one tail feather that had grown the previous autumn during molt. The acute stress response differed by population, but feather CORT did not. In one of the two populations, plasma CORT correlated with feather CORT, but oddly the sign of the relationship was negative and varied seasonally. Early in the season, birds with high feather CORT had low stress responses and vice versa; birds caught later in the season did not show a correlation. I conclude that feather CORT may not be a good predictor of the acute CORT response to stress in wild birds, but may inform other aspects of how populations respond to stressors in their environments.
23. Lucy Ho (wimsey@umich.edu)

GENETICALLY INFLUENCED SOCIAL VARIATION IN A HOWLER MONKEY HYBRID ZONE (ALOUATTA PIGRA X ALOUATTA PALLIATA)

L. Ho¹, L. Cortes-Ortiz², T. J. Bergman¹
¹Department of Psychology, ²Department of Ecology and Evolutionary Biology, University of Michigan, Ann Arbor, MI

Social differences between primate species may result from genetics, social factors such as group size, and ecological variation. I take advantage of a naturally occurring hybrid zone to analyze these separate factors and their effect on social behavior. I examined affiliation and aggression in two species of howlers and their hybrids: Alouatta pigra, Alouatta palliata, and A. pigra x A. palliata (respectively located in the Mexican states of Campeche, Veracruz, and Tabasco). Work in pure populations has shown that A. pigra females are more affiliative and less aggressive than A. palliata. I compared rates of female affiliation and frequency of female agonism across species, group size, and location (a proxy for environmental disturbance) in 17 groups of howlers (A. pigra = 3, A. palliata = 3, A. pigra x A. palliata = 11) using 1026 focal hours recorded in 2011 and 2012. Even after controlling for group size, A. pigra female rates of affiliation were significantly higher than that of A. palliata females, and rates of affiliation among the hybrid females were, on average, intermediate between purebred behavior. Though the frequency of agonism were extremely low across all groups, A. pigra females were less aggressive than A. palliata. While pigra-like female agonism was intermediate to the purebreds, palliata-like females actually exhibited higher frequencies of agonism, a difference that does not support an ecological explanation. These results suggest some genetic influence on aspects of social behavior.

24. Elliott Ihm (ellihm@yahoo.com)

REVERSING THE EFFECTS OF SOCIAL STRESS THROUGH ENVIRONMENTAL ENRICHMENT AND EXERCISE: AN ANIMAL MODEL

Psychology Department, Northern Illinois University, DeKalb, IL

Social bonds are important for human well-being, and their disruption has adverse effects on mental and physical health. The social behavior of prairie voles closely resembles that of humans, making them a useful animal model for studying the relationship between human social behavior and pathophysiology. The disruption of social bonds in prairie voles contributes to anxiety- and depression-like behaviors, but an enriched environment (including an exercise wheel, hiding places, and small objects) might prevent these effects. The current study examines whether environmental enrichment can reverse the negative effects of social isolation after they occur and whether this effect is due to exercise alone or to other aspects of an enriched environment. Adult female prairie voles were isolated from a sibling for four weeks, followed by an additional four weeks of isolation in enriched cages, cages with only a running wheel, or standard cages. Afterwards, all animals were exposed to several behavioral tasks used to quantify anxiety- and depression-like behaviors. Animals who remained in standard cages exhibited more anxiety- and depression-like behaviors than those who were given an enriched environment or a running wheel, demonstrating that environmental enrichment and exercise can reverse the negative behavioral effects of social isolation. These results demonstrate the efficacy of non-drug treatment strategies for analogs of human mood disorders related to sociality. Future studies should investigate differences in the neurobiological mechanisms underlying the effects of environmental enrichment and exercise on behaviors related to anxiety and depression.
FUNCTIONAL UPREGULATION OF α7 NEURONAL NICOTINIC ACETYLCHOLINE RECEPTORS BY NICOTINE EXPRESSED IN XENOPUS OOCYTES

M.F. Islam, K. Summers, P. Schwartz, J. Farley
Department of Neuroscience, Indiana University, Bloomington, IN

Upregulation of neuronal nicotinic acetylcholine receptors (nAChRs) (e.g., α4β2) appears critical for nicotine addiction, but the role of α7 upregulation, if any, is largely unknown. Previous in vitro studies of α7 nAChRs in Xenopus oocytes fail to observe upregulation in cells exposed to nicotine concentrations typical of tobacco users. These failures might be due to incomplete removal of nicotine as a result of slow release of nicotine from the cells, and subsequent desensitization of α7 receptors during functional assays. In our experiments, overnight exposure to nicotine (100 µM), followed by extensive 7 h washout yielded a statistically significant ~2-fold increase in macroscopic α7 R current on 5th day post-injection of α7 cRNA as measured by TEVC electrophysiology. Mean peak currents in controls were found to be 319±70.73 nA (n=37), while mean peak currents in nicotine exposed were found to be 647±128.26 nA (n=46) [p < 0.001]. These results only occurred on day 5, and not day's 2 to 4 post-injection of α7 cRNA, implicating higher level of alpha 7 expression and Ca^{2+} influx through α7 Rs might be the major determinants for upregulation.

ENVIRONMENTAL STRUCTURE INFLUENCES THE BEHAVIOR OF MOUSE HUDDLES

D.M. Jacobs¹, D.S. Shelton²,³,⁴, J.R. Alberts²,⁴
¹Individualized Major Program-Animal Behavior, ²Department of Biology, ³Department of Psychological and Brain Sciences, ⁴Center for the Integrative Study of Animal Behavior, Indiana University, Bloomington, IN

Understanding how complexity at the macro level arises from the interactions of individual components is a question central to many biological disciplines. Animals groups such as bird flocks, fish schools, and rodent huddles present an opportunity to link individual behavior with group-level dynamics. Huddling is the active maintenance of a clump by individual interactions, which can lead to distinct group-level geometries. Huddling can have indirect fitness consequences, including altering bioenergetics leading to faster growth rates. We examined the thermal consequences of different huddle formations in C57BL/6 mice (Mus musculus) and the contributions of individual and group behavior to huddle architecture. In a cool (22°C) or warm (36°C) ambient environment we presented mouse litters with either a flat nest that permitted horizontal movements (2D huddling), or a concave nest, which allowed the mice to move both horizontally and vertically (3D huddling). For each nest and temperature condition we recorded huddle temperatures, individual and group movement. We found 3D huddles were nearly 1°C warmer than 2D huddles, and groups and individuals contracted and expanded in cool and warm conditions, respectively. The affordances of the concave nest, but not the flat nest, permitted individuals to modulate activity rate, and the group to change direction in response to temperature. We found nest structure augments the expression of individual and group behavior leading to thermal differences in huddling. Individual movements led to the group forming a complex and mobile structure that was associated with thermal benefits to the members.
DO RATS BENEFIT FROM PRACTICING MEMORY RETRIEVAL?

J.A. Ketzenberger, W.T. Alford, J.D. Crystal
Department of Psychological and Brain Sciences, Indiana University, Bloomington, IN

Although it is intuitive that studying for a test promotes learning and taking a test merely serves to assess knowledge, recent evidence from studies of human cognition suggest that retrieval practice enhances long-term retention. Here we asked if rats benefit from retrieval practice. In an eight-arm radial maze, rats were trained with study-test sequences, in which they were permitted to find food at four baited arms in the study phase, and then given access to all eight arms in the test phase; food was available each day at the arms that had not been previously visited. To test whether rats benefit from retrieval practice, we designed two assessments; in the first, the rats were presented with the same procedure described above, except during the test they were shown two doors at a time, one they had seen in the study phase (foil door) and one they had not seen (target door). Target doors, but not foil doors, led to currently baited arms. After the rat had visited three target doors, all eight doors were opened and they had to find the last baited arm. In a control condition, the procedure was the same, except the foil door was absent. In a second assessment, we lowered the overall accuracy by introducing interference. The presence of the foil door significantly increased accuracy to find the last baited arm (i.e., a test common to all conditions). These data raise the possibility of studying retrieval practice in rats.

EXPLOITING SPONTANEOUS BEHAVIORS: USE OF THE STRING-PULLING TASK TO EVALUATE DISCRIMINATION LEARNING

J.R. Koppen, A. Blackwell, S.S. Stuebing, D.G. Wallace
Department of Psychology, Northern Illinois University, Dekalb, IL

Although an animal's natural repertoire of spontaneous behaviors lends itself to examining learning and memory phenomenon, many studies do not exploit these behaviors. Traditionally, discrimination learning research has used intense and lengthy training procedures. In contrast, researchers have observed among many species that when exposed to a string an animal will spontaneously pull on it, and learn to continuously do so if there is a food reward at the end of it. The spontaneous string-pulling ability has, therefore, begun to be utilized to study a variety of cognitive mechanisms. The current study uses the string-pulling task to evaluate discrimination learning. Rats were trained on two different sets of scented strings. When criterion was met for both discriminations, the rats were trained in a reversal paradigm, to determine if the memory for the discrimination was intact. Results demonstrated that the rats reached criterion for discrimination learning in less trials when compared to visual discrimination tasks and many olfactory discrimination tasks that have been used in previous research. In addition, rats showed a slower learning rate for the reversal training, suggesting that the memories of the previous discriminations were intact. The current study demonstrates that the string-pulling task can be used to evaluate mnemonic function and provides a rich paradigm to evaluate the neurobiology of cognitive processing.
SEXUALLY DIMORPHIC ENHANCEMENT OF CELL PROLIFERATION IN THE SUBVENTRICULAR ZONE OF MURINE BRAIN

S. Koyama¹, H.A. Soini², J.G. Foley³, M.V. Novotny², C. Lai¹
¹Department of Psychological and Brian Sciences; ²Department of Chemistry; ³Department of Medical Science, Indiana University, Bloomington, IN

Adult neurogenesis in female mice is known to be enhanced by exposure to soiled bedding from males, although the identity of the relevant chemosignals has remained unknown. Here we show that the previously recognized male mouse pheromones, the farnesenes and 2-sec-butyl-4,5-dihydrothiazole, strongly increase cell proliferation in the subventricular zone (SVZ) of adult female mice, but not younger female mice. The threshold concentrations required to induce enhanced cell proliferation in the SVZ were about 1000 times higher than that needed to initiate depolarization of vomeronasal neurons. In addition, we found that a unique female mouse pheromone, 2,5-dimethylpyrazine, facilitates similar changes in males. Male pheromones did not affect cell proliferation in males, and a female pheromone did not affect cell proliferation in females. Immunohistochemical analyses revealed that neural progenitor cells were present among the cells that had proliferated in response to pheromone. Our study supports a model in which pheromonal communication between males and females enhances reproductive success by controlling estrous cycle and by promoting neural progenitor proliferation in a reciprocal manner.

SPATIAL INFORMATION IN CHEMICAL SIGNALS: THE INTERACTION BETWEEN ODOR SOURCE AND HYDRODYNAMICS CAN IMPACT BEHAVIOR

S. Lahman, P. Moore
Department of Biology, Bowling Green State University, Bowling Green, OH

Within an aquatic ecosystem, many organisms rely on chemical signals in order to perform a range of ecological decisions. Understanding the role of chemical signals in the ecology of aquatic organisms requires a thorough understanding of the spatial and temporal distribution of sensory stimuli. For chemoreception, chemical signal dispersion is intimately tied to fluid mechanics. Alterations in the hydrodynamics of a habitat or in the way that chemical signals are introduced to habitats can have profound effects on sensory information, which can subsequently alter the behavior or ecology of organisms using chemical signals. As organisms have a defined threshold for the induction of chemically driven behaviors, variations in the information received will elicit alternate behavioral responses. This study examines the influence of point versus non-point introduction of chemical signals into a simulated flowing freshwater habitat. The fine scale spatio-temporal distribution of chemical signals was measured in situ using an electrochemical detector. Molecule concentration at varying distance and height from the source was quantified using the chemical tracer dopamine coupled with an electrochemical detection system (Epsilon, Bioanalytical Systems). The fine-scale distribution of chemical signals from point and non-point sources showed significant differences in the types of information that are available to organisms. This quantification of chemical signal dispersion patterns and the types of information that are available allows a greater understanding of chemoreception. Based on these results, organisms should be able adjust their search strategy to differences in information received.
VOCALIZATIONS OF SHORT-FINNED PILOT WHALES, *GLOBICEPHALA MACRORHYNCHUS*

J.H. Lee¹, D. Nowacek¹,²,³

¹Department of Zoology, ²Nicholas School, Ohio Wesleyan University, Delaware, OH, ³Duke University, Durham, NC

The short-finned pilot whale, *Globicephala macrorhynchus*, is an extremely vocal species producing a mixture of whistles, clicks, and pulsed calls. Their vocalizations have not been extensively studied compared to other cetaceans with complex vocal repertoires. In this study, short-finned pilot whales were tagged with multi-sensor acoustic recording tags off Cape Hatteras, NC. In 120 minutes, 3880 calls were recorded, including regular and shorter click sequences, single clicks, rasps, buzzes, squeaks, and whistles. Of the calls, 668 whistles were of sufficient quality for analysis, among which 94 distinctive categories of calls were identified. Twenty-nine of the categories contained 3 or more repeated calls and were defined as predominant call types (PCTs). From a qualitative whistle analysis, individually distinctive vocalizations, or at least group-specific calls or contours, seem evident. The whistle frequencies were higher on average when compared to the limited previous findings, but regional and individual differences appear likely. The mean duration of regular click sequences was 26.64 seconds, and 33% contained rasps or buzzes, indicators of foraging attempts, while shorter click sequences (average 2.24 seconds) did not contain any buzzes. The presence of these short click sequences could indicate an initial interrogation of a target and then a decision not to pursue them further. Through a thorough comparison of pilot whales’ repeated whistles, future work should examine whether pilot whales exhibit signature calls similar to those of bottlenose dolphins (*Tursiops truncatus*), and how their group-specific calls or contours are structured.

SOCIAL INTEGRATION IN BROWN-HEADED COWBIRD (*MOLOTHRUS ATER*) FLOCKS

G. Meredith¹, G. Kohn², M. West²,

¹Individualized Major Program-Animal Behavior, Ecology, and Conservation, ²Department of Psychological and Brain Sciences, Indiana University, Bloomington, IN

Brown-headed Cowbirds (*Molothrus ater*) perform an action referred to as the head-down display. The function of the head-down is disputed but hypotheses suggest it serves either as a means to appease conspecifics or create social integration. To test the function of the head-down, a flock manipulation was conducted in which an introduction of familiar birds was compared to an unfamiliar introduction. Flock manipulations within an aviary complex were used to simulate familiar and unfamiliar introductions of cowbirds. Aviaries 1 and 2 both contained familiar birds. Aviaries 3 and 4 were used for the unfamiliar introduction with the unfamiliar (new) birds added to Aviary 4. Two observers took scan sampling data on the four separate flocks. The partitions between 1 and 2 and also 3 and 4 were removed, resulting in a familiar introduction scenario (Aviaries 1 and 2) and unfamiliar introduction (Aviaries 3 and 4). After the two flocks were introduced, two observers recorded scan sampling data on the two flocks. Approach rates between baseline and trial (before and after the introduction) were highly correlated, meaning that the birds did not significantly alter their approach rate between the baseline and trial conditions. However, both female and male head-down rates were uncorrelated between the baseline and trial conditions. Specifically, the females reduced their head-down rates to males. My results contribute to the social facilitation hypothesis of the head-down because the females would approach the males more if it served an appeasing function.
Social Support is Beneficial for Coping with Stress: Studies Using an Animal Model

R. Murphy¹, K. Appleton², A.K. Johnson¹, N. McNeal¹, J. Wardwell¹,
C. Bishop¹, S. Steel¹, M.A. Scotti¹, A.J. Grippo¹
¹Department of Psychology, Northern Illinois University, DeKalb, IL,
²Bournemouth University, Dorset, UK,

Our social environment influences our experience of every day stress. Individuals with social support may be better able to cope with stress than those who experience stress alone. This project investigated the hypothesis that social support is beneficial for emotional and physiological health using a rodent species, the prairie vole. These animals are relevant to studies of stress and social bonding because prairie voles, like humans, form social bonds and sometimes mate for life. Male and female prairie voles were paired for 5 days and allowed to form a social bond. Following this period, half of the animals were isolated from the partner while the other half remained paired. After 5 days of isolation or continued pairing, all animals experienced several mild stressors for 10 days. Animals were exposed to two tests designed to measure depressive behavior in animals. Plasma was collected to measure circulating stress hormones. Isolated animals displayed increased depressive behaviors and poor stress-coping behaviors versus paired animals; and isolated females showed greater signs of depression than isolated males. Significantly higher stress hormone levels were observed in isolated females versus paired animals and isolated males. These results indicate that having a companion can improve stress-coping ability and mood, while social isolation impairs coping and produces depression. Social stress might be especially detrimental for females, based on the current findings. This research has implications for human mental health and can inform differential treatment strategies for men and women who are experiencing social stress or depression.

What Makes a Bird’s Head Turn? Scanning Behavior is Associated with Body Mass and the Centers of Acute Vision

Department of Biology Purdue University, West Lafayette, IN
*Authors contributed equally to this work

Vigilance behavior allows animals to gather visual information about potential threats (e.g., predators). Previous studies have shown that vigilance behavior patterns vary between species, but little is known about the factors affecting this degree of variation. We assessed the relationship between vigilance behavior (i.e., head movement rates) and the relative size of the centers of acute vision in the retina, taking into account body mass. We gathered information on 161 bird species. We found that head movement rates were significantly affected by the interaction between body mass and the centers of acute vision. Head movement rate decreased with body mass in a more pronounced way in species with smaller centers of acute vision compared to those with larger ones. These results suggest that small bird species move their heads at a higher rate to scan the visual environment and compensate for the low proportion of the visual field with high visual resolution. In large bird species, the costs of moving the head may be higher and may be reduced by having retinas with a larger proportion of their visual field with high visual resolution. The overall implication is that vigilance behavior as an antipredator strategy may be the result of a trade-off between the biomechanical limitations of moving the visual system (head movements) and the retinal configuration.
VARIATION IN ACOUSTIC PROPERTIES OF THE STRESS CALLS OF THE DUNE GECKO

STENODACTYLYS STHENODACTYLYS

E. Ogawa, N.M. Gordon
Department of Biology, University of Evansville, Evansville, IN

Understanding how animals communicate can provide insight into intra- and interspecific interactions. Signaling variation in diverse taxa may function for detection of sexual fitness, territoriality, and alarm. Acoustic communication is a common form of signaling in most major vertebrate lineages with the exception of the order Squamata where it is largely confined to Gekkonidae. While acoustic communication has been studied extensively in other vertebrates, the function of these signals in Gekkonidae remains essentially unknown. A crucial first step in determining the function of any signal is characterizing the signal and determining what properties contain substantial variation. Static properties are properties that remain essentially unchanged from signal to signal and usually convey a single message. Dynamic properties have a high degree of variability from signal to signal which could indicate that the property is used to communicate multiple messages or gradations in signal intensity. Determining the degree of static and dynamic variation in S. sthenodactylus alarm calls could yield further information of how dune geckos use alarm calls to communicate. This will also improve our understanding of acoustic behaviors in the family Gekkonidae. To analyze static and dynamic properties we evoked multiple alarm calls from thirteen S. sthenodactylus individuals and analyzed the variation in five acoustic properties (call duration, rise and fall time, inter-call interval, and dominant frequency) using the coefficient of variation. Our results quantify the degree of static and dynamic properties found in S. sthenodactylus alarm calls and show how much information may be contained in these signals.

A DETAILED ANALYSIS OF THE PRAYING MANTIS ELECTRORETINOGRAM:
IMPLICATIONS FOR SUCCESSFUL PREY RECOGNITION

B. W Popkiewicz, E.S. Mantes, A.E. Schirmer, F.R. Prete
Department of Biology, Northeastern Illinois University, Chicago, IL

There is a large body of data on praying mantis behavior, most focusing on their unique object recognition abilities. Despite this, little is known about the visual system mechanisms that underpin these abilities. Hence, we undertook a detailed analysis of the electroretinogram (ERG) of three species, Popa spurca, Tenodera sinensis, and Sphodromantis lineola. The ERG is an extracellular recording of the light-induced electrical activity of the compound eye photoreceptors, and the post-synaptic (lamina) cells on which they synapse. A typical mantis ERG recorded from a light-adapted eye is a complex waveform, consisting of four components: a transient and sustained ON potential representing photoreceptor depolarization, followed by transient and sustained OFF potentials representing repolarization of the lamina cells and the photoreceptors, respectively. However, all four components are evident only if the stimulus (i.e., light pulse) exceeds 400 ms. An ERG elicited from a dark-adapted eye differs in that the amplitudes of the sustained potentials are greater, and the transient responses are either reduced or absent. These data suggest that visual sensitivity increases in dim light when prey recognition poses a challenge. Decreasing light intensity results in a diminution of the ON and OFF photoreceptor potentials but not the lamina cell potentials. This suggests that when light dims, lamina cells receive pooled information from dark-adapting photoreceptors. In turn, this suggests that the lamina cells' consistent and reliable activity--even in dim light--represents the first stage in information processing related to object (hence, prey) recognition.
BEHAVIORAL RESPONSES TO CONSPECIFIC CHEMICALS OF TWO SCELOPORUS SPECIES DIFFERING IN SIGNALING MORPHOLOGY

J.A. Pruett\textsuperscript{1}, C. Vital\textsuperscript{2}, J.J. Zuniga-Vega\textsuperscript{3}, E.P. Martins\textsuperscript{4}, D.K. Hews\textsuperscript{1}

\textsuperscript{1}Department of Biology, Indiana State University, Terre Haute, IN, \textsuperscript{2}Universidad Autónoma de Ciudad Juárez, Mexico, \textsuperscript{3}Facultad de Ciencias Universidad Nacional Autónoma de Mexico, \textsuperscript{4}Center for the Integrative Study of Animal Behavior, Indiana University, Bloomington, IN

Lizards communicate through a variety of signal modalities that involve motion, display of color patches, and pheromones. Trade-offs among signal modalities along with variation in trait lability can affect evolution of multimodal signals. Previous work with \textit{Sceloporus} suggests that a species without color patches (white) is more responsive to chemical cues than a species with patches (blue). Here, we further investigate how the loss of blue coloration might have influenced the evolution of chemical signaling in \textit{Sceloporus}. We predicted that behavioral responses to chemical cues of conspecific males would be stronger in \textit{S. siniferus} (white) than in \textit{S. merriami} (blue). We presented swabs with chemical cues and clean swabs (control) to male lizards in the field and recorded chemosensory behaviors, aggressive displays and movement. Male \textit{siniferus} performed more visual displays overall than \textit{merriami}, however, exposure to male cues decreased visual display rates in both species. Rates of chemosensory behaviors overall were low for both species, but \textit{merriami} tended to exhibit more (tongue flick, chin wipe). Exposure to male cues reduced the distance and frequency of movements by \textit{siniferus} but not in \textit{merriami}. These data and our other \textit{Sceloporus} studies suggest that male \textit{merriami} are less likely to exhibit visual displays when presented only with conspecific chemical stimuli compared to when they are presented with visual stimuli. The overall high rates of visual displays by \textit{siniferus} may reflect the importance of motion versus color in certain habitats.

REDNESS MAY BE ATTRACTIVE TO ONE BUT NOT BOTH SEXES IN \textit{THORICHTHYS MEEKI}

S. Ramaker, P. Eason,
Department of Biology, University of Louisville, Louisville, KY

When both parents contribute significant resources to their offspring, theory predicts that both males and females should be choosy when it comes to selecting a mate. \textit{Thorichthys meeki} is a monogamous cichlid that provides up to three months of parental care. Given this high amount of care, we hypothesized that both sexes should selectively associate with high quality potential mates. In this species, males and females have varying degrees of red in their throat, which becomes most visible during displays when they flare their gills. Redness in this species is indicative of quality since carotenoids—the pigment responsible for red color—cannot be synthesized de novo. Thus redder individuals are in relatively good health and have been able to obtain ample resources. In this study, we separated \textit{T. meeki} by sex and fed them diets either high or low in carotenoid content for three months before being tested in a dichotomous choice aquarium with three compartments. We placed a focal individual in the center compartment while size-matched red and less-red individuals were placed in the two lateral compartments. Data was obtained on behavior, interaction, and association time. Preliminary results indicated that females preferentially associated and interacted with males fed a high carotenoid diet, while males showed no preference for females fed either diet. By identifying that males and females may assess different qualities in their potential mates we provide a framework for future studies on bi-lateral mate choice in this species.
39. Nikki Rendon (nrendon@indiana.edu)

PREDICTING AN AGGRESSIVE PHENOTYPE: TIMING OF MELATONIN SECRETION MEDIATES SEASONAL CHANGES IN REPRODUCTIVE PHYSIOLOGY AND ENDOCRINE PROFILES IN FEMALE SIBERIAN HAMSTERS (PHODOPUS SUNGORGUS)

N.M. Rendon¹,², G.E. Demas¹,²
¹Department of Biology, ²Center for the Integrative Study of Animal Behavior, Indiana University, Bloomington, IN

Among the suite of seasonal adaptations displayed by temperate zone rodents, males and females of some species demonstrate increased territorial aggression in the non-breeding season. The physiological mechanisms mediating aggression in the absence of gonadal steroids remain mostly unknown. The goal of this study was to determine if melatonin, the major biochemical cue signaling day length, regulates seasonal changes in aggression. To test this, female Siberian hamsters were housed in either long summer-like day or short winter-like day conditions and given daily melatonin or a vehicle. Melatonin was administered 2 or 8 hours before their entrained night period for 10 weeks to mimic non-breeding and breeding patterns of melatonin, respectively. Territorial aggression and peripheral steroid levels were quantified to assess the physiological responses to photoperiod and melatonin treatment. The results demonstrated that short-day and short-day like hamsters displayed gonadal regression and decreased levels of E₂, but increased levels of DHEA and significantly elevated levels of aggression compared with reproductive animals. Steroids were differentially altered in response to aggression trials but changes in steroid concentrations did not correlate with aggression. These findings suggest that physiological mechanisms in addition to circulating steroids (e.g., changes in steroid receptors or steroid metabolism) may contribute to seasonal changes in aggression. Further, these results support previous findings of non-breeding aggression in female hamsters and demonstrate that environmentally relevant patterns of melatonin regulate these seasonal and behavioral responses.

40. Sara Sabihi (sabihi.1@osu.edu)

OXYTOCIN IN THE MEDIAL PREFRONTAL CORTEX REDUCES ANXIETY IN FEMALE RATS

S. Sabihi¹,², N. Durosko¹,², B. Leuner¹,²
¹Department of Psychology, ²Department of Neuroscience, Ohio State University, Columbus, OH

The neuropeptide oxytocin (OT) has anxiolytic effects in rodents and humans. The medial prefrontal cortex (mPFC) has been shown to play a role in the modulation of anxiety behavior. The mPFC contains OT-sensitive neurons, expresses OT receptors, and may receive long range axonal projections from OT-producing neurons in the hypothalamus. This suggests the mPFC is a possible target where OT acts to diminish anxiety behavior. Age-matched adult virgin female Sprague-Dawley rats were implanted with bilateral cannula into the prelimbic region of the mPFC. After 1 week, rats were infused with oxytocin (0.1μg/1μl or 1.0μg/1μl), vasopressin, or saline. Animals then underwent testing for anxiety behavior on the elevated plus maze, and/or the open field. In some animals, social anxiety was also evaluated using the social interaction test. Rats receiving 1.0μg/1μl OT spent more time in the open arms of the maze and had more entries into the open arms. Using the effective dose of OT, separate groups of rats were tested in the open field. Those injected with OT crossed more inside gridlines and spent more time on the inside of the field. A comparable dose of vasopressin in the mPFC had no effect on anxiety behavior. OT, but not vasopressin, in the mPFC reduces inherent anxiety without altering social anxiety. These results suggest that the mPFC is a site where OT may act to reduce some types of anxiety-related behavior in females.
41. Andrew Sage (andrew.s.sage@mail.missouri.edu)

**COCAINE-INDUCED BEHAVIORS: THE ROLE OF SIGMA RECEPTORS**

A.S. Sage¹, K. H. Fan², J.R. Lever³⁴, S.Z. Lever²⁵, D.K. Miller¹

¹Department of Psychological Sciences, ²Department of Chemistry, ³Department of Radiology, ⁴Truman V.A. Medical Center, ⁵MU Research Reactor Center (MURR), University of Missouri, Columbia, MO

The goal of the present series of experiments was to determine the effects of sigma receptor ligands on the locomotor activating (Exp. 1) and the conditioned rewarding (Exp. 2) properties of cocaine. Administration (ip.) of a putative sigma receptor antagonist, 15-min prior to cocaine (20 mg/kg), dose-dependently attenuated cocaine-induced hyperactivity (Exp. 1) and cocaine conditioned place preference (Exp. 2) in mice. These data demonstrate that cocaine interacts with sigma receptors in the production of cocaine-induced behaviors. This mechanistic interaction is believed to occur in both dopamine-mediated motor (Nigrostriatal) and reward (Mesolimbocortical) pathways.

42. Latasha Skillman (lskillma@purdue.edu)

**MALE DIRECTED VS. FEMALE DIRECTED SONG IN BROWN HEADED COWBIRDS (MOLOTHRUS ATER)**

L. Skillman, K. Ronald, J. Lucas
Department of Biological Science, Purdue University, West Lafayette, IN

Male brown-headed cowbirds (*Molothrus ater*) often use a multimodal signal consisting of a song and a wingspread display during courtship and aggressive encounters with conspecifics. The song consists of three components: a low frequency phrase (P1), a 50 msec interphase unit (IPU), and a series of high frequency sweeps (P2). It can be presented without the wingspread display; but the wingspread display is never presented alone. Additionally, while there are differences between female- and male-directed wing-spread displays, previous studies have been unable to detect a difference between female and male directed song. However, because the song can function as a standalone signal and is effective in both attracting females and deterring males, we predicted that there would be differences in entropy and frequency based on the motivational rules hypothesis. We analyzed 253 songs (112 male directed and 141 female directed) and found that the entropy and frequency of P2 was dependent upon the sex of the receiver. Additionally, we will compare two methods for estimating the degree of overlap between female- and male-directed songs: cross correlations and a similarity index. These results suggest that males are able to fine tune their song based on their audience; males that are better able to fine-tune their songs may have a fitness advantage compared to males that sing similar song types to both sexes.
ODOR SHARING AMONG KIN IN BIRDS: ASSESSING WHETHER FEMALE SONGBIRDS TRANSFER PREEN OIL TO THEIR NESTLINGS DURING BROODING

S.P. Slowinski$^{1,2}$, D.J. Whittaker$^3$, E.D. Ketterson$^{1,2}$

$^1$Department of Biology, $^2$Center for the Integrative Study of Animal Behavior, Indiana University, Bloomington, IN, $^3$BEACON Center for the Study of Evolution in Action, Michigan State University, East Lansing, MI

Avian preen oil contains volatile compounds that likely play a role in intraspecific communication. Odor may be important for kin recognition in birds. Research on mammals suggests that a possible mechanism for the similarity of odors among kin may be the transference of odor-producing microbes in secretions. We investigated whether free-living female Dark-Eyed Juncos (*Junco hyemalis*) transfer preen oil (and, consequently, their own odor) to their nestlings during the early brooding stage at The Mountain Lake Biological Station in Pembroke, Virginia. Brooding females were captured at the nest using potter traps and mist nets. We applied 30 μl of Glo-germ, a non-toxic gel that glows under UV light, to the preen gland before releasing each focal female. We returned to the nest 4 to 7 hours after the original capture and application of the gel and removed the nestlings from the nest and inspected them under an ultra-violet light in dark conditions. We were able to detect Glo-germ on twelve out of a total of twenty-one nestlings that we inspected following our treatment. Our results support the hypothesis that female songbirds transfer preen oil to their nestlings during early brooding and suggest that a nestling's odor may be influenced by the odor of the mother. Future research will assess whether microbes that may be transferred from mother to offspring via preen oil affect the ontogeny of preen oil volatiles in nestlings, leading to similar odors among nest-mates and their mothers.

SENSITIVE METHOD FOR QUANTITATIVE MEASUREMENT OF JUVENILE HORMONES IN HEMOLYPH OF INDIVIDUAL *O. BINODIS* LARVAE BY GAS CHROMATOGRAPHY-MASS SPECTROMETRY

M.P. Andreas$^{1,2}$, G.C. Specht$^{1,2}$, M.I. Campos$^{1,2}$, H.A. Soini$^1$, A.P. Moczek$^2$, M.J. Wade$^2$

$^1$Institute for Pheromone Research and Department of Chemistry, $^2$Department of Biology, Indiana University, Bloomington, IN

Juvenile hormones (JH) are a class of insect hormones that control critical physiological aspects such as the environment-sensitive growth and development of both adult and larval insects. These acyclic sesquiterpenoids exist in several different JH forms (JHI, JHII, JHIII). Due to the adsorptive properties and low concentrations of JH, they prove to be difficult to measure. For these reasons, there are currently few JH quantitative studies. This project is concerned with quantifying trace amounts of the JHs in the hemolymph of the dung beetle *Onthophagus binodis*, and to relate JH concentrations to the degree of developmental plasticity observed in this species. Using gas chromatography-mass spectrometry (GC-MS), we developed a reproducible method for quantifying profiles for JHs at picogram levels. Utilizing cold protein precipitation and solvent microextraction, our analytical method allows for effective sampling of 5-10 μL of hemolymph from individual larvae, eliminating the need for pooling hemolymph. This leads to more accurate results when measuring the changes in the JH profiles within and across developmental stages. The method also eliminates the need for derivatization of JH, allowing for high analytical throughput. Whereas many methods developed for other insects test only for the presence of JH III, our method allows for analysis of multiple JHs. Presently, JH I and JH III have been detected in *O. binodis*, with JH I and JH III concentrations fluctuating during larval development. Our data currently suggests that these JH fluctuations in *O. binodis* correlate with known models developed in other insects.
Animals use environmental (visual, auditory, olfactory) and self-movement (vestibular, proprioception, optic flow) cues to maintain spatial orientation. Although disruptions in spatial orientation are frequently associated with acute and chronic neurological disorders, the nature of the processing deficit remains to be determined. The current study uses the organization of rat exploratory behavior under dark conditions to investigate the role of specific areas within the frontal cortex in self-movement cue processing. Control rats (n=6) or rats with damage localized to either the medial frontal (n=6) or orbital frontal (n=6) cortex were placed in a small refuge that provided access to explore a large circular table. Each rat was free to explore the table under dark conditions for an hour. Subsequent to home base establishment, the first five exploratory trips were captured and digitized using the peak motion capture system. Groups did not differ in the amount of time spent in the home base quadrant or the distance traveled during the session; however, damage to the medial frontal cortex disrupted exploratory trip organization. These results will be discussed in the context of a system of structures that mediate self-movement cue processing and implications for understanding spatial disorientation associated with neurological disorders.

While grouping can be an effective anti-predatory behavior, excessive grouping can lead to competition and aggression among conspecifics. Although animals may vary their grouping to match current surroundings and the accessibility of shelter, previous studies disagree on the impact of vegetation and refuge on the social behavior of small, shoaling, fish. Here, we used zebrafish (Danio rerio) to tease apart the effects of recent experience and immediate context, as well as differences in aggression versus shoaling behavior. We found that aggression varied tremendously with experimental context. Zebrafish that had been recently housed in physically-complex habitats showed more aggression than did fish that had experienced primarily-empty surroundings, but the magnitude of this difference depended on the immediate context in which the fish were measured, being mostly apparent when fish were tested in empty arenas. In contrast, we observed no effect of experimental treatment on shoal diameter, and no relationship between aggression and group dispersion. Thus, zebrafish appear to modify their individual aggression flexibly to accommodate current and recent environments, without altering other aspects of group dynamics.
CHARACTERIZING THE HOMOMORPHIC SEX CHROMOSOMES OF Aedes aegypti

M.A. Toups¹, D.W. Severson², L. Zhuo³, M.W. Hahn¹,³
¹Department of Biology, ²School of Informatics and Computing, Indiana University, Bloomington, IN,
³Department of Biological Sciences, University of Notre Dame, Notre Dame, IN

Unlike autosomes, sex chromosomes spend different amounts of time in males and females, which means they likely are hotspots for sexually antagonistic variation. Understanding the genetic content of sex chromosomes may have major implications for understanding what determines sex as well as sexual dimorphism. The generally accepted model of sex chromosomes predicts that the non-recombining region has progressively expanded from only the portion near the sex-determining locus to nearly the full extent of the sex chromosomes, forming heteromorphic sex chromosomes. However, why this progression from homomorphic sex chromosomes occurs in some species and not other remains a puzzling phenomenon. We investigated the mosquito Aedes aegypti, which has had homomorphic sex chromosomes for the last 100-150 million years. The Aedes aegypti genome is comprised of over 4500 scaffolds, with only ~250 scaffolds mapped onto chromosomes. We constructed a high-resolution linkage map using an F6 recombinant population that assigned 60% of the scaffolds to chromosomes. Furthermore, we identified regions associated with the non-recombining portions of the homomorphic sex chromosomes—the proto-X and proto-Y. Interestingly, preliminary analyses of the proto-X and proto-Y regions show no obvious homology, supporting the hypothesis that the non-recombining region is ancient. We explored the genetic content of the proto-X and proto-Y regions, gene movement on and off these proto-sex chromosomes, and sex-biased expression in and around the non-recombining region.

ADAPTATIONS TO LIFE IN THE DARK: THE EFFECTS OF STIMULUS DURATION, INTENSITY, AND CIRCADIAN RHYTHMS ON PHOTORECEPTOR RESPONSES IN THE MADAGASCAR HISSING COCKROACH (Gromphadorhina portentosa)

W.D. Bogue, A.F. Urdiales, E.S. Mantes, A.E. Schirmer, F.R. Prete,
Department of Biology, Northeastern Illinois University, Chicago, IL

The hissing cockroach, Gromphadorhina portentosa, is a large, long-lived insect presumed to live under leaf litter. It is interesting because of its loud hissing, and elaborate behaviors, including "vocalization" accompanied competition and courtship. However, little is known about the neurophysiological bases its behaviors. Our work focuses on how visual system organization relates to animal behavior and ecology. Within that context, we used electroretinograms (ERG) to assess key characteristics of this cockroach's visual system. The ERG is an electrophysiological technique used to ascertain the activity of retina photoreceptors in response to pulses of light. Our research revealed that G. portentosa's ERG consists of four electrophysiological components: (1, 2) transient and sustained ON potentials elicited by light Onset, and (3, 4) transient and sustained OFF potentials elicited by light Offset. Potentials 1, 2 & 4 represent light-induced photoreceptor depolarizations; potential 3 represents repolarization of postsynaptic interneurons. Increasing stimulus duration (100-6500 ms), or intensity did not increase ON potential amplitudes but caused sustained OFF potentials to reach maximum more quickly. The former suggests the cockroach's eye saturates even in low light which would make it functionally blind in bright light. The latter indicates that photoreceptors hyperpolarize very quickly in response to the cessation of bright light. ERGs recorded every 15 minutes for 72 hours revealed ~24hour oscillations in photoreceptor response rates, maximizing their integration times at night. This first analysis of G. portentosa's ERG suggests cellular and physiological changes adapted to life in the dark.
49. Allison Young (ay39@evansville.edu)

**VARIATIONS IN TESTOSTERONE LEVELS, BODY CONDITION AND DISPERAL DISTANCE OF MALE GRAY TREEFROGS (HYLA VERSICOLOR)**

A. Young\(^1\), M. Powell\(^1\), N.M. Gordon\(^1\), M. Hellman\(^2\)

\(^1\)University of Evansville, Evansville, IN, \(^2\)University of Nebraska-Lincoln, Lincoln, NE

Hormones are critical for many physiological functions in frogs, including regulating the reproductive cycle and inducing important behaviors such as mate signaling. By detecting and quantifying these hormones, underlying physiological processes can be further elucidated. We quantified testosterone, a steroid hormone responsible for regulating male behaviors, in gray treefrogs, *Hyla versicolor*. Gray treefrogs are a small, arboreal frog found throughout Eastern North America which spends most of the year dispersed in upland forests several hundred meters from breeding ponds. During the breeding season, females will migrate rapidly to breeding ponds for a single night of oviposition and then disperse back into the forest during the same night. While males may spend a week or more at a breeding pond before exhausting themselves calling for females, it is unclear how rapidly males approach and disperse from these ponds. Although several hormones have been quantified in female gray treefrogs during the reproductive and non-reproductive periods, male gray treefrog hormone levels remain unstudied. If males migrate more slowly toward choruses than females, we would expect that male frogs found closer to breeding ponds would have elevated reproductive steroids relative to males dispersed farther from ponds. We quantified testosterone levels in male treefrogs captured up to 300m from breeding ponds. Levels of testosterone were quantified using enzyme linked assays (ELISA). Here we show how testosterone concentrations correlate with dispersal distance and body condition.

50. Kathleen Zelle (kmzelle@wustl.edu)

**THE GENETICS OF BEHAVIORAL ISOLATION: SENSORY SYSTEMS AND PHEROMONAL COMMUNICATION IN DROSOPHILA**

K. Zelle\(^1\), Tianxin Ku\(^1\), A. Lube\(^1\), A. Hefetz\(^2\), Y. Ben-Shahar\(^1\)

\(^1\)Department of Biology, Washington University, Saint Louis, MO, \(^2\)Department of Zoology, Tel Aviv University, Ramat Aviv, Israel

Many animals produce species and sex-specific mating signals, which are used during sexual encounters to identify potential mates. During courtship, male *Drosophila melanogaster* rely heavily on input from multiple sensory modalities to detect these signals. However, the impact of individual modalities on *D. melanogaster* males’ decision to court conspecifics or heterospecifics is unclear. Using a genetics approach, we aimed to dissect the sensory-based decisions made by the male when faced with interspecific partners from diverse phylogenetic distances. Our data supports the role of gustatory pathways in regulating species behavioral barriers, shedding light on the mechanisms maintaining prezygotic isolation in the *Drosophila* clade. Further, gustatory input is specifically important during sexual decision-making as it allows for tasting of cuticular pheromones of other *Drosophila*. Typically, gustatory receptors (GRs) are located in the proboscis, legs, wing margins, and female ovipositor. However, our data show atypical expression of many GRs in the fly abdomen. We hypothesized that GRs that are expressed in both sensory neurons and abdominal oenocytes may be functioning in both the sensing and production of pheromones. We tested our hypothesis by genetically manipulating the expression of a specific GR gene in the oenocytes to determine the effects on sexual behaviors as well as cuticular pheromone profiles. Presented findings support our above hypothesis and indicate that single chemosensory genes can sustain behavioral barriers across closely related species, and may have played a behavioral role in the process of speciation.
SATURDAY SATELLITE SYMPOSIUM INVITED SPEAKERS

Keynote Speaker: Dr. John Godwin, Associate Professor, North Carolina State University

Dr. Godwin obtained his PhD in Zoology from the University of Hawaii at Manoa in 1992. After lecturing at the University of Texas at Austin, he joined the faculty of North Carolina State University in 1996. In 2000, he was inducted into the Academy of Outstanding Teachers at NCSU, and in 2009 he was honored by the National Academy of Sciences as an Education Fellow in the Life Sciences. Dr. Godwin’s research focuses on molecular endocrinology, neurobiology, neurogenomics, and behavior, with a primary focus on the mechanisms and evolution of animal behavior and sexuality.

Invited Speaker: Dr. Kimberly Rosvall, Assistant Research Scientist, Indiana University

Dr. Rosvall earned her PhD in Biology from Duke University in 2009 studying the evolution of same-sex aggression in female birds. She initially came to Indiana University as an NIH-funded postdoctoral fellow, and she continues on as a research-rank faculty member in the Biology Department. Dr. Rosvall’s research applies techniques and perspectives from behavioral ecology, neuroendocrinology, and functional genomics to answer fundamental questions about the evolution of behavior and to identify the mechanistic basis of behavioral adaptation and acclimation.

Invited Speaker: Dr. Dale Sengelaub, Professor, Indiana University

Dr. Sengelaub completed his PhD in Biopsychology at Cornell University in 1983. He has served on the faculty of the IU Department of Psychological and Brain Sciences for over twenty years, earning such distinctions as the CISAB Exemplar 2009), and the Herman Frederic Lieber Memorial Award for Distinguished Teaching (2010). Dr. Sengelaub studies the processes that regulate the structure and organization of both the developing and adult nervous system. Using a variety of species, neural systems, anatomical, and electrophysiological techniques, he addresses the factors which regulate neuron number, distribution, morphology, and connectivity in the brain and spinal cord.
SATURDAY SYMPOSIUM ABSTRACTS
(in order of presentation)

1. Alan Barker (alanbark@indiana.edu)

EFFECTS OF CHRONIC COCAINE ON REWARD OMISSION EFFECT IN SPRAGUE-DAWLEY RATS

A. Barker¹,², G. Rebec²
¹Department of Psychological and Brain Sciences, ²Neuroscience Program, Indiana University, Bloomington, IN

This project investigated the interaction between the personality trait of urgency and chronic exposure to different doses of cocaine in adult male rats. Particular constellations of personality variables are known to influence risk factors for an individual's susceptibility to drug consumption. Urgency, also known as frustration, predicts addiction liability for an individual and can be assessed using a reward omission testing (ROE) paradigm. There are overlapping neurological circuits and transmitter systems that participate both in the acute effects of cocaine, long-term changes to synaptic and neural morphology resulting from exposure to cocaine. However, the ability of cocaine exposure to modulate expression of urgency is unknown. Rats were given non-contingent administrations of cocaine via i.p. injections in a low (10.0 mg/kg) and high (20.0 mg/kg) dosing regimen for 10 days consecutively. Following drug exposure, rats were returned to their home cages for a two-week period of abstinence. Results indicate that cocaine exposure does indeed produce systematic changes in task-oriented responding in the ROE test in a dose-dependent inverted U-shape curve. Rats receiving the lowest dose of cocaine displayed exacerbated responding to reward omission indicated by a shorter latency to press the lever once presented, and a higher rate of pressing. Data collection occurred on four non-consecutive days, with an effect of day observed, demonstrating that the behavioral effects of cocaine persist for over two weeks, but ultimately attenuate over time. A mechanism to account for this is currently unknown.

2. Jessica Hanson (jeshanso@indiana.edu)

CONTEXT-DEPENDENT FLUCTUATION OF SEROTONIN IN THE AUDITORY MIDBRAIN: THE INFLUENCE OF SEX, REPRODUCTIVE STATE, AND EXPERIENCE

J. Hanson, L. Hurley
Department of Biology, Indiana University, Bloomington, IN

In the face of changing behavioral situations, plasticity of sensory systems can be valuable to facilitate appropriate behavioral responses. In the auditory system, the neurochemical serotonin is an important messenger for context-dependent regulation because it is sensitive to both external events and internal state and it modulates neural activity. Here we show, for the first time in female mice, serotonin increases in the auditory midbrain region, the inferior colliculus (IC) in response to two behavioral contexts: restriction and social contact. We investigated the effects of sex, experience, and estrous state on fluctuation of serotonin in the IC in both of these contexts, as well as potential relationships between behavior and serotonin. Contrary to our expectation, there were no sex differences in serotonergic increase in response to a restriction stimulus. Both sexes had larger increases in second exposures, suggesting experience plays a role in serotonergic release in the IC. In females serotonin increased during both restriction and interactions with males, however the increase was more rapid during restriction. There was no effect of female estrous phase on the serotonergic change for either context, but serotonin was related to behavioral activity in females interacting with males. These results show that changes in context induce increases in serotonin in the IC by a mechanism that appears to be uninfluenced by sex or estrous state, but may depend on experience and behavioral activity. These aspects must therefore drive the neuromodulatory influence of rapid increases of serotonin on auditory processing in the IC.
3. Jeffrey Lucas (jlucas@purdue.edu)

**SIGNALS AND INDIVIDUAL VARIATION IN SENSORY SYSTEMS**

J.R. Lucas, K. Ronald, M. Gall, K. Henry  
Department of Biological Sciences, Purdue University, West Lafayette, IN

The theoretical analysis of mate choice has focused on the evolution of male mating signals. The study of aspects of the receiver's role in the evolution of mating signals has focused on the ability of females to process these signals. Typically female sensory biology is taken as a fixed property of the population. However, individuals are likely to vary, sometimes substantially, in their processing of signals. I will illustrate some of these patterns with results on peripheral processing of auditory signals. This variation in the sensory system can potentially influence our understanding of the evolution of mating signals because sensory variation functionally induces variation in the capacity of a signal to convey information.

4. Invited Speaker: Dale Sengelaub (sengelau@indiana.edu)

**NADS, NEURONS, AND THE NASTY: THE CELLULAR BASIS OF MALE COPULATORY BEHAVIOR**

D.R. Sengelaub  
Department of Psychological and Brain Sciences, Program in Neuroscience,  
Indiana University, Bloomington, IN

The lumbar spinal cord of the rat contains a sexually dimorphic motor nucleus, the spinal nucleus of the bulbocavernosus (SNB). In males, SNB motoneurons innervate muscles of the penis, and control penile reflexes important for copulatory behavior. Androgens act at virtually every level of the SNB system, in development and throughout adult life. The relative simplicity of this neuromuscular system has allowed for considerable progress in identifying the cellular bases for the execution of copulatory reflexes, as well as understanding how changes in these behaviors result from changes in the morphology and function of the SNB motoneurons. In my talk I will describe the specializations in the organization of the SNB system that underlie its unique function, and will further describe several studies from developing and adult male rats demonstrating how changes in the SNB motoneurons drive changes in behavior.
5. Mark Peterson (petersmp@indiana.edu)

NATURAL VARIATION IN GENE EXPRESSION AND TESTOSTERONE PRODUCTION: IMPLICATIONS FOR THE EVOLUTION OF HORMONE-MEDIATED PHENOTYPES

M.P. Peterson¹,², K.A. Rosvall¹,², C.M. Bergeon Burns¹,²,³,⁴, A. Buechlein⁵, D.B. Rusch⁵, E.D. Ketterson¹,²

¹Department of Biology, ²Center for the Integrative Study of Animal Behavior, ⁵Center for Genomics and Bioinformatics Indiana University, Bloomington, IN, ³School of Renewable Natural Resources, Louisiana State University, ⁴AgCenter, Baton Rouge, LA

Testosterone is a key regulator of behavior, physiology, and energy balance. Experimental elevation of testosterone affects fitness and causes a range of phenotypic effects, including reduced immune function, increased aggression, and increased metabolic activity. These effects vary by sex and species, and they appear to be mediated via changes in gene expression. Individual variation in testosterone production (the ability to elevate testosterone in response to a standardized hormonal challenge) is also under selection and related to these same phenotypes. However, it is not clear how individual variation in testosterone production affects gene expression in a natural population, an essential step in understanding how testosterone-sensitive phenotypes are mediated in the wild. Therefore, we sought to identify correlations between testosterone production and gene expression in the liver of dark-eyed juncos (Junco hyemalis) using RNA-seq. We identified 135 genes in males, and 84 genes in females, with expression that co-varied with testosterone production. Many of these genes are associated with known phenotypic effects of testosterone, including immune function, metabolism, and muscle growth. When comparing the sexes, 10 genes were related to testosterone production in the same direction in both sexes, and no genes were related in opposite directions. By applying genomic techniques to a well-studied system, we were able to relate variation in gene expression to the species’ natural history—a foundation we believe is essential to drawing evolutionarily significant conclusions from genomics studies.

6. Ian Hall (ich2105@columbia.edu)

THE XENOPUS AMYGDALA GENERATES SocialLY APPROPRIATE VOCAL RESPONSES TO COMMUNICATION CUES

I.C. Hall¹, I.H. Ballagh², D.B. Kelley¹,²

¹Department of Biological Sciences, ²Program in Neurobiology and Behavior, Columbia University, New York, NY

Social interaction requires that relevant sensory information is effectively collected, classified, and distributed to the motor areas that initiate an appropriate behavioral response. Vocal exchanges, in particular, depend on linking auditory processing to an appropriate motor expression. Because of its role in integrating sensory information for the purpose of action selection, the amygdala has been implicated in social behavior in many vertebrate species. Here, we describe circuits that link hearing and utterance, and examine the role of the central amygdala (CeA) and bed nucleus of the stria terminalis (BNST) in the sensorimotor integration underlying vocal communication in the African clawed-frog, Xenopus laevis. Evidence from tracing with fluorescent dextran amines identifies the CeA as a target for ascending auditory information from the central thalamus and as a major afferent to the vocal pattern generator of the hindbrain. In the isolated (ex vivo) brain, electrical stimulation of the CeA, or the neighboring BNST, initiates bouts of fictive calling. In vivo, lesioning the CeA of males eliminates the appropriate vocal responses to females and broadcasts of female calls. Lesioning the BNST in males produces an overall decrease in calling behavior. Taken together these results suggest that the CeA serves as a site of sensory integration that initiates socially appropriate vocal responses to female cues, while the BNST plays a broader role in vocal initiation.
MECHANISMS OF A CRITICAL PERIOD: MAINTENANCE OF MUSCLE ERα PERMITS ESTRADIOL-DEPENDENT DENDRITE GROWTH IN A SEXUALLY DIMORPHIC NEUROMUSCULAR SYSTEM

L.M. Rudolph, D.R. Sengelaub
Department of Psychological and Brain Sciences, Program in Neuroscience, Indiana University, Bloomington, IN

The spinal cord of rats contains the sexually dimorphic, steroid-sensitive, motoneurons of the spinal nucleus of the bulbocavernosus (SNB). These motoneurons innervate penile musculature and control copulatory reflexes. The expression of these reflexes is dependent on SNB dendritic morphology. The development of SNB dendrites requires gonadal hormones. Estrogenic action at the target muscle supports SNB dendrite growth during a postnatal critical period, a period coincident with the transient expression of estrogen receptor α (ERα) in the muscle. During normal development, muscle ERα downregulates after postnatal day 21 (P21), closing the critical period, and making SNB dendrites insensitive to estradiol. Early castration prevents the developmental downregulation of muscle ERα, so we tested the hypothesis that the castration-induced maintenance of ERα would result in estrogen-dependent dendrite growth outside of the critical period. Male rats were castrated on P7 and left untreated or treated with estradiol from P28 to P49; a separate group of males was castrated on P28 and treated with estradiol through P49. SNB dendritic lengths were assessed at P49 and compared to those of intact males. Dendritic lengths of untreated castrates were reduced compared to intact males. Males castrated at P28 and treated with estradiol after the critical period had dendritic lengths that were not different from those of untreated castrates. When muscle ERα was preserved by early castration, estradiol treatment resulted in normal dendritic lengths. These data demonstrate that the castration-induced prevention of ERα downregulation allows estrogen-dependent SNB dendrite growth outside of the critical period.

MECHANISMS OF BEHAVIORAL ADAPTATION AND ACCLIMATION: IDENTIFYING PRESSURE POINTS OF SELECTION BY COMPARING ACROSS LEVELS OF BIOLOGICAL ORGANIZATION

K.A. Rosvall1, C.M. Bergeon Burns2, E.D. Ketterson1
1Department of Biology, Indiana University, Bloomington, IN, 2School of Renewable Natural Resources, Louisiana State University, Baton Rouge, LA

Plastic or evolved behavioral responses are thought to be one of the primary ways by which animals respond to environmental change, but it is not entirely clear how these behavioral mechanisms evolve. In particular, the steroid hormone testosterone regulates many traits and behaviors that are integrally linked with survival and reproductive success, and thus, this hormone is thought to play a central role in phenotypic evolution. Furthermore, because individual variation is the raw material of evolution, understanding sources of individual differences in testosterone and testosterone-mediated traits is a key step in understanding the evolution of these phenotypes. Our work seeks to identify the degree to which individual differences in testosterone-mediated behaviors are the consequence of individual variation in hormone production, hormone sensitivity, or some combination of the two. We further seek to identify whether these mechanisms of behavior are conserved as populations diverge, and whether subspecies differences in hormones and behavior represent plastic or evolved responses. In this talk, we summarize recent studies on the dark-eyed junco (Junco hyemalis) that compare different subspecies measured in the field and in a common garden. Specifically, we examine linkages between testosterone levels, testosterone-mediated behavior (aggression), and gene expression for steroid binding and processing molecules in the brain and gonads. By contrasting variation at the intra- and inter-population levels, our data shed light on the ‘pressure points’ of selection and the degree to which current and past evolutionary processes proceed via the same mechanisms.
9. Ryan Paitz (rpaitz@illinois.edu)

CHARACTERIZING THE CONVERSION OF YOLK ESTRADIOL TO ESTROGEN SULFATES DURING EMBRYONIC DEVELOPMENT IN THE RED-EARED SLIDER

R. Paitz, R. Bowden
School of Biological Sciences, Department of Animal Biology, Illinois State University, Bloomington, IL

In the red-eared slider turtle (*Trachemys scripta*), the process of sex determination is estrogen sensitive, with the application of exogenous estradiol resulting in the production of female hatchlings. Because the sex of developing embryos is estrogen sensitive in this species, we have been investigating the role that maternally derived estradiol may play in sex determination. We have previously demonstrated that early in development, exogenous estradiol is metabolized via sulfonation to several estrogen sulfate metabolites. Additionally, the application of exogenous estradiol sulfate to developing eggs influences sex determination in much the same manner as estradiol itself. This study examined the metabolic fate of endogenous estradiol by measuring maternally derived estradiol at oviposition and comparing those levels to levels of estrogen sulfates (estradiol sulfate, estrone sulfate, and estriol sulfate) both at the time of oviposition and after 20 days of development. We found that estrone sulfate was the only detectable estrogen sulfate and that levels increased over the first 20 days of development. Also, clutches that had higher estradiol levels in the yolk had significantly higher estrone sulfate levels at both day 0 and day 20. Together these data suggest that maternally derived estradiol is converted to estrone sulfate during development. We are currently investigating the effect of estrone sulfate on sex determination.

10. Alejandro Velez (avelezme@purdue.edu)

SEASONAL VARIATION IN AUDITORY PERFORMANCE IN THREE SONGBIRDS

A. Valez, M.D. Gall, J.R. Lucas
Department of Biology, Purdue University, West Lafayette, IN

Seasonal variation in morphological and behavioral traits associated with song production is well documented for songbirds. In contrast, we know little about potentially parallel seasonal changes in auditory performance. Here, we tested for seasonal variation in auditory processing in three species of songbirds: Carolina chickadees (*Poecile carolinensis*), tufted titmice (*Baeolophus bicolor*), and white-breasted nuthatches (*Sitta carolinensis*). We used three classes of auditory evoked potentials to measure three properties of the auditory system. The auditory brainstem response (ABR) to tone bursts revealed relatively lower overall auditory sensitivity in Carolina chickadees than in the other two species, and increased sensitivity in white-breasted nuthatches during the spring compared to the winter. The capacity of the auditory system to phase-lock to the fine temporal structure of a sound, as measured by the frequency following response (FFR), appears to improve in white-breasted nuthatches during the spring, compared to the winter. Finally, the envelope following response (EFR), a measurement of the ability of the auditory system to follow changes in amplitude over time, revealed higher sensitivity and less variation across seasons in white-breasted nuthatches. Our results suggest that peripheral auditory processing of songbirds changes seasonally in parallel with behavioral traits such as song production. Possible mechanistic and functional explanations for these results are discussed.
The study of sex differences has produced major insights into the organization of animal phenotypes and the regulatory mechanisms generating behavioral variation from similar genetic templates. Coral reef fishes display an extraordinary diversity of sexual expression including simultaneous hermaphroditism and functional, socially controlled sex change. These systems provide powerful models for understanding gonadal and non-gonadal influences on behavioral and physiological variation. We work with a species, the Caribbean bluehead wrasse (*Thalassoma bifasciatum*) that exhibits female-to-male functional sex change and discrete alternate male mating phenotypes. This talk will focus on transduction of social cues into reproductive responses by sex-changing female wrasses, how patterns in bluehead wrasses may relate to similar patterns in diverse range of fishes that display alternate mating phenotypes, and how we are using genomic approaches to understand the development and evolution of these sexual phenotypes.