# TALK ABSTRACTS

## 2022 ANIMAL BEHAVIOR CONFERENCE

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Organized alphabetically by presenter last name. Presenter last names are shown in bold.

### 'THE MEDICINE OF LIFE': SOCIAL LIFE AND SURVIVAL IN WILD PRIMATES

Susan C. **Alberts**
*Departments of Biology and Evolutionary Anthropology, Duke University*

For social species, including humans and many nonhuman primates, the link between social environments and survival is strong and pervasive. How and why the environment gets 'under the skin' to affect survival is therefore of central interest in biomedical research, but can be difficult to research in humans because of our long lifespan and many environmental and behavioral confounds. Here, I synthesize recent research on baboons (*Papio cynocephalus*) in the Amboseli basin in southern Kenya to identify key aspects of the social environment that affects survival. I describe how both early life environments – including social, parental, and ecological influences – and adult social experiences – including social status and affiliative social relationships – are linked to adult and immature survival in this population. I also demonstrate a strong link between adult lifespan and elevated glucocorticoids (GCs), a biological marker of 'stress.' In doing so I demonstrate that studies of wild primates, which frequently generate prospective, longitudinal data across the full life course, are uniquely positioned to shed light on the evolutionary history and mechanistic underpinnings of biological and social processes that affect health.

### DETERMINING THE FUNCTIONAL ROLE OF DIFFERENT ELEMENTS OF COLOR IN PARENT-OFFSPRING INTERACTIONS IN HOUSE SPARROW NESTS

Shana **Border** and Matthew Dugas
*School of Biological Sciences, Illinois State University*

As part of their begging display, many young birds display ornamental coloration. In passerine nestlings, these colors are especially noticeable on mouthparts. Both among and within species, the coloration of the rictal flange tissue that outlines the passerine gape is variable in "yellowness", a feature reflecting the carotenoid content of tissue, richness in the ultraviolet (UV) wavelengths, and in the overall amount of light it reflects, or brightness. By experimentally manipulating the coloration of flange tissue in nestling house sparrows (*Passer domesticus*), we tested two hypotheses for the evolution of nestling mouth colors: that they maximize visual conspicuousness to parents, and that they signal information about nestling quality. Larger house sparrow nestlings display yellower flanges and, once the effects of carotenoids are accounted for, brighter flanges, but there is no information about size contained in UV-richness. Parents preferentially allocated feedings to offspring

manipulated to appear yellow, but this feature had no discernable effect on parents' ability to deliver prey quickly. Parents did not bias food deliveries with respect to manipulations of brightness or UV-richness, and while UV-richness had no effect on parents' ability to deliver prey, brightness did when prey were large. Overall, these results suggest that carotenoid-richness evolved to signal quality, whereas the selective pressure on tissue brightness was primarily parental prey transfer, and UV coloration may simply be a by-product of tissue structure, at least in this bird.

## THE HONESTY OF BEGGING IN A PARTIAL BEGGING SYSTEM

Olivia L. **Brooks**, Evan N. Talbott-Swain, and Matthew B. Dugas
*School of Biological Sciences, Illinois State University*

Offspring solicitations (begging) are hypothesized to evolve to communicate private information about how an offspring might benefit from parental investment. Such 'honest begging' hypotheses have primarily been studied in altricial birds, where offspring are entirely dependent on parents. Additional insights about the initial evolution of begging can be gained by studying partial begging systems, in which offspring beg for food from parents, but can also self-feed. Most larval poison frogs forage within their nurseries, but in some species, mothers provide unfertilized trophic eggs to their developing young. While egg-feeding is obligate in some lineages, in others tadpoles both self-feed and beg for food. We tested hypotheses about what information is contained in tadpole begging displays in one such partial beggar, *Ranitomeya imitator*, by experimentally manipulating tadpole condition and assaying begging. Although tadpoles in the two groups were drastically different in condition, their begging displays did not differ. This suggests that *R. imitator* begging contains information about something other than condition, perhaps simply alerting parents to their presence. Future work will test for other sources of information R. imitator parents might use to make decisions about within-brood food distribution, shedding light on the origins of offspring-parent communication.

## HAEMOSPORIDIANS CO-INFECTION AND PARASITEMIA EFFECT IN A POLYMORPHIC SPECIES: EFFECT ON REPRODUCTIVE STRATEGIES

Zoé **Delefortrie**[1,2], Hugo Gante[1,2,3,4], Oscar Gordo[5], Kristopher Schwab[1,2], and Rusty Gonser[1,2]
*[1]Departement of Biology and [2]The Center for Genomic Advocacy, Indiana State University; [3]Department of Biology, KU Leuven; [4]Royal Museum for Central Africa, Tervuren; [5]Catalan Ornithological Institute*

Host-parasite interactions play a significant role in evolutionary mechanisms by generating high genetic diversity. Parasite infections impose fitness costs that can trigger host changes in reproductive strategies to assure the best reproductive output possible. Individuals can either invest in parasite defense such as immune system stimulation or perform terminal investment. In this study, I have investigated how haemosporidians co-infection and parasitemia influences reproductive strategies in white-throated sparrows, *Zonotrichia*

*albicollis*. I have tested the effect of co-infection and parasitemia on reproductive success (fledgling number, extra-pair paternity, ratio social/genetic offspring) and the effect of parental infections on nestling quality (mean nestling growth rate and body condition). I found that co-infection increased mean nestling body condition. On the other hand, parasitemia negatively impacted the chances to acquire extra-pair paternity and increased the social/genetic offspring ratio. Furthermore, parental parasitemia levels had mixed effects on nestling quality. I observed that high parasitemia in fathers could potentially trigger a switch in reproductive strategy towards a terminal investment. In contrast, females' high parasitemia did not trigger a switch in reproductive strategy. These intriguing results suggest differences between white-throated sparrows' sexes reproductive strategies in response to parasitemia.

## DOES INCURRING A COST INFLUENCE HELPING BEHAVIOR IN RATS?

Caroline Driscoll and Lee Dugatkin
*Department of Biology, University of Louisville*

Although there is substantial evidence of empathy in nonhuman animals, only recently have more sophisticated empathetic abilities, such as targeted helping behavior, been studied. In previous studies of rats, freeing a distressed cagemate had little cost associated with it; our study aimed to expand our understanding of empathy and helping behavior by adding a cost to the act of releasing a trapped cagemate, to determine if helping behavior is tempered by such a cost. This new dimension to a cost-benefit approach to prosocial behavior in nonhumans will further our understanding of potentially empathetically motivated behavior, from both evolutionary and psychological perspectives. In our study a restrainer containing a trapped rat was placed at one end of an arena. The restrainer had a door that can only be opened from the outside. The trapped rat's cagemate was then placed in the arena, free to roam, and with access to a tunnel leading to an escape area where the distress cues of the trapped rat are greatly minimized. Rats do not like to cross cold, shoulder-deep water, and so to add a cost to targeted helping, a cold-water barrier separating the free rat from the restrainer was added to some of our treatments. Free rats were tested in one of four groups: (1) trapped cagemate separated by water barrier (2) trapped cagemate and no water barrier, (3) empty restrainer separated by water barrier and (4) empty restrainer and no water barrier. Door-opening frequencies were significantly greater when the restrainer contained a distressed cagemate compared to when the restrainer was empty, suggesting a trapped cagemate motivates door-opening behavior. Door-opening frequencies were similar during trapped cagemate conditions in the (1) cost and (2) no cost treatments, suggesting an added cost does not disrupt helping behavior and that a distressed cagemate is sufficiently motivating to stimulate helping behavior even when it poses a personal cost to the helper.

## ABSENCE OF ANTI-PARASITIC REFERENTIAL ALARM CALLS IN THE GALAPAGOS YELLOW WARBLER POPULATION ALLOPATRIC FROM OBLIGATE BROOD PARASITES

Facundo **Fernandez-Duque**[1], Shelby L. Lawson[2], Janice K. Enos[2], Sharon A. Gill[3], Sonia Kleindorfer[4], and Mark E. Hauber[2]

*[1]Program in Ecology, Evolution, and Conservation Biology and [2]Department of Ecology, Evolution, and Behavior, University of Illinois Urbana-Champaign; [3]Department of Biological Sciences, Western Michigan University; [4] Konrad Lorenz Research Center for Behaviour and Cognition, University of Vienna*

Yellow Warblers (*Setophaga petechia*) use referential seet calls to warn of nearby brood parasitic Brown-headed Cowbirds (*Molothrus ater*). Seet calls are produced primarily when brood parasitism risk is highest, specifically during egg laying and incubation stages, and rarely when parasitism risk is low. Additionally, past research suggests that the ability to understand and respond to this signal is cowbird-experience dependent (e.g., prior breeding exposure or geographic overlap with cowbirds). Here we tested whether the Galapagos subspecies of yellow warbler (*Setophaga petechia aureola*), which has been geographically isolated from brood parasites for ~300,000 years, retains the ability to produce and respond to referential seet calls. We presented playbacks of Brown-headed Cowbird calls (brood parasite), seet calls (referential anti-parasitic call), chip calls (general alarm call), predator calls (Short-eared Owl, *Asio flammeus*; Smooth-billed Ani, *Crotophaga ani*, nest predator) and controls to breeding Yellow Warbler pairs and compared behavioral and vocal responses between treatments and between mainland North American vs. Galapagos playbacks. We found that Galapagos Yellow Warblers showed lower aggression to playbacks signaling brood parasitic risk (seet and cowbird calls) compared to other experimental treatments, and compared to responses of mainland warblers. Critically, Galapagos Yellow Warblers never produced any seet calls in response to playbacks. Our results suggest that in geographic isolation from cowbirds, Galapagos Yellow Warblers no longer use or recognize referential alarm calls indicating brood parasitic nest threats.

## EFFECTS OF CORN GROWN ON DREDGE-AMENDED SOIL ON HIPPOCAMPAL DEVELOPMENT AND BEHAVIOR

Kaylyn A.S. **Flanigan**[1], Megan A. Rúa[2], and Jari G. Willing[1]

*[1]Department of Psychology, Bowling Green State University*; *[2]Department of Biological Sciences, Wright State University*

Lake Erie is dredged of 1.5 million tons of sediment yearly. Historically this sediment has been disposed of into open waters; however, in effort to decrease sediment in the lake, the passage of Senate Bill 1 requires alternate disposal of the dredged material as of 2020. The Ohio Environmental Protection Agency (OH EPA) has proposed alternative disposal techniques, one of which is fertilizer for agricultural fields. Dredge material contains nutrients and organic matter which would encourage crop growth; however, this material also contains what the OH EPA refers to as contaminants of concern (COC) in the form of organic contaminants and heavy metals. Crops grown on this material may be used as

animal feed and eventually introduced into human food sources. The implications of bioaccumulation of COC via trophic transfer have not been evaluated. These toxins, including heavy metals, polychlorinated biphenyls, and polycyclic hydrocarbons, impact development especially when exposed during critical periods. Foundational processes of neurodevelopment have been shown to be impacted by such chemicals. Impediments in essential neurodevelopmental processes have broad effects on behavior including anxiety, learning, and memory. To investigate potential behavioral and neurodevelopmental effects, corn grown on the dredged-amended sediment was added to female rats' diet throughout pregnancy and lactation. Following pup weaning, behavioral tests measuring anxiety, learning, and memory were conducted to assess COC-exposure's effect on behavior. The brain area associated with learning and memory, the hippocampus, was collected and stained to quantify regional volume in effort to evaluate exposure to COCs on brain development. Results indicate both behavioral and neural differences exist in subjects perinatally exposed to COCs via corn grown on dredge material. Namely, increased anxiety-like and/or decreased exploratory behavior and reduced hippocampal volume.

## BY LAND OR BY SEA? ORIENTATION AND NAVIGATION BY RIPARIAN LONG-JAWED ORB WEAVERS (*TETRAGNETHA ELONGATA*) WHEN DISPLACED ONTO WATER

Brian G. Gall, Sidney J. Goedeker, Nettie A. Eigel, and Theresa E. Wrynn
*Department of Biology, Hanover College*

An organism's ability to identify goals within their environment, orient towards those goals, and successfully navigate to them are critical to all aspects of survival. We conducted a series of studies to describe and understand the mechanisms of orientation behavior in riparian Long-jawed orb weavers (*Tetragnetha elongata*). Displacement experiments indicate that spiders seek to minimize time on the water's surface and conduct circular orientation behaviors to identify shoreline and achieve rapid zonal recovery. Despite published assumptions of poor vision, spiders were able to identify shoreline even at distances of 3m. Occlusion experiments indicate vision is critical to this orientation, while additional experiments shed light on the input stimuli used in orientation and the source of selection driving this behavior. These results describe a previously unknown suite of orientation behavior in these riparian spiders and provide clues as to the proximate and ultimate drivers of orientation and navigation in these spiders.

## EFFECT OF CESAREAN SECTION ON MICROGLIA AND THE GUT MICROBIOME IN SIBERIAN HAMSTER OFFSPRING

Elizabeth A. Morrison[1,2,3], Jessica Deyoe[1], M. Liu[1], Luke Gohmann[1], J. Boice[1], Cara Wellman[2,3,4], Irene Newton[1], and Greg Demas[1,2]
*[1]Department of Biology, [2]Center for the Integrative Study of Animal Behavior, [3]Program in Neuroscience, and [4]Department of Psychological and Brain Sciences, Indiana University*

During vaginal birth, infants are exposed to vaginal and fecal microorganisms. However, in cases of cesarean section (c-section) delivery, this transfer of microbes from mother to infant is disrupted. Infants delivered via c-section have a different gut microbiome composition, lower gut bacterial diversity, and are at higher risk for immune-related diseases later in life than infants born vaginally. In a process termed vaginal inoculation, some medical professionals are exposing newborns to vaginal microorganisms from mother following c-section delivery. However, it is unknown if vaginal inoculation puts infants at higher risk for relevant infections, and the physiological and immune consequences of post-cesarean section vaginal inoculation are understudied. In the present study, we investigate the potential consequences of vaginal inoculation on c-sectioned neuroimmune cells and gut microbiome composition using Siberian hamsters (*Phodopus sungorus*). C-section and vaginally-born male and female offspring were inoculated with maternal vaginal samples. At one week of age, the quantity and morphology of microglia were measured in the corpus callosum and hippocampus, alongside cecal gut microbiome composition. Our study investigates the gut-brain relationship from vaginal inoculation in an animal model, and provides preliminary insight to how bacteria may mediate early postnatal development in babies.

## SEX-SPECIFIC REGULATION OF STEROIDOGENIC ENZYMES AND SEASONAL AGGRESSION IN SIBERIAN HAMSTERS

Kathleen M. Munley[1,2], Jonathan C. Trinidad[3], and Gregory E. Demas[1,2]
*[1]Department of Biology, [2]Center for the Integrative Study of Animal Behavior, and [3]Department of Chemistry, Indiana University*

Coordinating physiological and behavioral processes across the annual cycle is essential in enabling individuals to maximize fitness. While the mechanisms underlying seasonal reproduction and its associated behaviors are well-characterized, fewer studies have examined the neuroendocrine processes that control non-reproductive social behaviors (e.g., aggression) on a seasonal timescale. Our previous work suggests that melatonin, dehydroepiandrosterone (DHEA), and neurosteroids are important in regulating non-breeding aggression in Siberian hamsters (*Phodopus sungorus*); it is unclear, however, what the relative roles of adrenal and neural steroids are in contributing to aggressive behavior and if the importance of these pathways differs between males and females. In this study, we housed male and female hamsters in long days (LDs, characteristic of breeding season) or short days (SDs, characteristic of non-breeding season), administered timed melatonin (M) or control injections, and quantified aggression after 10 weeks of treatment. Following behavioral testing, we measured the activity of 3β-hydroxysteroid dehydrogenase (3β-HSD), an enzyme that catalyzes the conversions of pregnenolone to progesterone and DHEA to androstenedione, in the adrenal glands and two brain regions associated with aggression [anterior hypothalamus (AH) and periaqueductal gray (PAG)] via liquid chromatography-mass spectrometry. Although both males and females displayed increased aggression in response to melatonin and SDs, only males showed an increase in adrenal 3β-HSD activity. In contrast, LD-M and SD females exhibited reductions in 3β-HSD activity in the adrenal

glands and AH. There were no seasonal differences in 3β-HSD activity in the PAG in either sex. Collectively, these results suggest a potential role for 3β-HSD in modulating non-breeding aggression and, more broadly, demonstrate how distinct neuroendocrine mechanisms may underlie the same behavioral phenotype in males and females.

## CARRYOVER EFFECTS IN FIELD-CAUGHT POLYPHENIC SPADEFOOT TOADS

Dante J. **Nesta**, Sarah R. Lagon, and Cris C. Ledón-Rettig
*Department of Biology, Indiana University*

Environmental stressors experienced during early development can have lasting effects on individual phenotypes, carrying through to adulthood. Spadefoot toads in the genus *Spea*, which exhibit a larval resource polyphenism – the environmentally sensitive development of discrete and alternate morphs exhibiting different resource use – are no exception. In the absence of inducing cues, *Spea* larvae (*i.e.*, tadpoles) develop into omnivores that feed on detritus, a characteristic of the ancestral condition. Larvae faced with stressful conditions, such as an alternative diet consisting of live prey, rapid pond drying, and increased competition, may develop into carnivores. The carnivore morph is characterized by integration of a suite of morphological, physiological, and behavioral traits, producing a predator capable of hunting live macroscopic prey, including fairy shrimp and even conspecific larvae. A previous study working with laboratory-bred *Spea bombifrons* found that larval diet type and amount influenced juvenile physiology and behaviors. Laboratory-bred individuals can provide useful insight into such phenomena, but these patterns may not necessarily reflect the environmental complexity of natural habitats. We collected *S. bombifrons* carnivore and omnivore larvae from their natal ponds in the southwestern United States and reared these animals under common conditions through metamorphosis to assess carryover effects of the larval polyphenism on juvenile phenotypes. Juvenile frogs were assayed for prey acquisition and jumping abilities as well as stress-induced levels of circulating corticosterone. Our data demonstrate that larval morph induction influences juvenile behaviors which may affect the fitness of recently metamorphosed frogs. This research provides a foundation for determining how carryover effects influence fitness in natural populations and how they may evolve across populations exhibiting varying degrees of developmental plasticity.

## GENOME WIDE ASSOCIATION STUDY OF SUGAR-BASED COMPENSATORY FEEDING IN *DROSOPHILA*

Mubaraq **Opoola**[1], Makayla Wright[2], Sarayu Alli[1], Nick Wright[1], and Dae-Sung Hwangbo[1]
*[1]Department of Biology, University of Louisville, [2]Department of Biology, Northern Kentucky University*

Sugar is a key part of the daily diet, and it is often a contributing factor to many metabolic disorders such as diabetes, cancer etc. Understanding the genetic mechanism for sugar consumption-based feeding is critical to combating the metabolic disorders because not so much is known in terms of genetic factors controlling sugar-based feeding. The goal of this

study is to find gene(s) and pathways linked to sugar consumption by employing Genome Wide Association Study (GWAS) in 180 Drosophila Genetic Reference Panel (DGRP) strains as a model organism. For 7 days, each of the DGRP lines was fed 5% (low) and 20% (high) sugar diet with an equivalent amount of other ingredients. Using the modified Con-Ex test to measure food consumption, most of the lines tested so far displayed compensatory feeding with different degree of variation among the lines in response to the two sugar diets ingested over the 7-day period. Using the phenotypic data for GWAS, we were able to map quantitative trait loci for sugar dependent feeding behavior and found some candidate genes linked to high sugar-based compensatory feeding. These discoveries provide information on the genetics involved in sugar-based feeding in the body, as well as how it can be controlled to accommodate various health situations.

## DO *DROSOPHILA MELANOGASTER* FEMALES CHANGE THEIR SPERM USE PATTERNS IN RESPONSE TO PERCEIVED CHANGES IN MALE QUALITY?

Brooke **Peckenpaugh** and Leonie Moyle
*Department of Biology, Indiana University*

In addition to premating choices, females that mate multiply make postcopulatory choices about which sperm fertilize their eggs (cryptic female choice). However, it remains unclear how females make these choices, and what impact they have on female fitness. In this study, we test whether *Drosophila melanogaster* females adjust their sperm use patterns in response to altered precopulatory indicators of male quality—male pheromones—even when male postcopulatory contributions remain the same. To do this, we manipulated male pheromones to resemble either heterospecific (*D. yakuba*) males—thereby reducing their perceived quality as a mate—or to resemble their own genotype (as controls). We compare second male paternity (proportion of offspring sired) between treatment vs control males by mating each with females that have previously mated with a GFP-labelled tester genotype. We find that females of some genotypes use proportionally less sperm from males that are perceived as lower quality mates, suggesting that *Drosophila* females may make adaptive choices about sperm use based on precopulatory indicators of male quality.

## COOPERATION AMONG COLONY MEMBERS ROLE OF INDIVIDUALS WITHIN THE CONTEXT OF FORAGING IN THE NAKED MOLE-RAT

Alexander **Pergams**[1], Joel Brown[1,2], and Thomas Park[1]
[1]*Department of Biological Sciences, University of Illinois at Chicago;* [2]*Integrated Mathematical Oncology, Moffitt Cancer Center*

Naked mole-rats are one of the only eusocial mammals, and thus are assumed to have group-oriented behavior similar to that of eusocial insects. In the context of foraging, naked mole-rats should sacrifice individual foraging opportunities and subject themselves to increased predation risk for the benefit of the colony. However, unpublished data has suggested that unlike other (less social) rodents, naked mole-rats may be unwilling or

unable to share information regarding the location of high-quality food patches. I measured giving-up densities (the amount of food left behind in a patch after a period of foraging) in food patches of varying spatial scales and took video of marked individuals within foraging arenas. My objectives were to 1) determine If naked mole-rats successfully share information about high quality food patches, 2) to determine if foraging is delegated to a few individuals or more evenly spread among colony members, and 3) to determine if there is a correlation between size (and thus rank) of an individual and time spent foraging.

## LABORATORY HOUSING AFFECTS PUBERTAL ONSET, ANXIETY-LIKE BEHAVIOR, AND OBJECT INTERACTION IN LONG EVANS RATS

Victoria R. Riesgo, Meghan E. Vogt, Kaylyn A.S. Flanigan, and Jari G. Willing
*Department of Psychology, Bowling Green State University*

Animal research facilities utilize a variety of different environmental protocols to humanely house laboratory rodents. However, many components of these housing environments, including bedding, diet, water bottles, and cage material, can inadvertently expose rodents to increased levels of endocrine-disrupting compound (EDCs), which can have lasting effects on many commonly assessed physiological and behavioral endpoints in rodent research assessed physiological and behavioral endpoints in rodent research. The present study compares the effects of two commonly used husbandry protocols for male and female Long Evans rats on body weight, pubertal onset and a battery of behavioral tests measuring activity, anxiety-like behavior and cognition. The first group was raised in a comparatively high-EDC environment (standard rodent chow, plastic cages, plastic water bottles, corn cob bedding), while the other group was raised in a relatively low-EDC environment (phytoestrogen-free chow, polyethylene cages, glass water bottles and wood-chip bedding). Compared to those in the high-EDC group, animals raised in the low-EDC environment reached pubertal onset earlier, displayed reduced anxiety-like behavior in an elevated plus maze and open field test, and displayed less overall object exploration in a novel object recognition task. Importantly, the effects of the different environmental conditions were only observed when animals were housed in them throughout development, as an acute environmental switch from one condition to the other in adulthood did not yield significant differences. These results provide further evidence for the role of commonly used animal housing environments on development and behavior, and importantly, highlight the significance of reporting husbandry conditions in literature to promote reproducibility in sciences using animal subjects.

## BEHAVIORAL SEX DIFFERENCES CAUSED BY DISTINCT VASOPRESSIN SOURCES

Nicole Rigney
*Neuroscience Institute, Georgia State University*

The neuropeptide arginine-vasopressin (AVP) has long been implicated in the regulation of social behavior and communication, often sex-specifically, but the source of AVP release

relevant for behavior has not been precisely determined. AVP cells in the bed nucleus of the stria terminalis (BNST) are a major source of sex-different AVP in brain regions associated with social behavior. However, other sources, such as the paraventricular nucleus of the hypothalamus (PVN), release AVP to similar brain regions. Consequently, to define the behavior-relevant sources, I used targeted genetic approaches (cell ablations, shRNA, optogenetics) that demonstrated AVP within the BNST regulates male social investigation and male-typical communicative behavior. In contrast, PVN AVP cells regulate social investigation by females, but not males, and anxiety-like behavior by males, but not females. BNST AVP cells provide several brain regions, such as the dorsal raphe and lateral habenula, with dense, sexually dimorphic AVP innervation, and after blocking vasopressin receptors (V1aR) in these regions, male, but not female social communicative behaviors were impaired. Finally, using a rabies tracing strategy, we established that BNST AVP cells receive strong inputs from areas known to regulate social behaviors, such as preoptic area and/or are enriched with V1aR or AVP. Our findings indicate that AVP in the BNST plays a larger role in controlling social behavior in males than in females, whereas females use different AVP cell circuitry (PVN) for regulating social behavior. This work suggests that sex differences in the neurochemical underpinnings of behavior may contribute to sex differences in disorders of social behavior and communication.

## EFFECTS OF AGE ON THE SPATIAL ORGANIZATION OF OPEN FIELD BEHAVIOR IN FEMALE RATS

Ericka Schaeffer[1], Jenna Osterlund Oltmanns[1], Ashley Blackwell[1], Rachel Einhaus[1], Gwendolyn Kartje[2,3], and Douglas Wallace[1]

*[1]Psychology Department, Northern Illinois University; [2]Loyola University Health Sciences Division; [3]Edward Hines Jr. Veterans Affairs Hospital, Research Service*

Developmental changes in neuroplasticity have been implicated in the age-related decline in performance observed on spatial tasks. Previous work has shown the organization of movement around an established home base, a discrete location where an animal frequently stops, is dependent on hippocampal and vestibular function. Although pathology within the brain occurs throughout natural aging, its effects on home base behavior has yet to be evaluated across age. The current study characterized the organization of 3-month (n=7) and 10-month (n=7) old female Long Evans rats' behavior in a circular open field apparatus for 40 minutes under dark conditions. Twenty minutes of dark open field movement was segmented into sequences of stops and progressions to derive measures of general locomotion, progression path circuity, and stop clustering to evaluate home base stability. While 10-month rats were more hyperactive and made more circuitous progressions, dependent on path length, relative to 3-month rats, home base stability remained consistent across both age groups. These results support age related decline in tasks dependent on spatial processing occurring earlier in development than previously anticipated, as majority of the work characterized developmental changes in elderly models (18-24 months). Future work is needed to evaluate if differences in performance can be attributed to neural systems that support this processing, such as the vestibular apparatus, basal forebrain hippocampal system, or cortex.

## CURRENT AND POTENTIAL FINDINGS ON SPECIES DIVERSITY IN THE GENETIC AND NEUROENDOCRINE REGULATION OF SEXUALLY DIMORPHIC COMMUNICATION IN ELECTRIC FISH

G. Troy Smith
*Department of Biology and Center for the Integrative Study of Animal Behavior, Indiana University*

Communication signals used in courtship or combat can vary dramatically across the sexes. In vertebrates, gonadal hormones often regulate sex-related variation in communication. Comparative studies in several model systems have explored the neuroendocrine mechanisms regulating sex differences in communication. One of the most tractable systems for examining mechanisms of sex differences at multiple levels of analysis is the neural circuitry controlling the production and perception of electric communication signals in South American knifefishes. The weak electric signals produced by these fishes' electric organs are detected by sensitive electroreceptors that allow the fish to perceive their surroundings in dark, murky water. The fish can also detect electrical signals of other fish and can thus use these signals to communicate species identity, sex, social rank, and/or motivation. Electric communication signals of electric fish are well-suited to examine mechanisms of sex differences because (1) they are easy to record and analyze; (2) in many species, they vary across and/or within sexes; (3) sex-related variation in the signals is regulated by androgens and/or estrogens; (4) the neural circuit that controls the signals is discrete and relatively simple; and (5) closely related species vary substantially both in signal structure and in the sex-related variation of their signals. In this talk, I will describe how the activity of brainstem and spinal cord neurons controls the properties of electric communication signals, how hormones regulate sex differences in the signals, and how within- and across-species variation in sensitivity to hormones contributes to variation in sex differences. Finally, I will describe recent work in my laboratory that examines how species differences in the expression of genes that mediate hormone action and of genes that influence neuronal excitability are linked to species and population differences in sexually dimorphic communication.

## PHENOTYPIC PLASTICITY IN RESPONSE TO CONSPECIFIC CUES IN POISON FROG TADPOLES

Lisa Surber and Eva Fischer
*Department of Evolution, Ecology, and Behavior, University of Illinois Urbana-Champaign*

An essential challenge for all animals is to respond appropriately to environmental cues. For cannibalistic dyeing poison frog (*Dendrobates tinctorius*) tadpoles, conspecific cues present a unique conflict at the intersection of predation, competition, and nutritional resources. The goal of this project was to understand phenotypic differences between tadpoles raised in the presence or absence of conspecific chemical cues. Overall, tadpoles raised in the absence of conspecific cues grew larger and were more aggressive than those raised in the presence of conspecific cue. These findings have ecological relevance are the basis for ongoing studies analyzing hormonal and neuronal mechanisms that underlie these phenotypic shifts.

## RELATIVE IMPACTS OF PRE-EXISTING AND NEW *PLASMODIUM* INFECTIONS ON MALE SONGBIRD REPRODUCTIVE CAPACITY

Katie M. Talbott and Ellen D. Ketterson
*Department of Biology, Indiana University*

Avian hosts and the mosquito-borne blood parasite *Plasmodium* are a well-studied model system in the fields of behavioral and disease ecology. Because infections are common, quantifying the impact of these parasites on host physiology and behavior may help clarify the role of parasites as a selective pressure on avian reproductive success. Previous studies investigating the association between blood-borne parasites and avian reproductive success in wild birds have yielded mixed results; in some populations, parental infections are associated with reduced feeding rates and numbers of offspring, while in others, infected parents produce more and/or heavier offspring. Interpreting results from such observational studies is difficult when a bird's history of parasite exposure is unknown. One explanation for mixed results is that chronic infections (i.e., long-term infections with low parasite loads) may protect a bird from future declines in health or reproductive capacity if they are re-exposed to parasites. We tested this hypothesis using wild-caught male dark-eyed juncos in breeding condition. We asked whether metrics of health (body condition, hematocrit, and activity rate) or reproductive capacity (maximum testosterone levels and sperm storage capacity) varied between uninfected juncos and those with chronic infections. We then experimentally inoculated juncos with either *Plasmodium*-infected junco blood or uninfected junco blood. We then sampled health and reproductive capacity metrics weekly for five weeks to determine whether chronically infected juncos responded to experimental inoculation differently than those without chronic infections. We found that chronically infected birds showed a smaller decrease in hematocrit and sperm storage capacity following inoculation. Our presentation discusses the results of this project in the context of trade-offs between reproductive success and self-maintenance in breeding-condition male songbirds.

## COPING WITH CLIMATE CHANGE DURING EARLY DEVELOPMENT: RESPONSES TO EXPERIMENTAL HEAT IN WILD NESTLINGS

Mary J. Woodruff, Susanna N. Tsueda, and Kimberly A. Rosvall
*Department of Biology and Center for the Integrative Study of Animal Behavior, Indiana University*

Heat waves are increasing in intensity, and they pose a potential threat to numerous aspects of animal life, including physiology and development. Previous work, largely in ectotherms or agricultural endotherms, has established that heat induces physiological stress responses, including upregulation of heat shock proteins (HSPs) that counteract cellular damage. Studies on heat effects have more recently been applied to wild birds, but results are mixed. In a previous study, we found that mild heat initiated thermoregulatory behaviors in nestling birds but did not trigger HSP elevation in the blood, suggesting that behavior may buffer animals from heat to some degree. Mild heat during the peak of nestling growth even had positive effects on morphological development. However, we do

not know whether nestlings respond to more intense heat in a similar way. Here, we exaggerated the heat challenge to mirror projected climatic changes occurring this century. Specifically, we used air-activated warmers to elevate nest temperature for 12-day-old tree swallows (*Tachycineta bicolor*). After 4 hours of temperatures elevated 4°C above controls, we measured morphology and HSP gene expression in the blood. We found that HSP gene expression was significantly higher in heated vs. control chicks, suggesting that heat initiated a physiological protective response. Further, heated birds weighed less than controls by the end of the experiment, potentially due to evaporative cooling water loss from panting. Thus, while there seem to be subtle positive effects of mild heat, more intense heat may have more dramatic impacts on nestling physiology and development. Taking a more global perspective, these results inform our understanding of how wild animals cope with the growing threat of climate change.

## LINKING THE TELOMERE REGULATOR POT1 WITH PHENOTYPIC VARIATION WITHIN AND AMONG POPULATIONS

Sarah E. Wolf and Kimberly A. Rosvall
*Biology Department and Center for the Integrative Study of Animal Behavior, Indiana University*

Telomere length is linked to life history traits and is an established biomarker of age. Biomedical work relates shelterin proteins – the regulators of telomere conformation and repair – with the extremes of lifespan, e.g. immortalized cells found in cancer. However, whether natural variation in shelterin proteins mediate micro- and macroevolutionary patterns of phenotypic variation is unexplored. Here, we ask how the shelterin protein POT1, which blocks telomere repair, predicts trait variation within and among populations of wild tree swallows (*Tachycineta bicolor*). First, we found that lower POT1 gene expression is linked to higher individual performance, including reproductive quality and the ability to maintain parental care during stress. Food restriction for offspring of stressed moms also caused the young to exhibit lower POT1 gene expression and increased telomere repair, suggesting that POT1 predicts performance and responds to stress in potentially adaptive ways. Variation in this 'protective' phenotype further predicted offspring recruitment into the breeding population, collectively linking POT1 to fitness within a population. Next, we quantified gene expression and telomeres at 9 sites along a latitudinal gradient, to explore whether POT1 explains variation among populations that differ in life history traits. Evidence shows that adult, but not chick telomeres, vary by population. Moreover, at sites with longer adult telomeres, chicks tended towards lower POT1, suggesting that early variation in this shelterin protein may contribute to macroevolutionary divergence in adult telomere dynamics. These findings provide compelling evidence that shelterin proteins may be visible to natural selection, ultimately shaping phylogeographic patterns of ageing and life history traits.

# SHOULD I STAY OR SHOULD I GO? OPTIMAL FORAGING BEHAVIOR OR SERIAL PATTERN LEARNING?

Thomas R. Zentall[1], Henna Chandel[1], Morgan Boring[1], and Edward A. Wasserman[2]
*[1]Department of Psychology, University of Kentucky; [2]Psychological and Brain Sciences, The University of Iowa*

Optimal foraging theory suggests that animals have evolved to maximize their net rate of energy intake; all things being equal, they should leave the current depleting patch when an alternative patch would provide more food or food sooner. In nature, however, all things are not typically equal. For example, uncertainty about the value of alternative patches, the time to travel to those patches, and the potential dangers incurred in changing patches may delay leaving the depleting patch, when it would otherwise be optimal. We tested this theory by providing pigeons with a choice between a progressive schedule in which food could be obtained with an increasing number of pecks and a multiple schedule in which a colored light signaled the number of pecks required for food reinforcement. The pigeons could switch from the progressive schedule to the multiple schedule at any time. We asked if the pigeons would tend to switch when the schedule signaled by the multiple schedule required fewer responses than the next reinforcer provided by the progressive schedule. We found that the pigeons tended to switch to the multiple schedule sooner than would have been optimal. We propose that on the progressive schedule, the signal to switch was not just the number of pecks to the next reinforcer, but also the more general cue that reinforcement was becoming more difficult to obtain—a form of serial pattern learning.